RECLAMATION

*Managing Water in the West*

# Coordinated Long-Term Operation of the Central Valley Project and State Water Project

**Mid-Pacific Region**
**Bay-Delta Office**

## Final Environmental Impact Statement

U.S. Department of the Interior
Bureau of Reclamation

November 2015

# Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

# Executive Summary

## ES.1 Introduction

This Environmental Impact Statement (EIS) for the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) has been prepared by the Department of the Interior, Bureau of Reclamation (Reclamation). Reclamation is the Federal lead agency for compliance with the National Environmental Policy Act (NEPA) and is completing the EIS as ordered by the United States District Court for the Eastern District of California (District Court). In 2008 and 2009, following litigation on previous Biological Opinion (BOs), Reclamation provisionally accepted and began implementing the BOs on continued long-term operation of the CVP, in coordination with the operation of the SWP issued by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), respectively, pursuant to the Federal Endangered Species Act of 1973 (ESA) as amended (United States Code [U.S.C.] 1531 et. seq.). In 2014, the Ninth Circuit upheld the District Court's ruling that Reclamation's provisional acceptance and implementation of the BOs required Reclamation to comply with NEPA. The District Court remanded Reclamation's decision back to the agency to comply with the court's ruling.

The EIS evaluates potential long-term direct, indirect, and cumulative impacts on the environment that could result from implementation of modifications to the continued long-term operation of the CVP and SWP.

## ES.2 Background

### ES.2.1 Central Valley Project

The first Federal action authorizing the CVP was by the Rivers and Harbors Act of August 30, 1935. The CVP was reauthorized for construction, operation, and maintenance by the Secretary of the Department of the Interior (Secretary), pursuant to the Reclamation Act of 1902, as amended and supplemented (the Federal Reclamation laws), and by the Rivers and Harbors Act of August 26, 1937. In 1992, the Central Valley Project Authorization Act of August 26, 1937 was amended by Section 3406(a) of the Central Valley Project Improvement Act (CVPIA), Public Law 102-575. (http://www.usbr.gov/history/cvpintro.html)

The CVP is composed of 20 reservoirs with a combined storage capacity of more than 11 million acre-feet, over 10 hydroelectric powerplants, and more than 500 miles of major canals and aqueducts. The major CVP facilities are located in the Sacramento-San Joaquin Rivers Delta Estuary (Delta) watershed including:

- **Major Reservoirs:** Trinity Lake (Trinity River), Whiskeytown Lake (Clear Creek); Shasta Lake (Sacramento River), Folsom Lake (American River), New Melones Reservoir (Stanislaus River), portions of the San Luis Reservoir complex (local drainages), and Millerton Lake (San Joaquin River).
- **Major Pumping Plants and Conveyance Facilities**: Red Bluff Pumping Plant (diverts water from Sacramento River into CVP Tehama-Colusa Canal), Folsom South Canal (diverts water from Folsom Lake to portions of Sacramento County), Contra Costa Canal Pumping Plant (diverts water from the Delta into CVP Contra Costa Canal), C.W. "Bill" Jones Pumping Plant (diverts water from the Delta into CVP Delta-Mendota Canal), Clear Creek Tunnel (conveys water from Trinity Lake to Whiskeytown Lake), Pacheco Tunnel and Conduit (conveys water from San Luis Reservoir to Santa Clara and San Benito counties), and Friant Kern and Madera canals (convey water from Millerton Lake to the eastern San Joaquin Valley).

These facilities are operated as an integrated project, although they are authorized and categorized in distinct units or divisions.

### ES.2.2 State Water Project

The State Legislature appropriated funds to the California Department of Water Resources (DWR) to construct the SWP under the State Central Valley Project Act (Water Code section 11100 et seq.), Burns-Porter Act (California Water Resources Development Bond Act), State Contract Act (Public Contract Code section 10100 et seq.), Davis-Dolwig Act (Water Code sections 11900 - 11925), and other acts of the State Legislature.

Major SWP facilities include:

- **Reservoirs:** Lake Oroville and the Thermalito Complex (Feather River); Antelope Lake, Lake Davis, and Frenchman Lake (upper Feather River upstream of Lake Oroville); portions of the San Luis Reservoir complex (local drainages); reservoirs located downstream of San Luis Reservoir along the California Aqueduct and other SWP conveyance facilities (Quail Lake, Pyramid Lake, Castaic Lake, Silverwood Lake, Crafton Hills Reservoir, and Lake Perris).
- **Major Pumping Plants and Conveyance Facilities**: Barker Slough Pumping Plant (diverts water into SWP North Bay Aqueduct); Clifton Court Forebay and Harvey O. Banks Pumping Plant (diverts water from the Delta into SWP South Bay Aqueduct and the SWP California Aqueduct); California Aqueduct and associated pumping plants (convey water to the San Joaquin Valley, San Luis Obispo and Santa Barbara counties along the central coast, and southern California); Coastal Branch of the California Aqueduct (conveys

water to San Luis Obispo and Santa Barbara counties); and East Branch and West Branch (convey water to Southern California).

### ES.2.3 Coordinated Operation of the CVP and SWP

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the Coordinated Operation Agreement (COA). The CVP and SWP are also operated under State Water Resources Control Board (SWRCB) decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP.

Implementation of the COA has evolved continually since 1986 as CVP and SWP facilities, operational criteria, and physical and regulatory environment have changed. For example, adoption of the CVPIA in 1992 changed the purposes and operations of the CVP, and ESA responsibilities have affected operation of the CVP and SWP. DWR and Reclamation have operational arrangements to accommodate new facilities, water quality objectives, the CVPIA, other SWRCB criteria, and the ESA, but the COA has not been formally modified to address these newer operating conditions.

### ES.2.4 Federal Endangered Species Consultation

The following species and their critical habitat listing rules were considered in recent ESA consultations with the USFWS and NMFS for the coordinated long-term operation of the CVP and SWP and in the analyses in this EIS.

- The Sacramento River winter-run Chinook Salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit (ESU) was originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 Federal Register (FR) 46515). They were re-classified as an endangered species on January 4, 1994 (59 FR 440).
- Central Valley spring-run Chinook Salmon (*O. tshawytscha*) ESU was listed as threatened on June 18, 2005 (70 FR 37160).

- The Central Valley Steelhead (*O. mykiss*) distinct population segment (DPS) was listed as threatened on January 5, 2006 (71 FR 834).
- Southern Oregon/Northern California Coast Coho Salmon (*O. kisutch*) ESU was listed as threatened on June 18, 2005 (70 FR 37160).
- Southern DPS of the North American Green Sturgeon (*Acipenser medirostris*) was listed as threatened on June 6, 2006 (71 FR 17757).
- The Southern Resident DPS of Killer Whales (*Orcinus orca*) was listed as endangered on November 18, 2005 (NMFS 2005).
- The Delta Smelt (*Hypomesus transpacificus*) was listed as threatened on March 5, 1993 (58 FR 12854). The species was recently proposed for re-listing as endangered under the ESA.

Fall and late-fall runs of Chinook Salmon are currently Federal Species of Concern, but have not been formally listed.

The Central California Coast Steelhead (*O. mykiss*) DPS was listed as threatened on January 5, 2006 (71 FR 834). The 2009 NMFS BO determined that the long-term operation of the CVP and SWP would not likely adversely affect Central California Coast Steelhead DPS and its critical habitat. Therefore, no further analysis of this DPS was performed and addressed in this EIS.

#### ES.2.4.1 Recent ESA Consultation Activities and Court Rulings

In August 2008, Reclamation submitted a biological assessment (BA) to the USFWS and NMFS to initiate formal consultation. BO's were issued by the USFWS (December 15, 2008) and NMFS (June 4, 2009) with separate Reasonable and Prudent Alternative (RPA) actions to allow CVP and SWP to continue operating without causing jeopardy to listed species or adverse modification to designated critical habitat. Reclamation provisionally accepted and began implementing the two BOs with the RPAs.

Several lawsuits were filed in the District Court challenging aspects of the 2008 USFWS BO and the 2009 NMFS BO and Reclamation's acceptance and implementation of the associated RPAs. Many of the lawsuits consolidated into two proceedings focused on each BO. The outcomes of the *Consolidated Delta Smelt Cases* and the *Consolidated Salmonid Cases* are summarized below.

- *Consolidated Delta Smelt Cases*
  - On November 16, 2009, the District Court ruled that Reclamation violated NEPA by failing to conduct a NEPA review of the potential impacts to the human environment before provisionally accepting and implementing the 2008 USFWS BO, including the RPA.
  - On December 14, 2010, the District Court found certain portions of the 2008 USFWS BO to be arbitrary and capricious in several respects, and remanded those portions of the BO to the USFWS without vacatur for further consideration. The District Court ordered Reclamation to review

its decision to provisionally accept and implement the BO and RPA in accordance with NEPA.

- The decision of the District Court related to the USFWS BO was appealed to the United States Court of Appeals for the Ninth Circuit (Appellate Court). On March 13, 2014, the Appellate Court reversed the District Court decision and upheld the BO. However, the Appellate Court affirmed the judgment of the District Court with respect to the NEPA claims.
- The District Court amended the Judgement on September 30, 2014 consistent with the Appellate Court's decision. Petitions for Writ of Certiorari were submitted to the U.S. Supreme Court; however, the U.S. Supreme Court decided to not hear the cases.

- *Consolidated Salmonid Cases*
    - On March 5, 2010, the District Court ruled that Reclamation violated NEPA by failing to undertake a NEPA analysis of potential impacts to the human environment before provisionally accepting and implementing the 2009 NMFS BO and RPA.
    - On September 20, 2011, the District Court found the 2009 NMFS BO was arbitrary and capricious in several respects, and remanded the 2009 NMFS BO without vacatur for further consideration.
    - The decisions of the District Court related to the 2009 NMFS BO were appealed to the Appellate Court. On December 22, 2014, the Appellate Court reversed the District Court decision and upheld the BO.
    - The District Court issued the Final Order on May 5, 2015 consistent with the Appellate Court's Decision.

## ES.3 Need to Prepare this Environmental Impact Statement

To comply with the District Court's 2010 orders regarding NEPA for the coordinated long-term operation of the CVP and SWP, Reclamation initiated preparation of this EIS in 2011. This EIS documents Reclamation's analysis of the effects of modifications to the coordinated long-term operation of the CVP and SWP that are likely to avoid jeopardy to listed species and destruction or adverse modification of designated critical habitat.

In accordance with the October 1, 2014, District Court's order in the *Consolidated Delta Smelt Cases*, the Final EIS and Record of Decision are to be completed on or before December 1, 2015. By order dated October 8, 2015, this date has been extended to January 12, 2016.

Many of the provisions of the RPAs, as set forth in the 2008 USFWS BO and the 2009 NMFS BO, require further study, monitoring, consultation, implementation of adaptive management programs, and subsequent environmental documentation for future facilities to be constructed or modified. Specific actions related to these provisions are not known at this time. Therefore, this EIS assumes the completion of future actions, including provisions of the RPAs, in a manner that would be consistent with ESA and does not address impacts during construction or start-up phases of these actions.

# ES.4 Use of the Environmental Impact Statement

This EIS may be used by Reclamation or cooperating agencies that are participating in the preparation of this EIS to inform future decisions related to operation of the CVP and SWP, and implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO.

# ES.5 Purpose and Need

NEPA regulations require a statement regarding "the underlying purpose and need to which the agency is responding in proposing the alternatives, including the proposed action" (40 Code of Federal Regulations (CFR) 1502.13).

## ES.5.1 Purpose of the Action

The purpose of the action considered in this EIS is to continue the operation of the CVP in coordination with operation of the SWP, for its authorized purposes, in a manner that:

- Is similar to historic operational parameters with certain modifications;
- Is consistent with Federal Reclamation law; other Federal laws and regulations; Federal permits and licenses; State of California water rights, permits, and licenses; and
- Enables Reclamation and DWR to satisfy their contractual obligations to the fullest extent possible.

## ES.5.2 Need for the Action

Continued operation of the CVP is needed to provide river regulation, navigation; flood control; water supply for irrigation and domestic uses; fish and wildlife mitigation, protection, and restoration; fish and wildlife enhancement; and power generation. The CVP and the SWP facilities are also operated to provide recreation benefits and in accordance with the water rights and water quality requirements adopted by the SWRCB.

The USFWS and NMFS concluded in their 2008 and 2009 BOs, respectively, that the coordinated long-term operation of the CVP and SWP, as described in the 2008 Reclamation BA, jeopardized the continued existence of listed species and adversely modified critical habitat. To remedy this, the USFWS and NMFS provided RPAs in their respective BOs.

The Appellate Court confirmed the District Court ruling that Reclamation must conduct a NEPA review to determine whether the provisional acceptance and implementation of the RPA actions cause a significant effect to the human environment.

## ES.6 Project Area

The project area boundaries are defined by the locations of most of the CVP facilities and their service areas; and all of the SWP facilities and the SWP service areas. The CVP facilities associated with Millerton Lake, including the Madera and Friant-Kern canals and their service areas, and the San Joaquin River Restoration Program are not part of the project area for this EIS because the operations of these facilities were not addressed in either the 2008 USFWS BO or 2009 NMFS BO.

## ES.7 Study Period

The coordinated long-term operation of the CVP and SWP, as described in this EIS, would continue to at least 2030 before CVP and SWP operations would change. These changes could include projects considered as part of the cumulative effects analyses. Therefore, the EIS analyzes future conditions projected for the Year 2030. It is recognized that many changes between existing conditions and 2030 would occur without changes to CVP and SWP operations, including local land use decisions, implementation of new water management facilities, and climate change.

As the changing conditions described above and other future changes occur, changes in long-term operation of the CVP and SWP may be required. This may require the re-initiation of consultation on the 2008 USFWS BO and 2009 NMFS BO. Therefore, because the above-described changes in conditions are likely to occur by 2030 and because new BOs would be required, this EIS considers a study period that concludes in 2030.

## ES.8 Proposed Action and Preferred Alternative

The Notice of Intent to prepare this EIS was published in March 2012 identified an "initial Proposed Action" that included the operational actions of the 2008 USFWS BO and 2009 NMFS BO, without structural changes included in the RPA actions that would require future studies and environmental documentation to define recommended actions, including fish passage around the CVP dams. The initial Proposed Action is included in this EIS as Alternative 2.

Based upon the analysis in this EIS of aquatic resources by 2030, climate change may result in substantially higher air temperatures than during recent conditions. Higher air temperatures would likely increase water temperatures in both the CVP reservoirs and in the rivers downstream of the CVP dams. Under these conditions, Reclamation may not be able to operate the reservoirs under the initial Proposed Action without fish passage in a manner that would meet water temperature objectives; and it may not be possible to avoid jeopardizing the continued existence of listed species and/or resulting in an adverse modification of critical habitat.

Based upon the results of the impact analyses presented in this EIS, the Preferred Alternative is the No Action Alternative. The No Action Alternative contains all of the RPA actions in the 2008 USFWS BO and 2009 NMFS BO, as amended, including the RPA actions to evaluate fish passage to upstream habitats that exhibit lower water temperatures. Further discussion of the selection of the Preferred Alternative will be included in the Record of Decision.

The Environmentally Preferred Alternative also will be identified and disclosed in the Record of Decision, as required by the Council of Environmental Quality regulations.

## ES.9 Summary Description of Alternatives

Identification of the No Action Alternative and the range of alternatives for this EIS were developed to respond to the purpose and need for the action and to comments received during the scoping process and preparation of the EIS.

Twenty-three alternative concepts were identified during the scoping process and through meetings with stakeholders and agencies during preparation of this EIS. The alternative concepts were compared to screening criteria that were developed based on the purpose of the action. The alternative concepts were also reviewed to determine if they addressed substantial issues. Based upon the comparison of screening criteria to the alternative concepts, 17 of the 23 alternative concepts were identified to be included in one or more of the alternatives evaluated in this EIS. The alternative concepts were combined into five specific alternatives that were consistent with assumptions for the year 2030. Further development of the alternatives was informed by subsequent comments received during preparation of the EIS.

All of the alternatives, including the No Action Alternative, include the same assumptions related to (1) climate change and sea level rise in Year 2030, and (2) development throughout California in accordance with existing general plans, existing contracts, and implementation of reasonable and foreseeable water resources management projects.

### ES.9.1 Inclusion of the Second Basis of Comparison

The No Action Alternative is defined as the projections of current conditions and trends into the future without implementation of the alternatives. These projected conditions are defined in Question 3 of the Council on Environmental Quality (CEQ) Forty Most Asked Questions as "'no change' from current management direction or level of management intensity." The No Action Alternative also can be defined as “no project” in cases where a new project is proposed for implementation. However, all of the alternatives evaluated in this EIS are to continue the coordinated long-term operation of the CVP and SWP. Therefore, the definition of the No Action Alternative used for this EIS is continuation of the current management direction and level of intensity.

For this EIS, the No Action Alternative is based upon the continued operation of the CVP and SWP in the same manner as was occurring at the time of the publication of the Notice of Intent in March 2012. Thus, the No Action Alternative consists of the coordinated long-term operation of the CVP and SWP, including full implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO, because Reclamation provisionally accepted the BOs in 2008 and 2009, respectively, began implementing the RPAs, and continues to implement the RPAs to date. The No Action Alternative also includes changes not related to the long-term operation of the CVP and SWP or implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO.

Numerous scoping comments requested that the No Action Alternative not include the RPAs in the 2008 USFWS BO and 2009 NMFS BO because, at that time, the District Court had remanded the BOs back to USFWS and NMFS. The comments indicated that the EIS should include a “basis of comparison” for the alternatives that was similar to conditions prior to implementation of the RPAs. Scoping comments also indicated that a ”No Action Alternative scenario” without implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO could be used to analyze the effects of implementing the RPAs.

Determining an appropriate baseline without the 2008 USFWS BO and 2009 NMFS BO actions and yet continuing to meet all of Reclamation’s statutory and regulatory requirements is a difficult task. Simply analyzing a No Action Alternative that is similar to the project description described in either the 2004 Biological Assessment or 2008 Biological Assessment is insufficient, as each was found to jeopardize listed species, the 2004 Biological Assessment by the District Court in 2007, and the 2008 Biological Assessment by USFWS and NMFS. Either of these operations would be inconsistent with Reclamation’s existing policy and management direction.

Because the RPAs were provisionally accepted and the No Action Alternative represents a continuation of existing policy and management direction, the No Action Alternative includes the RPAs. However, in response to scoping comments and subsequent comments from stakeholders and interest groups, and to provide a basis for comparison of the effects of implementation of the RPAs (per the District Court’s mandate), this EIS includes a “Second Basis of Comparison” that represents a condition in 2030 without implementation of the 2008 USFWS BO and 2009 NMFS BO. All of the alternatives are compared to the No Action Alternative and to the Second Basis of Comparison to describe the effects that could occur in 2030 under both bases of comparison.

Several of the 2008 USFWS BO RPA and 2009 NMFS BO RPA actions had been initiated prior to issuance of the 2009 NMFS BO; those actions are included in the

Second Basis of Comparison. Reasonably foreseeable actions included in the No Action Alternative that are not related to the 2008 USFWS BO or 2009 NMFS BO are also included in the Second Basis of Comparison.

### ES.9.2 No Action Alternative

The definition of the No Action Alternative is based upon the following assumptions.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; and operational requirements of the 2008 USFWS BO and the 2009 NMFS BO.
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs, including:
  - 2008 USFWS BO RPA Component 4, Habitat Restoration and 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Habitat; and Action I.6.2, Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass; Action I.6.3, Lower Putah Creek Enhancements; Action I.6.4, Improvements to Lisbon Weir; and Action I.7, Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass - Restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.
  - 2009 NMFS BO RPA Action I.1.3, Clear Creek Spawning Gravel Augmentation - Gravel augmentation in Clear Creek in addition to several gravel augmentation programs in the Sacramento Valley watershed being implemented in accordance with CVPIA.
  - 2009 NMFS BO RPA Action I.1.4, Spring Creek Temperature Control Curtain Replacement - Replacement of the Spring Creek Temperature Control Curtain.
  - 2009 NMFS BO RPA Action I.2.6, Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead - Habitat restoration of Battle Creek.
  - 2009 NMFS BO RPA Action I.3.1, Operate Red Bluff Diversion Dam with Gates Out - Implementation of Red Bluff Pumping Plant.
  - 2009 NMFS BO RPA Action I.5, Funding for CVPIA Anadromous Fish Screen Program - Implementation of the CVPIA Anadromous Fish Screen Program.
  - 2009 NMFS BO RPA Action II.1, Lower American River Flow Management - Implementation of the American River Flow Management Standard.

- Implementation of existing and future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS, including:
  - Trinity River Restoration Program.
  - Clear Creek Mercury Abatement and Fisheries Restoration Project.
  - Iron Mountain Mine Superfund Site cleanup.
  - Mainstem Sacramento River and American River Gravel Augmentation Programs.
  - Nimbus Fish Hatchery Fish Passage Project.
  - Folsom Dam Water Control Manual Update.
  - FERC Relicensing for Middle Fork of the American River Project.
  - Lower Mokelumne River Spawning Habitat Improvement Project.
  - Dutch Slough Tidal Marsh Restoration.
  - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation.
  - Tidal Wetland Restoration in the Delta and Suisun Marsh.
  - San Joaquin River Restoration Program.
  - Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project.
  - Grasslands Bypass Project.
  - Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS).
  - Municipal Water Supply Projects identified in Urban Water Management Plans that have undergone environmental review and are reasonably foreseeable.
  - Water Transfer Projects.

### ES.9.3 Second Basis of Comparison

The definition of the Second Basis of Comparison is based upon the following assumptions.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB without implementation of the 2008 USFWS BO and the 2009 NMFS BO.
- Implementation of existing and future actions that would occur by 2030 without implementation of the BOs, including actions that have already been constructed or have substantial progress:

- Restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass (as being implemented under a separate program adopted in 2014, Suisun Marsh Habitat Management, Preservation, and Restoration Plan, and referenced in 2008 USFWS BO RPA Component 4, Habitat Restoration; and as being developed under Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan and referenced in 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Habitat; and Action I.6.2, Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass; Action I.6.3, Lower Putah Creek Enhancements; Action I.6.4, Improvements to Lisbon Weir; and Action I.7, Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass).
- Gravel augmentation in the Sacramento Valley and Stanislaus River watershed (as being implemented under a separate program and including program under CVPIA and referenced in 2009 NMFS BO RPA Action I.1.3, Clear Creek Spawning Gravel Augmentation).
- Replacement of the Spring Creek Temperature Control Curtain (as was constructed and placed into operation in 2011 and referenced in 2009 NMFS BO RPA Action I.1.4, Spring Creek Temperature Control Curtain Replacement).
- Habitat restoration of Battle Creek (as being implemented under a separate program and referenced in 2009 NMFS BO RPA Action I.2.6, Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead).
- Implementation of Red Bluff Pumping Plant (as was constructed and placed into operation in 2012 and referenced in 2009 NMFS BO RPA Action I.3.1, Operate Red Bluff Diversion Dam with Gates Out).
- Implementation of the CVPIA Anadromous Fish Screen Program (as was initiated in the 1990s and referenced in 2009 NMFS BO RPA Action I.5, Funding for CVPIA Anadromous Fish Screen Program).
- Implementation of the American River Flow Management Standard (as was initiated in 2006 and referenced in 2009 NMFS BO RPA Action II.1, Lower American River Flow Management).
- Trinity River Restoration Program.
- Clear Creek Mercury Abatement and Fisheries Restoration Project.
- Iron Mountain Mine Superfund Site cleanup.
- Mainstem Sacramento River and American River Gravel Augmentation Programs.
- Nimbus Fish Hatchery Fish Passage Project.
- FERC Relicensing for Middle Fork of the American River Project.

- Lower Mokelumne River Spawning Habitat Improvement Project.
- Dutch Slough Tidal Marsh Restoration.
- Tidal Wetland Restoration in the Delta and Suisun Marsh.
- San Joaquin River Restoration Program.
- Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project.
- Grasslands Bypass Project.
- Municipal Water Supply Projects identified in Urban Water Management Plans that have undergone environmental review and are reasonably foreseeable.
- Water Transfer Projects.

### ES.9.4 Alternative 1

Alternative 1 was created because many comments requested an alternative that reflected conditions without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs. Since the Second Basis of Comparison is not a true alternative, in accordance with NEPA guidelines, Reclamation could not select the Second Basis of Comparison as a preferred alternative. Therefore, Alternative 1 is identical to the Second Basis of Comparison.

### ES.9.5 Alternative 2

Alternative 2 was first included in the Notice of Intent and identified as an initial proposed action that included the operational actions of the 2008 USFWS BO and 2009 NMFS BO. Alternative 2 does not include RPA actions that would require future studies and environmental documentation to define recommended actions (generally, structural actions). Therefore, Alternative 2 includes the assumptions in the No Action Alternative except:

- 2009 NMFS BO RPA Action I.2.5, Winter-Run Passage and Re-Introduction Program at Shasta Dam.
- 2009 NMFS BO RPA Action II.3, Structural Improvements for Temperature Management on the American River.
- 2009 NMFS BO RPA Action II.5, Fish Passage at Nimbus and Folsom Dams.
- 2009 NMFS BO RPA Action II.6, Implement Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations.
- 2009 NMFS BO RPA Action III.2.1, Increase and Improve Quality of Spawning Habitat with Addition of Gravel.
- 2009 NMFS BO RPA Action III.2.2, Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on Stanislaus River.

- 2009 NMFS BO RPA Action III.2.3, Restore Freshwater Migratory Habitat for Juvenile Steelhead on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.4, Fish Passage at New Melones, Tulloch, and Goodwin Dams.
- 2009 NMFS BO RPA Action IV.4, Tracy Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates.
- 2009 NMFS BO RPA Action V Fish Passage.

### ES.9.6 Alternative 3

Alternative 3 was developed based upon a scoping comment from the Coalition for a Sustainable Delta, including actions related to their "RPA Alternative 1," and a scoping comment received from Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID). The definition of Alternative 3 is based upon the following assumptions.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; without the operational requirements of the 2008 USFWS BO and the 2009 NMFS BO RPAs.
- Implementation of the 2012 operations plan for New Melones Reservoir proposed by OID and SSJID.
- Additional demands for American River water supplies for up to 17,000 acre-feet/year under a Warren Act contract for El Dorado Irrigation District and 15,000 acre-feet/year under a water service contract for El Dorado County Water Agency.
- Implementation of actions described in the scoping comments letter from the Coalition for a Sustainable Delta related to their "RPA Alternative 1."
  - The Old and Middle River (OMR) flow criteria under Alternative 3 are based on concepts addressed in the 2008 USFWS BO and 2009 NMFS BO related to adaptive restrictions for temperature, turbidity, salinity, and presence of Delta Smelt.
  - Flood control operations for the New Melones Reservoir would be the same as under the No Action Alternative. However, New Melones Reservoir would be operated for different fishery flows, water quality flows, and San Joaquin River base flows and pulse flows at Vernalis.

- – Implement predator control programs for Black Bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt, including establishment of new catch limits.
- – Restore or create at least 10,000 acres of tidally influenced seasonal or perennial wetlands (these conditions are the same as under the No Action Alternative and Second Basis of Comparison).
- – Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River upstream of the Head of Old River in March through June with a release site near Chipps Island.
- – Modify ocean harvest limits for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced.

- Implementation of future actions that would occur by 2030 without implementation of any alternatives considered in this EIS, as described above for the Second Basis of Comparison.

### ES.9.7 Alternative 4

Alternative 4 was developed based upon a scoping comment from the Coalition for a Sustainable Delta, including actions related to their "RPA Alternative 2." The definition of Alternative 4 is based upon the following assumptions.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; without the operational requirements of the 2008 USFWS BO and the 2009 NMFS BO, as described under Second Basis of Comparison.
- Implementation of actions described in the scoping comments letter from the Coalition for a Sustainable Delta related to their "RPA Alternative 2."
  - – Limit floodplain development to protect salmonids and Delta Smelt by incorporating guidance into flood hazard mapping to comply with ESA; prioritizing consideration of ESA listed species and critical habitats in flood insurance studies; refine community rating system to provide credits for natural and beneficial functions; prohibit new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway.
  - – Modify the requirements of the U.S. Army Corps of Engineers related to removal of vegetation on levees to allow for the planting of trees and shrubs along the levees; and installation of vegetation, woody material, and root re-enforcement material on the levees instead of riprap for erosion protection.

   - Implement predator control programs for Black Bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt, including establishment of new catch limits.
   - Restore or create at least 10,000 acres of tidally influenced seasonal or perennial wetlands (these conditions are the same as under the No Action Alternative and Second Basis of Comparison).
   - Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River upstream of the Head of Old River in March through June with a release site near Chipps Island.
   - Modify ocean harvest limits to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years.
- Implementation of future actions that would occur by 2030 without implementation of any alternatives considered in this EIS, as described above for the Second Basis of Comparison.

### ES.9.8 Alternative 5

Alternative 5 was developed considering comments from environmental interest groups during the scoping process. Alternative 5 is similar to the No Action Alternative with reduced potential for reverse flows in April and May and with associated increased Delta outflow; and use of the SWRCB D-1641 pulse flow at Vernalis. The definition of Alternative 5 is based upon the following assumptions.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; including the requirements of the 2008 USFWS BO and the 2009 NMFS BO.
- The OMR flow criteria similar to the RPA criteria in the 2008 USFWS BO and 2009 NMFS BO plus a requirement for positive OMR (no reverse flows) in April and May of all water year types.
- New Melones Reservoir operations are similar to assumptions under the No Action Alternative except additional requirements were added to meet the SWRCB D-1641 April and May pulse flows at Vernalis on the San Joaquin River.
- Additional demands for American River water supplies for up to 17,000 acre-feet/year under a Warren Act Contract for El Dorado Irrigation District and 15,000 acre-feet/year under a water service contract for El Dorado County Water Agency.
- Implementation of future actions that would occur by 2030 without implementation of any alternatives considered in this EIS, as described above for the No Action Alternative.

## ES.10 Impact Analysis

An EIS must evaluate the effects of implementation of the alternatives on the environment; and identify any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment and long-term productivity; and any irreversible or irretrievable commitments of resources if the alternatives are implemented. The impact analyses section of each resource chapter (Chapters 5 through 21 of the EIS) address direct, indirect, and cumulative effects of the alternatives as compared to the No Action Alternative and the Second Basis of Comparison in the following manner:

- Alternatives 1 through 5 are compared to the No Action Alternative.
- Alternatives 1 through 5 and the No Action Alternative are compared to the Second Basis of Comparison.

Potential mitigation measures are presented to the extent possible for each resource to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Tables ES.1 and ES.2 present summaries of the environmental changes of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison, respectively. These tables are located at the end of this Executive Summary.

These tables summarize the results of both the quantitative and qualitative impact analyses. The tables include relative quantitative differences for adverse impacts to provide a basis for consideration of mitigation measures. Differences in the quantitative analyses of 5 percent or less are considered to be “similar” because the modeling analyses are based on CalSim II model output which operates with monthly time steps. Therefore, it was determined that changes in the model of 5 percent or less were related to the uncertainties in the model processing.

Changes in surface water conditions are provided as a basis for identifying the impacts as described in Aquatic, Terrestrial, and Recreation resources. Therefore, no mitigation measures are presented for Surface Water Resources.

## ES.11 Public Involvement and Next Steps

Public involvement was initiated with the scoping process on March 28, 2012, with the publication of the Notice of Intent in the Federal Register (FR) and continued through June 28, 2012. Initially, the public scoping process was to be completed on May 29, 2012. During the public scoping process, other agencies and interested persons requested an extension of the public scoping period to allow additional opportunities to provide scoping comments. In response to these requests, Reclamation published a notice on May 25, 2012, extending the public scoping period through June 28, 2012. Reclamation held five scoping meetings which were attended by 256 individuals. Scoping comments were used in the development of a reasonable range of alternatives and identification of key issues.

Reclamation also posted on its website an initial range of alternatives discussed at a stakeholders meeting on October 19, 2012. Several project status meetings were held with cooperating agencies and other stakeholders during preparation of the Draft EIS. Comments received during these processes were used to refine the description of the alternatives.

The Draft EIS was issued for public review in July 2015. Reclamation posted notification of the availability of the Public Draft EIS and the location and timing of four public meetings on its website, in the Federal Register, and through press releases. Approximately 860 written and verbal comments were received on the Draft EIS. All of the comments received on the Draft EIS were considered in preparation of the Final EIS. Written responses to all substantive comments received are included in Appendices 1A through 1E of the Final EIS.

Reclamation will make the Final EIS available for 30 days before finalizing the Record of Decision (ROD). In the ROD, which is the final step in the NEPA process, Reclamation will document its decision on which actions, if any, to take to address the primary objectives. Reclamation will also identify the Environmentally Preferred Alternative, describe other risk reduction plans it considered, identify any mitigation plans, and describe factors and comments taken into consideration when making its decision.

**Table ES.1 Comparison of Alternatives 1 through 5 to the No Action Alternative**

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Surface Water** | | | | | |
| Trinity Lake | Water surface elevations similar.<br>Storage similar or increased. | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. |
| Trinity River at Lewiston Dam | Flows similar or increased. | No change. | Flows similar or increased. | Flows similar or increased. | Water surface elevations similar.<br>Storage similar. |
| Shasta Lake | Water surface elevations similar.<br>Storage similar or increased. | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar. |
| Sacramento River at Keswick Dam | Flows similar or increased except reduced in September and November (up to 44%). | No change. | Flows similar or increased except reduced in September and November (up to 42%). | Flows similar or increased except reduced in September and November (up to 44%). | Flows similar. |
| Sacramento River at Freeport | Flows similar or increased except reduced in September and November (up to 47%). | No change. | Flows similar or increased except reduced in September and November (up to 48%). | Flows similar or increased except reduced in September and November (up to 47%). | Flows similar. |
| Clear Creek near Igo | Flows same except reduced in May (41%). | No change. | Flows same except reduced in May (29%). | Flows same except reduced in May (41%). | No change. |
| Lake Oroville | Water surface elevations similar.<br>Storage reduced except in June (up to 22%). | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage reduced except in June (up to 22%). | Water surface elevations similar.<br>Storage similar. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Feather River downstream of Themalito Complex | Flows similar or increased except reduced in July-September and November-December (up to 65%). | No change. | Flows similar or increased except reduced in July-September and October-January (up to 70%). | Flows similar or increased except reduced in July-September and November-December (up to 65%). | Flows similar or increased except reduced in April-May (up to 27%). |
| Folsom Lake | Water surface elevations similar<br>Storage similar or increased except reduced in June-August in above normal and below normal years (up to 15%). | No change. | Water surface elevations similar<br>Storage similar or increased except reduced in July-August in above normal and August-September in below normal years (up to 10%). | Water surface elevations similar<br>Storage similar or increased except in reduced June-August in above normal and below normal years (up to 15%). | Water surface elevations similar.<br>Storage similar. |
| American River at Nimbus Dam | Flows similar or increased except reduced in September-November and June-July (up to 48%). | No change. | Flows similar or increased except reduced in August-November and June (up to 46%). | Flows similar or increased except reduced in September-November and June-July (up to 48%). | Flows similar or increased except reduced in September and April-May (up to 14%). |
| New Melones Reservoir | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar.<br>Storage reduced in July-September in above normal years (up to 6%); and all months in below normal, dry, and critical dry years (up to 19 percent). |
| Stanislaus River at Goodwin Dam | Flows similar or increased except reduced in July-August, December, and March (up to 18%). | No change. | Flows similar or increased except reduced in October and February-July (up to 73%). | Flows similar or increased except reduced in July-August, December, and March (up to 18%). | Flows similar or increased except reduced in June-August (up to 18%). |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| San Joaquin River at Vernalis | Flows similar or increased except reduced in October and April (up to 19%). | No change. | Flows similar or increased except reduced in October and May-June (up to 21%). | Flows similar or increased except reduced in October and April (up to 19%). | Flows similar or increased. |
| San Luis Reservoir | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased except in below normal years in June-July (up to 9%); in dry years in April-September (up to 17%); and in critical dry years in April-January (up to 18%). |
| Flows into Yolo Bypass | Flows similar or increased except in October in wet years (20%). | No change. | Flows similar or increased except in October in wet years (25%). | Flows similar or increased except in October in wet years (20%). | Flows similar. |
| Delta Outflow | Reduced flows in many months. Increased flows in some months, including in December, February-March, and June in wet years (up to 1,492 cfs); and similar or increased flows in June and September in dry years (up to 385 cfs). | No change. | Reduced flows in many months. Increased flows in some months, including in December-March, in wet years (up to 3.307cfs); and increased flows in January-February and June-July in dry years (up to 277 cfs). | Reduced flows in many months. Increased flows in some months, including in December, February-March, and June in wet years (up to 1,492 cfs); and similar or increased flows in June and September in dry years (up to 385 cfs). | Flows would be similar or increased. |
| Reverse Flows in Old and Middle Rivers | Increased negative flows except in July-September. | No change. | Increased negative flows except in July-September. | Increased negative flows except in July-September. | Increased positive flows except in July-August. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Water Supplies** | | | | | |
| Non-CVP and Non-SWP Deliveries | Deliveries similar.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. |
| CVP Water Deliveries<br>(including CVP agricultural and municipal and industrial water service contracts; Sacramento River Settlement Contracts, San Joaquin River Exchange Contracts, and Eastside Division Contracts) | Deliveries similar or increased.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased in wet to dry years.<br>Reduced deliveries in the Eastside Division Contractors in critical dry years (8%).<br>Potential Mitigation measure: Reclamation would support water transfers from other basin water rights holders. |
| SWP Water Deliveries<br>(In accordance with Table A contracts without Article 21 water) | Deliveries similar or increased.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Surface Water Quality** | | | | | |
| Salinity in Northern Delta (near Emmaton) | Salinity increased in fall and winter months (up to 377%).<br>Reduced in June in wet to dry years (up to 30%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in fall and winter months in wet and above normal years (up to 378%).<br>Reduced in June of above normal years and September of below normal years (up to 8%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in the western Delta in fall and winter months (up to 377%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in January-February in all years (up to 8%).<br>Reduced in April-June in critical dry years (up to 15%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Salinity in Western Delta (near Port Chicago) | Salinity increased in Oct-March in below normal, dry, and critical dry years, and September wet and above normal years (up to 96%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-January, April-May, June, and September in wet and above normal years (up to 95%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in Oct-March in below normal, dry, and critical dry years, and September wet and above normal years (up to 96%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity similar in most months except reduced in April-May in dry and critical dry years (up to 8%).<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Salinity in Western Central Delta (near Antioch) | Salinity increased in fall and winter months (up to 265%).<br>Reduced in June in wet to below normal years (up to 14%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in fall and winter months (up to 262%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in fall and winter months (up to 265%).<br>Reduced in June in wet to below normal years (up to 14%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in February in critical dry years (7%).<br>Reduced in April-May in below normal to critical dry years, and in June in critical dry years (up to 20%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Salinity in Western Central Delta (near Contra Costa Water District Intakes) | Salinity increased in October-January and September in wet and above normal years (up to 65%).<br>Reduced in March-June in wet to below normal years (up to 32%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-December in all year types, and January in above normal to dry years, and in September in wet and above normal years (up to 76%).<br>Reduced in April-June (up to 34%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in October-January and September in wet and above normal years (up to 65%).<br>Reduced in March-June in wet to below normal years (up to 32%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in April-June in below normal to critical dry years (up to 40%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Salinity in Southern Delta (near CVP and SWP intakes) | Salinity increased in fall and early winter months (up to 65%).<br>Reduced in February-June (up to 22%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-December (up to 29% at Jones Pumping Plant intake and up to 41% at Clifton Court intake).<br>Reduced in June (up to 13% at Jones Pumping Plant intake and up to 19% at Clifton Court intake).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in fall and early winter months (up to 65%).<br>Reduced in February-June (up to 22%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in June in dry and critical dry years (up to 12%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Mercury in Delta Fish | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | Mercury concentrations similar concentrations.<br>No mitigation needed. |
| Selenium in Delta and Delta Fish | Selenium concentrations similar concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. |
| **Groundwater Resources** | | | | | |
| Trinity River Region | Similar groundwater conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Central Valley Region: Sacramento Valley | Similar groundwater conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. |
| Central Valley Region: San Joaquin Valley | Reduced groundwater pumping (8%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced groundwater pumping (6%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | Reduced groundwater pumping (8%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | Similar groundwater pumping; and similar to higher groundwater elevations (2-25 feet).<br>Similar groundwater quality.<br>Similar subsidence potential.<br>No mitigation needed. |
| San Francisco Bay Area, Central Coast, and Southern California Region | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | No change.<br>No mitigation needed. | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | Similar groundwater pumping; and groundwater elevations.<br>Potentially similar groundwater quality.<br>Similar subsidence potential.<br>No mitigation needed. |
| **CVP and SWP Energy Resources** | | | | | |
| Energy Generated and Used by CVP and SWP Water Users | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (41%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (27%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (41%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | Similar CVP and SWP net generation.<br>Similar reduced energy use.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Aquatic Resources** | | | | | |
| Trinity River: Coho Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Spring-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Steelhead | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Green Sturgeon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity Lake and Lewiston Reservoir: Reservoir Fish | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Pacific Lamprey | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Eulachon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Winter-run Chinook Salmon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Spring-run Chinook Salmon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Late Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Steelhead | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Green Sturgeon and White Sturgeon | Likely to result in improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Likely to result in improved conditions.<br>No mitigation needed. | Likely to result in improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Delta: Delta Smelt | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta.<br>No mitigation measures have been identified at this time. | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |
| Delta: Longfin Smelt | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices).<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices).<br>No mitigation measures have been identified at this time. | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices).<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |
| Delta: Sacramento Splittail | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Reservoir Fish | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Pacific Lamprey | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Striped Bass, American Shad, and Hardhead | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation measures have been identified at this time. | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Stanislaus River: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain.<br>No mitigation needed. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Stanislaus River: Steelhead | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. |
| Stanislaus River: White Sturgeon | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| New Melones Reservoir; Reservoir Fish | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Stanislaus River: Other Fish | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions for lampreys and Hardheads.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation needed for lamprey and Hardhead. No mitigation measures have been identified at this time for Striped Bass. | Similar conditions for lampreys and Hardheads.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation needed for lamprey and Hardhead. No mitigation measures have been identified at this time for Striped Bass. | Similar conditions.<br>No mitigation needed. |
| Pacific Ocean: Killer Whale | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Terrestrial Resources** | | | | | |
| Terrestrial Resources along Shoreline of CVP and SWP Reservoirs | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Terrestrial Resources along Rivers Downstream of CVP and SWP Reservoirs | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | No change.<br>No mitigation needed. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Improved conditions along Stanislaus River.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Terrestrial Resources in Yolo Bypass | Similar conditions in Yolo Bypass.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions in Yolo Bypass.<br>No mitigation needed. | Similar conditions in Yolo Bypass.<br>No mitigation needed. | Similar conditions in Yolo Bypass.<br>No mitigation needed. |
| Terrestrial Resources in Western Delta | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | No change.<br>No mitigation needed. | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | Similar habitat in western Delta.<br>No mitigation needed. |
| **Geology and Soils Resources** | | | | | |
| Geology and Soils Resources | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Agricultural Resources** | | | | | |
| Agricultural Production and Employment | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Land Use** | | | | | |
| Municipal and Industrial Land Use | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Visual Resources** | | | | | |
| Visual Resources of Land Irrigated with CVP and SWP Water | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Visual Resources at Reservoirs that Store CVP and SWP Water | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Recreation Resources** | | | | | |
| Recreation Resources at Reservoirs that Store CVP and SWP Water | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Recreation Resources in Rivers downstream of CVP and SWP Reservoirs | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing.<br>No mitigation measures identified at this time. | Similar or improved conditions.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing.<br>No mitigation measures identified at this time. | Similar conditions.<br>No mitigation needed. |
| **Air Quality and Greenhouse Gas Emissions** | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Improved air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Reduced air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Improved air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Similar air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Increased Greenhouse Gas Emissions (GHG) due to Changes in Energy Resources Related to CVP and SWP Water Use | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. |
| **Cultural Resources** | | | | | |
| Potential for Disturbance of Cultural Resources | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| **Public Health** | | | | | |
| Water Supply Availability for Wildland Firefighting | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Potential Exposure to Mercury in Fish in Delta | Similar or reduced concentrations. No mitigation needed. | No change. No mitigation needed. | Similar or reduced concentrations. No mitigation needed. | Similar or reduced concentrations. No mitigation needed. | Similar concentrations. No mitigation needed. |
| **Socioeconomics** | | | | | |
| Agricultural and Municipal and Industrial Employment | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Municipal and Industrial Water Supply Operating Expenses | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Recreational Economics CVP and SWP Reservoirs | Similar or improved conditions. No mitigation needed. | No change. No mitigation needed. | Similar or improved conditions. No mitigation needed. | Similar or improved conditions. No mitigation needed. | Similar or improved conditions. No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Recreational Economics Related to Striped Bass Fishing in Delta | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced recreational opportunities and associated economics.<br>No mitigation identified at this time. | Reduced recreational opportunities and associated economics.<br>No mitigation identified at this time. | Similar conditions.<br>No mitigation needed. |
| Commercial and Sport Ocean Salmon Fishing | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced commercial and sport ocean salmon fishing and associated economics.<br>No mitigation identified at this time. | Reduced commercial and sport ocean salmon fishing and associated economics.<br>No mitigation identified at this time. | Similar conditions.<br>No mitigation needed. |
| **Indian Trust Assets** | | | | | |
| Potential for Disturbance of Indian Trust Assets | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. |
| **Environmental Justice** | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Improved air quality conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced air quality conditions.<br>No mitigation needed. | Improved air quality conditions.<br>No mitigation needed. | Similar air quality conditions.<br>No mitigation needed. |
| Potential Exposure to Mercury in Fish in Delta | Similar or reduced concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or reduced concentrations.<br>No mitigation needed. | Similar or reduced concentrations.<br>No mitigation needed. | Similar concentrations.<br>No mitigation needed. |

**Table ES.2 Comparison of Alternatives 1 through 5 and the No Action Alternative to the Second Basis of Comparison**

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Surface Water Conditions** | | | | | | |
| Trinity Lake | Water surface elevations similar<br>Storage would be similar in most months, except reduced in November-December in above normal years (up to 6%) and all months in critical dry years (up to 10%). | No change. | Water surface elevations similar<br>Storage would be similar in most months, except reduced in November-December in above normal years (up to 6%) and all months in critical dry years (up to 10%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage would be similar in most months, except reduced in all months in critical dry years (up to 10%). |
| Trinity River at Lewiston Dam | Flows similar or increased except reduced in December-February in wet to below normal years (up to 30%). | No change. | Flows similar or increased except reduced in December-February in wet to below normal years (up to 30%). | Flows similar or increased. | No change. | Flows similar or increased except reduced in December-February in wet to below normal years (up to 21%). |
| Shasta Lake | Water surface elevations similar<br>Storage reduced in September-February in wet to dry years (up to 11%) and in all months in critical dry years (up to 14%). | No change. | Water surface elevations similar<br>Storage reduced in September-February in wet to dry years (up to 11%) and in all months in critical dry years (up to 14%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage reduced in September-February in most months of wet to dry years (up to 10%), and in all months in critical dry years (up to 17%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River at Keswick Dam | Flows reduced (up to 21%) except September and November. | No change. | Flows reduced (up to 21%) except September and November. | Flows similar or increased except reduced in August in below normal years (up to 6%). | No change. | Flows reduced (up to 16%) except September and November. |
| Sacramento River at Freeport | Flows similar or increased except reduced in May and June (up to 27%). | No change. | Flows similar or increased except reduced in May and June (up to 27%). | Flows similar or increased except reduced in June in below normal years (up to 13%). | No change. | Flows similar or increased except reduced in May and June (up to 28%). |
| Clear Creek near Igo | Flows similar or increased. | No change. | Flows similar or increased. | No change. | No change. | Flows similar or increased. |
| Lake Oroville | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). | No change. | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). | Water surface elevations similar<br>Storage similar. | No change. | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). |
| Feather River downstream of Thermalito Complex | Flows similar or increased except reduced in August-June (up to 52%). | No change. | Flows similar or increased except reduced in August-June (up to 52%). | Flows similar or increased except reduced in August-June (up to 28%). | No change. | Flows similar or increased except reduced in August-June (up to 58%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Folsom Lake | Water surface elevations similar<br>Storage similar in many months except reduced flows in September-January (up to 12%) in wet to below normal years and July-September in critical dry years (up to 11%). | No change. | Water surface elevations similar<br>Storage similar in many months except reduced flows in September-January (up to 12%) in wet to below normal years and July-September in critical dry years (up to 11%). | Water surface elevations similar<br>Storage similar. | No change. | Water surface elevations similar<br>Storage similar in many months except reduced flows in August-January (up to 13%) in wet to below normal years and July in critical dry years (8%). |
| American River at Nimbus Dam | Flows similar or increased except reduced in June-August, December, February, and April (up to 25%). | No change. | Flows similar or increased except reduced in June-August, December, February, and April (up to 25%). | Flows similar or increased except reduced flows in June-August and April (up to 17%). | No change. | Flows similar or increased except reduced in December-February, April, June, and August (up to 25%). |
| New Melones Reservoir | Water surface elevations similar<br>Storage similar in wet, below normal, and dry years, and in most months in above normal and critical dry years. Storage reduced in October in above normal water years (6%) and in October-January and April-June in critical dry years (up to 7%). | No change. | Water surface elevations similar<br>Storage similar in wet, below normal, and dry years, and in most months in above normal and critical dry years. Storage reduced in October in above normal water years (6%) and in October-January and April-June in critical dry years (up to 7%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage reduced in all months in all water year types (up to 23%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River at Goodwin Dam | Flows similar or increased except reduced in November-March and May-June (up to 25%). | No change. | Flows similar or increased except reduced in November-March and May-June (up to 25%). | Flows reduced in all months (up to 79%) except April and August. | No change. | Flows reduced in all months (up to 25%) except October, April, and May. |
| San Joaquin River at Vernalis | Flows similar or increased except reduced in November and May-June (up to 9%). | No change. | Flows similar or increased except reduced in November and May-June (up to 9%). | Flows similar or increased except reduced in May-June (up to 27%). | No change. | Flows similar or increased except reduced in November and June (up to 10%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| San Luis Reservoir | Water surface elevations reduced in all months in wet to below normal water years and in February-September in dry and critical dry years (up to 16%).<br>Storage reduced in October-June in most water years (up to 71%). | No change. | Water surface elevations reduced in all months in wet to below normal water years and in February-September in dry and critical dry years (up to 16%).<br>Storage reduced in October-June in most water years (up to 71%). | Water surface elevations similar except reduced in January-February in above normal years (up to 6%) and February-August in critical dry years (up to 7%).<br>Storage similar or increased in some months except in December-February and June in wet years (up to 16%), October-July in above normal and below normal years (up to 40%), January-September in dry years (up to 19%), and October-August in critical dry years (up to 29%). | No change. | Water surface elevations reduced in all months in all year types (up to 70%).<br>Storage would be reduced in October-August in wet to below normal years (up to 17%), in January-September in dry years (up to 14%), and in all months in critical dry years (up to 14%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Flows into Yolo Bypass | Flows similar or increased except reduced in November-December in wet years (up to 15%), January-March in above normal years (14%), December-March in below normal years (up to 25%), and December in dry years (6%). | No change. | Flows similar or increased except reduced in November-December in wet years (up to 15%), January-March in above normal years (14%), December-March in below normal years (up to 25%), and December in dry years (6%). | Flows similar except reduced in October of wet years (6%). | No change. | Flows similar or increased except reduced in November-January in wet years (up to 15%), January-March in above normal years (15%), December-March in below normal years (up to 24%), and December in dry years (7%). |
| Delta Outflow | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,590 cfs). | No change. | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,590 cfs). | Flows would increase in many months.<br>Reduced flows in some months, including October and March-June in wet years (up to 1,127 cfs), and October and May-June in dry years (up to 373 cfs). | No change. | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,713 cfs), and June in dry years (526 cfs). |
| Reverse Flows in Old and Middle Rivers | Increased positive flows except in June-August in most years and March in wet years. | No change. | Increased positive flows except in June-August in most years and March in wet years. | Increased negative flows in June-August in most years and March in wet years. | No change. | Increased negative flows in July-August in most years and March and June in wet years. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Water Supplies** | | | | | | |
| Non-CVP and Non-SWP Deliveries | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. |
| North of Delta CVP Water Deliveries: Agricultural Water Contractors | Deliveries reduced up to 16% over the long-term to 34% in critical dry years. | No change. | Deliveries reduced up to 16% over the long-term to 34% in critical dry years. | Deliveries similar over the long-term. Reduced up to 9% in dry years to 11% in critical dry years. | No change. | Deliveries reduced up to 16% over the long-term to 31% in critical dry years. |
| North of Delta CVP Water Deliveries: Municipal and Industrial Water Contractors | Deliveries similar. | No change. | Deliveries similar. | Deliveries similar. | No change. | Deliveries similar. |
| South of Delta CVP Water Deliveries: Agricultural Water Contractors | Deliveries reduced up to 23% over the long-term to 33% in critical dry years. | No change. | Deliveries reduced up to 23% over the long-term to 33% in critical dry years. | Deliveries similar over the long-term. Reduced up to 8% in dry years to 14% in critical dry years. | No change. | Deliveries reduced up to 24% over the long-term to 33% in critical dry years. |
| South of Delta CVP Water Deliveries: Municipal and Industrial Water Contractors | Deliveries reduced up to 10% over the long-term to 5% in critical dry years. | No change. | Deliveries reduced up to 10% over the long-term to 5% in critical dry years. | Deliveries similar. | No change. | Deliveries reduced up to 10% over the long-term to 8% in critical dry years. |
| CVP Water Deliveries: Eastside Division Contractors | Deliveries reduced up to 19% in critical dry years. | No change. | Deliveries reduced up to 19% in critical dry years. | Deliveries similar. | No change. | Deliveries reduced up to 19% in critical dry years. |
| North of Delta: SWP Water Deliveries under Table A without Article 21 water | Deliveries reduced up to 13% over the long-term to 20% in critical dry years. | No change. | Deliveries reduced up to 13% over the long-term to 20% in critical dry years. | Deliveries similar over the long-term and in dry years. Reduced by 10% in critical dry years. | No change. | Deliveries reduced up to 19% over the long-term to 21% in critical dry years. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| North of Delta: SWP Water Deliveries under Table A without Article 21 water | Deliveries reduced up to 18% over the long-term to 22% in critical dry years. | No change. | Deliveries reduced up to 18% over the long-term to 22% in critical dry years. | Deliveries similar over the long-term and in dry years. Reduced by 11% in critical dry years. | No change. | Deliveries reduced up to 19% over the long-term to 23% in critical dry years. |
| **Surface Water Quality** | | | | | | |
| Salinity in Northern Delta (near Emmaton) | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). | No change. | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). | Salinity increased in June in wet to dry years (up to 35%).<br>Reduced in fall and winter months in wet and above normal years (up to 24%). | No change. | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). |
| Salinity in Western Delta (near Port Chicago) | Salinity reduced in September-May (up to 49%). | No change. | Salinity reduced in September-May (up to 49%). | Salinity increased in June in wet to below normal years (up to 9%).<br>Reduced in January-March (up to 25%). | No change. | Salinity reduced in September-May (up to 49%). |
| Salinity in Western Central Delta (near Antioch) | Salinity increased in June in wet to below normal years (up to 16%).<br>Reduced in fall and winter months (up to 73%). | No change. | Salinity increased in June in wet to below normal years (up to 16%).<br>Reduced in fall and winter months (up to 73%). | Salinity increased in May in wet years and June in wet to dry years (up to 20%).<br>Reduced in January-April (up to 40%). | No change. | Salinity increased in June in wet to below normal years (up to 14%).<br>Reduced in fall and winter months (up to 73%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Salinity in Western Central Delta (near Contra Costa Water District Intakes) | Salinity increased in March-June (up to 47%).<br>Reduced in October-January and September (up to 42%). | No change. | Salinity increased in March-June (up to 47%).<br>Reduced in October-January and September (up to 42%). | Salinity increased in March-April in dry and critical dry years (up to 16%).<br>Reduced in December-February in dry and critical dry years (up to 23%). | No change. | Salinity increased in March-June (up to 63%).<br>Reduced in October-January and September (up to 41%). |
| Salinity in Southern Delta (near CVP and SWP intakes) | Salinity increased in February-June (up to 23%).<br>Reduced in October-January (up to 28%). | No change. | Salinity increased in February-June (up to 23%).<br>Reduced in October-January (up to 28%). | Salinity increased in February-May in dry and critical dry years (up to 23%). | No change. | Salinity increased in February-June (up to 26%).<br>Reduced in October-January (up to 28%). |
| Mercury in Delta Fish | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |
| Selenium in Delta and Delta Fish | Selenium concentrations similar concentrations. | No change. | Selenium concentrations similar concentrations. | Selenium concentrations similar concentrations. | No change. | Selenium concentrations similar concentrations. |
| **Groundwater Resources** | | | | | | |
| Trinity River Region | Similar groundwater conditions. | No change. | Similar groundwater conditions. | Similar groundwater conditions. | No change. | Similar groundwater conditions. |
| Central Valley Region: Sacramento Valley | Similar groundwater conditions. | No change. | Similar groundwater conditions. | Similar groundwater conditions. | No change. | Similar groundwater conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Central Valley Region: San Joaquin Valley | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | Similar groundwater pumping; and similar to lower groundwater elevations (2-25 feet).<br>Similar groundwater quality.<br>Similar subsidence potential. | No change. | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. |
| San Francisco Bay Area, Central Coast, and Southern California Region | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. |
| **CVP and SWP Energy Resources** | | | | | | |
| Energy Generated and Used by CVP and SWP Water Users | Similar CVP net generation.<br>Increased net generation over the long-term (29%).<br>Potentially increased energy use by CVP and SWP water users. | No change. | Similar CVP net generation.<br>Increased net generation over the long-term (29%).<br>Potentially increased energy use by CVP and SWP water users. | Similar CVP net generation.<br>Increased net generation over the long-term (10%).<br>Potentially increased energy use by CVP and SWP water users. | No change. | Similar CVP net generation.<br>Increased net generation over the long-term (30%).<br>Potentially increased energy use by CVP and SWP water users. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Aquatic Resources** | | | | | | |
| Trinity River: Coho Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Spring-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Fall-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Steelhead | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Green Sturgeon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity Lake and Lewiston Reservoir: Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Pacific Lamprey | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Eulachon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Winter-run Chinook Salmon | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. | No change. | Similar conditions. | Improved habitat conditions due to improved escapement potential and predator controls. | Similar conditions. | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River System: Spring-run Chinook Salmon | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. | No change. | Similar conditions. | Improved habitat conditions due to harvest limitations and predator controls. | Similar conditions. | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. |
| Sacramento River System: Fall-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Similar conditions. |
| Sacramento River System: Late Fall-run Chinook Salmon | Improved habitat conditions due to measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Improved habitat conditions due to measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River System: Steelhead | Improved habitat conditions due to fish passage programs to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Improved habitat conditions due to fish passage programs to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |
| Sacramento River System: Green Sturgeon and White Sturgeon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030 that are not improved by other actions. | No change. | Similar conditions. | Improved habitat conditions due to lower water temperatures. | No change. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030 that are not improved by other actions. |
| Delta: Delta Smelt | Improved habitat conditions due to reduced potential for entrainment during larval and juvenile stages, and reduced salinity in the fall in the western Delta. | No change. | Similar conditions. | Similar conditions. | No change. | Improved habitat conditions due to reduced potential for entrainment during larval and juvenile stages, and reduced salinity in the fall in the western Delta. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Delta: Longfin Smelt | Improved habitat conditions due to more positive Old and Middle River flows and other factors (as indicated by higher Longfin Smelt abundance indices). | No change. | Similar conditions. | Similar conditions. | No change. | Improved habitat conditions due to more positive Old and Middle River flows and other factors (as indicated by higher Longfin Smelt abundance indices). |
| Delta: Sacramento Splittail | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Pacific Lamprey | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Striped Bass, American Shad, and Hardhead | Similar conditions for Hardhead.<br>Improved habitat conditions for Striped Bass and American Shad due to improved survival in larval and juvenile stages and reduced salinity in the spring in the western Delta. | No change. | Similar conditions. | Similar habitat conditions for Hardhead, Striped Bass, and American Shad.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | No change in habitat conditions for Hardhead, Striped Bass, and American Shad.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions for Hardhead.<br>Improved habitat conditions for Striped Bass and American Shad due to improved survival in larval and juvenile stages and reduced salinity in the spring in the western Delta. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River: Fall-run Chinook Salmon | Similar or improved conditions. | No change. | Similar conditions. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain. | Similar or improved conditions. |
| Stanislaus River: Steelhead | Improved habitat conditions due to measures to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain. | Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain. | Improved habitat conditions due to measures to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |
| Stanislaus River: White Sturgeon | Conditions may be similar; however, improved conditions could occur due to lower water temperatures. | No change. | Similar conditions. | Similar conditions. | No change. | Conditions may be similar; however, improved conditions could occur due to lower water temperatures. |
| New Melones Reservoir; Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Improved conditions for black bass nest survival. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River: Other Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions for lamprey and Hardhead.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions for lamprey and Hardhead.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions. |
| Pacific Ocean: Killer Whale | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Terrestrial Resources** | | | | | | |
| Terrestrial Resources along Shoreline of CVP and SWP Reservoirs | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Terrestrial Resources along Rivers Downstream of CVP and SWP Reservoirs | Similar or improved conditions along Trinity, Sacramento, American, and Stanislaus rivers.<br>Reduced conditions along Feather River.<br>No mitigation measures identified at this time for changes along Feather River. | No change. | Similar or improved conditions along Trinity, Sacramento, American, and Stanislaus rivers.<br>Reduced conditions along Feather River.<br>No mitigation measures identified at this time for changes along Feather River. | Similar or improved conditions along Trinity, Sacramento, Feather, and American rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along Stanislaus River. | No change. | Similar or improved conditions along Trinity, American, and Stanislaus rivers.<br>Reduced conditions along Feather and Sacramento rivers.<br>No mitigation measures identified at this time for changes along Feather and Sacramento rivers. |
| Terrestrial Resources in Yolo Bypass | Similar conditions in Yolo Bypass. | No change. | Similar conditions in Yolo Bypass. | Similar conditions in Yolo Bypass. | No change. | Similar or reduced conditions in Yolo Bypass. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Terrestrial Resources in Western Delta | Increased extent of freshwater habitat in western Delta. | No change. | Increased extent of freshwater habitat in western Delta. | Similar conditions. | No change. | Increased extent of freshwater habitat in western Delta. |
| **Geology and Soils Resources** | | | | | | |
| Geology and Soils Resources | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Agricultural Resources** | | | | | | |
| Agricultural Production and Employment | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Land Use** | | | | | | |
| Municipal and Industrial Land Use | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Visual Resources** | | | | | | |
| Visual Resources of Land Irrigated with CVP and SWP Water | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Visual Resources at Reservoirs that Store CVP and SWP Water | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 9%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Recreation Resources** | | | | | | |
| Recreation Resources at Reservoirs that Store CVP and SWP Water | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 9%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Recreation Resources in Rivers downstream of CVP and SWP Reservoirs | Similar or improved conditions; except reduced conditions in June and August along the Feather and American rivers, and in May along the Feather River and Sacramento River near Freeport. | No change. | Similar or improved conditions; except reduced conditions in June and August along the Feather and American rivers, and in May along the Feather River and Sacramento River near Freeport. | Similar or improved conditions along rivers.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing. | No change along rivers.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing. | Similar or improved conditions; except reduced conditions in May and June and August along the Sacramento and Feather rivers, in August along the American River; and in June-August along Stanislaus River. |
| **Air Quality and Greenhouse Gas Emissions** | | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. | Similar conditions. | No change. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Increased Greenhouse Gas Emissions due to Changes in Energy Resources Related to CVP and SWP Water Use | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. |
| **Cultural Resources** | | | | | | |
| Potential for Disturbance of Cultural Resources | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Public Health** | | | | | | |
| Water Supply Availability for Wildland Firefighting | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (6%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (6%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (9%). |
| Potential Exposure to Mercury in Fish in Delta | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Socioeconomics** | | | | | | |
| Agricultural and Municipal and Industrial Employment | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Municipal and Industrial Water Supply Operating Expenses | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Recreational Economics CVP and SWP Reservoirs | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. |
| Recreational Economics Related to Striped Bass Fishing in Delta | Similar conditions. | No change. | Similar conditions. | Reduced recreational opportunities and associated economics. | Reduced recreational opportunities and associated economics. | Similar conditions. |
| Commercial and Sport Ocean Salmon Fishing | Similar conditions. | No change. | Similar conditions. | Reduced commercial and sport ocean salmon fishing and associated economics. | Reduced commercial and sport ocean salmon fishing and associated economics. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Indian Trust Assets** | | | | | | |
| Potential for Disturbance of Indian Trust Assets | No change. | No change. | No change. | No change. | No change. | No change. |
| **Environmental Justice** | | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Potential increase in emissions (up to 18%). | No change. | Potential increase in emissions (up to 18%). | Similar conditions. | No change. | Potential increase in emissions (up to 18%). |
| Potential Exposure to Mercury in Fish in Delta | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |

# Contents

# Appendixes

# Tables

# Figures

# Abbreviations and Acronyms

| | |
|---|---|
| µg/g | Micrograms per gram |
| µg/L | Micrograms/liter |
| µg/m$^3$ | Micrograms per cubic meter |
| µmhos/cm | Micromhos per centimeter |
| µS/cm | MicroSiemens per centimeter |
| AB | Assembly Bill |
| ACID | Anderson-Cottonwood Irrigation District |
| ACS | American Community Survey |
| AF | Acre-foot/Acre-feet |
| AFRP | Anadromous Fish Restoration Program |
| AFSP | Anadromous Fish Screen Program |
| AIP | Alternative Intake Project |
| ANN | Artificial Neural Network |
| AQMP | Air Quality Management Plan |
| ARB | California Air Resources Board |
| ARG | American River Group |
| AVEK | Antelope Valley-East Kern Water Agency |
| (b)(2)IT | B2 Interagency Team |
| BA | Biological Assessment |
| BARDP | Bay Area Regional Desalination Project |
| BCAA | bromochloroacetic acid |
| BCC | Birds of Conservation Concern |
| BCDC | San Francisco Bay Conservation and Development Commission |
| BCSD | Bias-correction and Spatial Disaggregation |
| BDCP | Bay Delta Conservation Plan |
| BIA | Bureau of Indian Affairs |
| BKD | Bacterial Kidney Disease |
| BLM | Bureau of Land Management |
| BO | Biological Opinion |
| BP | Before Present |
| BRT | Biological Review Team |
| BSPP | Barker Slough Pumping Plant |
| BVWD | Bella Vista Water District |

| | |
|---|---|
| °C | Centigrade degrees |
| CA | California Aqueduct |
| CAA | Clean Air Act |
| CAAQS | California Ambient Air Quality Standard |
| CAL FIRE | California Department of Forestry and Fire Prevention |
| CASGEM | California Statewide Groundwater Elevation Monitoring Program |
| CalEPA | California Environmental Protection Agency |
| CAISO | California Independent System Operator Corporation |
| CALFED | CALFED Bay-Delta Program |
| CAL FIRE | California Department of Forestry and Fire Prevention |
| CAT | California Climate Action Team |
| CBMWD | Central Basin Municipal Water District |
| CCAA | California Clean Air Act |
| CCC | Criteria Continuous Concentration |
| CCF | Clifton Court Forebay |
| CCSD | Cambria Community Services District |
| CCTT | Clear Creek Technical Team |
| CCWD | Contra Costa Water District |
| CDFW | California Department of Fish and Wildlife (previously known as Department of Fish and Game) |
| CDP | Census Designated Place |
| CDPH | California Department of Public Health |
| CDWA | Central Delta Water Agency |
| CEC | California Energy Commission |
| CEQ | Council on Environmental Quality |
| CEQA | California Environmental Quality Act |
| CESA | California Endangered Species Act |
| CFR | Code of Federal Regulations |
| cfs | Cubic feet per second |
| CGS | California Geological Survey |
| $CH_4$ | Methane |
| CHRIS | California Historical Resources Information System |
| cm | centimeter |
| CMARP | Comprehensive Monitoring, Assessment and Research Program |
| CMC | Criteria Maximum Concentration |
| CMIP3 | Coupled Model Intercomparison Project Phase 3 |

| | |
|---|---|
| CNAGPRA | California Native American Grave Protection and Repatriation Act |
| CNAHC | California Native American Heritage Commission |
| CNDDB | California Natural Diversity Database |
| CNPS | California Native Plant Society |
| CPUC | California Public utilities Commission |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| $CO_2e$ | Carbon dioxide equivalent |
| COA | Coordinated Operation Agreement |
| COC | Constituents of Concern |
| CRD | Contract Rate of Delivery |
| CRHR | California Register of Historical Resources |
| CRPR | California Rare Plant Rank |
| CSD | Community Service District |
| CSJWCD | Central San Joaquin Water Conservation District |
| CTR | California Toxics Rule |
| CVHM | Central Valley Hydrologic Model |
| CVOO | Central Valley Operations Office |
| CVP | Central Valley Project |
| CVPA | Central Valley Project Act |
| CVPIA | Central Valley Project Improvement Act |
| CVPM | Central Valley Production Model |
| CVRWQCB | Central Valley Regional Water Quality Control Board |
| CV-Salts | Central Valley Salinity Alternatives for Long-term Sustainability |
| CWA | Clean Water Act |
| CZMA | Coastal Zone Management Act |
| D-893 | State Water Resources Control Board Decision 893 |
| D-1422 | State Water Resources Control Board Decision 1422 |
| D-1485 | State Water Resources Control Board Decision 1485 |
| D-1616 | State Water Resources Control Board Decision 1616 |
| D-1629 | State Water Resources Control Board Decision 1629 |
| D-1641 | State Water Resources Control Board Decision 1641 |
| DAT | Data Assessment Team |
| DBCP | Dibromochloropropane |
| DBP | Disinfection byproducts |
| DBW | Department of Boating and Waterways |

| | |
|---|---|
| DCC | Delta Cross Channel |
| DCCA | Dichloroacetic Acid |
| DCID | Deer Creek Irrigation District |
| DCT | Delta Condition Team |
| DDD | Dichlorodiphenyldichloroethane |
| DDE | Dichlorodiphenyldichloroethylene |
| DDT | Dichlorodiphenyltrichloroethane |
| Delta | Sacramento-San Joaquin Rivers Delta Estuary |
| Delta Reform Act | Sacramento-San Joaquin Delta Reform Act of 2009 |
| DFA | California Department of Food and Agriculture |
| DICU | Delta Island Consumptive Use |
| District Court | U.S. District Court for the Eastern District of California |
| DMC | Delta-Mendota Canal |
| DMC/CA Intertie | Delta-Mendota Canal and California Aqueduct Intertie |
| DO | Dissolved Oxygen |
| DOC | Dissolved organic carbon |
| DOI | Department of the Interior |
| DOM | Dissolved Organic Matter |
| DOSS | Delta Operations Salmonid and Sturgeon |
| DPC | Delta Protection Commission |
| DPM | Delta Passage Model |
| DPS | Distinct Population Segment |
| DSRAM | Delta Smelt Risk Assessment Matrix |
| dw | dry weight |
| DWR | California Department of Water Resources |
| EDWPA | El Dorado Water and Power Authority |
| EBMUD | East Bay Municipal Utility District |
| EC | Electrical Conductivity |
| ECe | Electrical Conductivity of a Saturated Soil Index |
| ECw | Electrical Conductivity |
| EFH | Essential Fish Habitat |
| E:I | Export to Inflow Ratio |
| EID | El Dorado Irrigation District |
| EIR | Environmental Impact Report |
| EIS | Environmental Impact Statement |
| EJ | Environmental Justice |
| EO | Executive Order |
| EOM | end-of-month |

| | |
|---|---|
| EOS | End-of-September |
| EQ | exceedance quotient |
| ERP | Ecosystem Restoration Program |
| ESA | Endangered Species Act |
| ESU | Evolutionary Significant Unit |
| ET | evapotranspiration |
| ETM | Estuarine Turbidity Maximum |
| EWA | Environmental Water Account |
| EWP | Environmental Water Program |
| °F | Fahrenheit degrees |
| FCAA | Federal Clean Air Act |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| FID | Fresno Irrigation District |
| FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| FMMP | Farmland Mapping and Monitoring Program |
| FMP | Farm Process |
| FMS | Flow Management Standard |
| FMWT | Fall Midwater Trawl Survey |
| FP | Fully-Protected Species |
| FPPA | Farmland Protection Policy Act |
| FR | Federal Register |
| FRFH | Feather River Fish Hatchery |
| FRPA | Fish Restoration Program Agreement |
| FRPP | Farm and Ranch Land Protection Program |
| FRWP | Freeport Regional Water Project |
| ft | Foot/Feet |
| ft/s | Feet per second |
| FTE | full-time equivalent |
| GAMA | Groundwater Ambient Monitoring and Assessment |
| GBP | Grasslands Bypass Project |
| GCID | Glenn-Colusa Irrigation District |
| GCM | global climate model |
| GDP | gross domestic product |
| GHG | Greenhouse Gas |
| GIS | geographic information system |
| gpm | Gallons per minute |

| | |
|---|---|
| GORT | Gate Operations Review Team |
| GSA | Groundwater Sustainability Agency |
| GSP | Groundwater Sustainability Plan |
| GWh | Gigawatt-hour |
| GWMP | Groundwater Management Plans |
| GWP | Global Warming Potential |
| HAP | Hazardous Air Pollutants |
| HC | Hydrocarbons |
| HCP | Habitat Conservation Plan |
| HFC | hydrofluorocarbons |
| HFC | High Flow Channel |
| HGMP | Hatchery Genetic Management Plan |
| HOR | Head of Old River |
| HORB | Head of Old River Barrier |
| I/E or I:E | Inflow to Export Ratio (San Joaquin River) |
| I-O | Input-Output Model |
| ID | Irrigation District |
| IEP | Interagency Ecological Program |
| IEUA | Inland Empire Utilities Agency |
| IFIM | Instream Flow Incremental Methodology |
| IHN | Infectious Hematopoietic Necrosis |
| ILRP | Irrigated Lands Regulatory Program |
| in | Inch/Inches |
| IPCC | Intergovernmental Panel on Climate Change |
| IPO | Interim Plan of Operation |
| IRWMP | Integrated Regional Water Management Plan |
| ISRMA | Interlakes Special Recreation Management Area |
| ITA | Indian Trust Assets |
| JCSD | Jurupa Community Services District |
| JPOD | Joint Point of Diversion |
| Km | Kilometers |
| KRCD | Kings River Conservation District |
| LACSD | Los Angeles County Sanitation District |
| lbs | Pounds |
| LFC | Low Flow Channel |
| LIM | Land Inventory and Monitoring System |

| | |
|---|---|
| LYRA | Lower Yuba River Accord |
| m | meter |
| m/day | meters per day |
| M&I | Municipal and Industrial |
| m/s | meter per second |
| MACT | Maximum Achievable Control Technology |
| MAF | Million acre-feet or Million acre-foot |
| MBTA | Migratory Bird Treaty Act |
| MCAA | Monochloroacetic Acid |
| MCL | Maximum Contaminant Level |
| MERP | Mercury Exposure Reduction Program |
| Metropolitan | Metropolitan Water District of Southern California |
| mg/L | Milligrams per liter |
| mgd | Million gallons per day |
| MIDS | Morrow Island Distribution System |
| MLD | Most Likely Descendent |
| mm | Millimeter |
| mmhos/cm | millimhos per centimeter |
| MMPA | Marine Mammal Protection Act |
| MOA | Memorandum of Agreement |
| MORE | Mokelumne River Water & Power Authority |
| MOU | Memorandum of Understanding |
| MRR | minimum release requirements |
| msl | Mean Sea Level |
| mS/cm | MilliSiemens per Centimeter |
| MVCD | Mosquito and Vector Control Districts |
| MW | Megawatt |
| MWDOC | Metropolitan Water District of Orange County |
| MWDSC | Metropolitan Water District of Southern California |
| MWh | Megawatt-hours |
| N | Nitrogen |
| $N_2O$ | Nitrous oxide |
| NAA | No Action Alternative |
| NAAQS | National Ambient Air Quality Standard |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NAHC | Native American Heritage Commission |
| NAICS | North American Industry Classification |

| | |
|---|---|
| NASS | National Agricultural Statistics Service |
| NAWMP | North American Waterfowl Management Plan |
| NBA | North Bay Aqueduct |
| NCPA | Northern California Power Agency |
| NCCP | Natural Community Conservation Plan |
| NDMA | N-nitrosodimethylamine |
| NDWA | North Delta Water Agency |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NEPA | National Environmental Policy Act |
| ng/L | nanograms per liter |
| NHPA | National Historic Preservation Act |
| NHTSA | National Highway and Traffic Safety Administration |
| NMFS | National Marine Fisheries Service |
| NMFS BO | National Marine Fisheries Service 2009 Biological Opinion |
| $NO_2$ | nitrogen dioxide |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| $NO_x$ | Nitrogen oxides |
| NPDES | National Pollutant Discharge Elimination System |
| NPPA | Native Plant Protection Act |
| NPS | National Park Service |
| NRA | National Recreation Area |
| NRCS | Natural Resources Conservation Service |
| NRHP | National Register of Historic Places |
| NRWQC | National Recommended Water Quality Criteria |
| NSJCGBA | Northeastern San Joaquin County Groundwater Banking Authority |
| NSPS | New Source Performance Standards |
| NSR | New Source Review |
| NTR | National Toxics Rule |
| NTU | Nephelometric Turbidity Unit |
| NWR | National Wildlife Refuge |
| $O_3$ | Ozone |
| OBB | Orange Blossom Bridge |
| OBTCC | Oak Bottom Temperature Control Curtain |
| OCAP | Operations Criteria and Plan |
| OEHHA | California Office of Environmental Health Hazard Assessment |

| | |
|---|---|
| OFF | Operations and Fishery Forum |
| OID | Oakdale Irrigation District |
| OMR | Old and Middle Rivers |
| OMWD | Olivenhain Municipal Water District |
| OWA | Oroville Wildlife Area |
| P | Phosphorous |
| PAH | Polycyclic Aromatic Hydrocarbons |
| Pb | Lead |
| PBDE | Polybrominated Diphenyl Ethers |
| PBO | Programmatic Biological Opinion |
| PCB | Polychlorinated Biphenyls |
| PCE | Perchloroethylene |
| PCE | Primary Constituent Element |
| PCWA | Placer County Water Agency |
| PDA | Public-Domain Allotments |
| PEIS | Programmatic Environmental Impact Statement |
| PFC | perfluorocarbons |
| PFMC | Pacific Fishery Management Council |
| PG&E | Pacific Gas & Electric Company |
| PHG | Public Health Goal |
| PM | Particulate matter |
| $PM_{10}$ | Particulate matter less than 10 microns in aerodynamic diameter |
| $PM_{2.5}$ | Particulate matter less than 2.5 microns in aerodynamic diameter |
| POD | Pelagic Organism Decline |
| Porter-Cologne Act | Porter Cologne Water Quality Control Act |
| ppb | Parts per billion (by volume) |
| ppm | Parts per million (by volume) |
| PRC | California Public Records Code |
| Projects | Central Valley Project and State Water Project |
| PSD | Federal Prevention of Significant Deterioration |
| psu | Practical Salinity Unit |
| PTE | Potential To Emit |
| PWD | Palmdale Water District |
| RBDD | Red Bluff Diversion Dam |
| RBPP | Red Bluff Pumping Plant |
| RCWD | Rancho California Water District |

| | |
|---|---|
| Reclamation | Department of the Interior, Bureau of Reclamation |
| RHNA | Regional Housing Needs Assessment |
| RM | River Mile |
| RMP | Resource Management Plan |
| ROD | Record of Decision |
| ROG | Reactive Organic Gas |
| RPA | Reasonable and Prudent Alternative |
| RPS | California Renewable Portfolio Standard |
| RRDS | Roaring River Distribution System |
| RWQCB | Regional Water Quality Control Board |
| SA | Settlement Agreement |
| SAFCA | Sacramento Area Flood Control Agency |
| SB | Senate Bill |
| SBA | South Bay Aqueduct |
| SBC | Second Basis of Comparison |
| SBCWD | San Benito County Water District |
| SCDD | Spring Creek Debris Dam |
| SCE | Southern California Edison |
| SCI | Sacramento Catch Index |
| SCVWD | Santa Clara Valley Water District |
| SDWA | Safe Drinking Water Act |
| Secretary | Secretary of the Department of the Interior |
| SED | Substitute Environmental Document |
| SEWD | Stockton East Water District |
| SF6 | sulfur hexafluoride |
| SGA | Sacramento Groundwater Authority |
| SGMA | California Sustainable Groundwater Management Act |
| Shasta-Trinity LRMP | Shasta-Trinity National Forest Land and Resource Management Plan |
| SHPO | State Historic Preservation Officer |
| SIP | State Implementation Plan |
| SJRRRP | San Joaquin River Restoration Program |
| SJRTC | San Joaquin River Technical Committee |
| SJVAPCD | San Joaquin Valley Air Pollution Control District |
| SLC | State Lands Commission |
| SLE | St. Louis Encephalitis Virus |
| SMP | Suisun Marsh Habitat Management, Preservation, and Restoration Plan |

| | |
|---|---|
| SMPA | Suisun Marsh Preservation Agreement |
| SMSCG | Suisun Marsh Salinity Control Gate |
| SMUD | Sacramento Municipal Utilities District |
| SNMP | Salt and Nitrate Management Plan |
| $SO_2$ | Sulfur Dioxide |
| SOx | sulfur oxides |
| SOG | Stanislaus Operations Group (also known as the Stanislaus Operations Team [SOT]) |
| SONCC | Southern Oregon/Northern California Coast |
| SRA | State Recreation Area |
| SRCA | Sacramento River Conservation Area |
| SRCD | Suisun Resource Conservation District |
| SRES | Special Report on Emissions Scenarios |
| SRTTG | Sacramento River Temperature Task Group |
| SRWA | Sacramento River Wildlife Area |
| SSC | Species of Special Concern |
| SSJID | South San Joaquin Irrigation District |
| SSWD | South Sutter Water District |
| SWAP | Statewide Agricultural Production Model |
| SWAMP | State Water Resources Control Board Surface Water Ambient Monitoring Program |
| SWG | Smelt Working Group |
| SWP | State Water Project |
| SWPOCO | State Water Project Operations Control Office |
| SWRCB | State Water Resources Control Board |
| TAC | Toxic Air Contaminant |
| TAF | Thousands of acre-feet |
| TBP | Temporary Barrier Project |
| TCAA | Trichloroacetic Acid |
| TCD | Temperature Control Device |
| TCDD | Tetrachlorodibenzodioxin |
| TCE | Trichloroethylene |
| TDS | Total Dissolved Solids |
| TFCF | Tracy Fish Collection Facility |
| TMDL | Total Maximum Daily Load |
| TOC | Total Organic Carbon |
| tpy | Tons per year |
| TRRP | Trinity River Restoration Program |

| | |
|---|---|
| TSS | Total Suspended Sediment |
| UCD | University of California, Davis |
| UCCE | University of California Cooperative Extension |
| USACE | U.S. Army Corps of Engineers |
| USC | United States Code |
| USDA | U.S. Department of Agriculture |
| USEPA | U.S. Environmental Protection Agency |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| USFWS BO | U.S. Fish and Wildlife Service 2008 Biological Opinion |
| USGS | U.S. Geological Survey |
| USGVMWD | Upper San Gabriel Valley Municipal Water District |
| UWMP | Urban Water Management Plan |
| VAMP | Vernalis Adaptive Management Program |
| VIC | Variable Infiltration Capacity |
| VOC | Volatile organic compound |
| VVWRA | Victor Valley Wastewater Reclamation Authority |
| WBMWD | Western Basin Municipal Water District |
| WBS | water balance subregion |
| WDCWA | Woodland-Davis Clean Water Agency |
| WEE | Western Equine Encephalitis |
| Western | Western Area Power Administration |
| WMA | Wildlife Management Area |
| WMD | Western Municipal Water District |
| WNV | West Nile Virus |
| WOMT | Water Operations Management Team |
| WQCP | Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary |
| WR | Water Rights |
| WRESL | water resources simulation language |
| WRO | Water Rights Order |
| WSD | Water Storage District |
| WSRCD | Western Shasta Resource Conservation District |
| WUA | Weighted Useable Area |
| ww | wet weight |
| WY | Water Year |

| | |
|---|---|
| YCWA | Yuba County Water Agency |
| YOY | Young-of-the-Year |
| Yuba Accord | Lower Yuba River Accord |

This page left blank intentionally.

Chapter 1

# Introduction

## 1.1 Introduction

This Environmental Impact Statement (EIS) on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) has been prepared by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). Reclamation is the Federal lead agency for compliance with the National Environmental Policy Act (NEPA) as ordered by the United States District Court for the Eastern District of California (District Court). In 2008 and 2009, following litigation on previous Biological Opinion (BOs), Reclamation provisionally accepted and began implementing the BOs on continued long-term operation of the CVP, in coordination with the operation of the SWP issued by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), respectively, pursuant to the Federal Endangered Species Act of 1973 (ESA) as amended (United States Code [U.S.C.] 1531 et. seq.). In 2014, the Ninth Circuit upheld the District Court's ruling that Reclamation's provisional acceptance and implementation of the BOs required Reclamation to comply with NEPA. The District Court remanded Reclamation's decision back to the agency to comply with the court's ruling.

This EIS evaluates potential long-term direct, indirect, and cumulative impacts on the environment that could result from implementation of modifications to the continued long-term operation of the CVP and SWP. This EIS does not evaluate impacts related to implementing project-specific actions, such as impacts during construction and startup periods for actions that are not fully defined at this time and that may be implemented by Reclamation or other agencies as part of the long-term operation of the CVP and SWP.

## 1.2 Background

This chapter presents an overview of the CVP and SWP, the coordinated operation of the CVP and SWP, and endangered species consultations related to the long-term operation of the CVP and SWP. The long-term operation of the CVP and SWP is described in more detail in Chapter 3, Description of Alternatives; Chapter 5, Surface Water Resources and Water Supplies; and Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

### 1.2.1 Overview of the Central Valley Project

California initiated a comprehensive water plan for the state more than 100 years ago to provide water conservation, flood control, water storage, and water distribution. In 1933, the state legislature, governor, and the electorate approved construction of the CVP. Because of difficulty in marketing bonds to finance construction, the project could not be constructed by the state, and the Federal government was requested to construct the CVP.

The first Federal authorization of the CVP was by the Rivers and Harbors Act of August 30, 1935. The CVP was reauthorized for construction, operation, and maintenance by the Secretary of the Department of the Interior (Secretary), pursuant to the Reclamation Act of 1902, as amended and supplemented by the Rivers and Harbors Act of August 26, 1937. The 1937 act also provided that the dams and reservoirs of the CVP "… be used, first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and, third, for power."

In 1992, the Central Valley Project Authorization Act of August 26, 1937, was amended by Section 3406(a) of the Central Valley Project Improvement Act (CVPIA), Public Law 102-575. The CVPIA modified the 1937 act and specified that the dams and reservoirs of the CVP be used "first, for river regulation, improvement of navigation, and flood control; second for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and third for power and fish and wildlife enhancement."

The CVP is composed of more than 18 reservoirs with a combined storage capacity of more than 11 million acre-feet, more than 10 hydroelectric power plants, and more than 500 miles of major canals and aqueducts (Figure 1.1 at the end of this chapter). The major CVP reservoirs are in the Sacramento-San Joaquin Rivers Delta Estuary (Delta) watershed, including Shasta Lake on the Sacramento River, Folsom Lake on the American River, New Melones Reservoir on the Stanislaus River, and Millerton Lake on the San Joaquin River. The CVP also diverts water from Trinity Lake (on the Trinity River) to the Sacramento River system. CVP pumping plants and canals include the Red Bluff Pumping Plant, which diverts water from the Sacramento River into the CVP Tehama-Colusa Canal; Folsom South Canal, which conveys water from Folsom Lake to southeastern Sacramento County; Contra Costa Canal Pumping Plant, which diverts water from Rock Slough in the Delta into the CVP Contra Costa Canal; and Jones Pumping Plant, which diverts water from the south Delta into the CVP Delta-Mendota Canal (DMC).

These facilities are generally operated as an integrated project, although they are authorized and categorized in more distinct units or divisions. However, not all facilities are operated to meet each of the above-identified project purposes. For example, flood control is not an authorized purpose of the CVP Trinity River Division.

The facilities, operational criteria and constraints, and authorizations of the CVP are described in Chapter 5, Surface Water Resources and Water Supplies.

### 1.2.2 Overview of the State Water Project

After World War II, California's population almost doubled, and more water was needed. In addition, devastating floods occurred in northern and central

California in the 1950s. To provide more reliable water supplies and reduce the flood risk in the Sacramento Valley, the state legislature appropriated funds to the California Department of Water Resources (DWR) to construct the SWP under the State Central Valley Project Act (Water Code Section 11100 et seq.), Burns-Porter Act (California Water Resources Development Bond Act), State Contract Act (Public Contract Code Section 10100 et seq.), Davis-Dolwig Act (Water Code Sections 11900 through 11925), and other acts of the state legislature. The plans for the SWP included a reservoir on the Feather River near Oroville (Lake Oroville), a Delta cross channel, an electric power transmission system, an aqueduct to convey water from the Delta to Solano and Napa counties (North Bay Aqueduct), an aqueduct to convey water from the Delta to the San Francisco Bay Area (South Bay Aqueduct and a reservoir in Alameda County), an aqueduct (California Aqueduct) with the San Luis Dam to convey water from the Delta to the San Joaquin Valley and southern California, and several reservoirs in southern California.

DWR is required to plan for recreational and fish and wildlife uses of water in connection with the SWP and other state-constructed water projects (Water Code Sections 233, 345, 346, 12582). The Davis-Dolwig Act (Water Code Sections 11900 through 11925) established the policy that preservation of fish and wildlife is part of state costs to be paid by SWP water supply contractors, and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund.

### 1.2.3 Coordinated Operation of the CVP and SWP

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the Coordinated Operation Agreement (COA). The CVP and SWP are also operated under State Water Resources Control Board (SWRCB) decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

The COA established the operating framework for the CVP and SWP based upon conditions in the 1980s, by setting forth: (1) definitions of the CVP and SWP facilities and their water supplies, (2) procedures for coordination of operations, (3) formulas for sharing joint responsibilities for meeting Delta standards and ensuring no injury to other legal uses of water, (4) criteria for sharing unstored flow in the Delta, (5) a framework for exchange of water and services between the SWP and CVP, and (6) provisions for periodic reviews. Coordinated operation by agreed-on criteria can increase the efficiency of both the CVP and the SWP.

Implementation of the COA has evolved continually since 1986 as CVP and SWP facilities, operational criteria, and physical and regulatory environment have changed. For example, adoption of the CVPIA in 1992 changed purposes and operations of the CVP, and ESA responsibilities have affected operation of the CVP and SWP. Since 1986, facilities operations have been modified in response to statutory and regulatory requirements that were not part of the original COA assumptions or requirements. In addition, water quality objectives have been revised by the SWRCB since 1986 in the 1995 and 2006 Water Quality Control Plans and implemented through SWRCB Decision 1641. DWR and Reclamation have operational arrangements to accommodate new facilities, water quality objectives, the CVPIA, other SWRCB criteria, and the ESA, but the COA has not been formally modified to address these newer operating conditions.

### 1.2.4 Federal Endangered Species Consultation

In addition to the conditions and limitations imposed by the SWRCB on the water rights permits and licenses for the CVP and SWP, Federal agencies have an obligation pursuant to Section (7a)(2) of the ESA to determine that any discretionary action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of their critical habitat [16 U.S.C. 1536 (a)(2)]. A discretionary agency action jeopardizes the continued existence of a listed species if the action is reasonably expected to directly or indirectly appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the listed species (50 Code of Federal Regulations [CFR] 402.02).

In carrying out its obligations, Reclamation must consult with the appropriate regulatory agency or agencies (e.g., USFWS and NMFS) when an action may affect listed species. After the formal consultation process, those agencies render written statements (Biological Opinions or BOs) setting forth their opinion as to effects of the agency action on listed species and its designated critical habitat. If these agencies conclude that the action will jeopardize the continued existence of a listed species or result in the destruction or adverse modification of their designated critical habitat, they must suggest a Reasonable and Prudent Alternative (or RPA) to the agency action if one exists. As defined in the ESA, RPAs "refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat" (40 CFR 402.02).

If the SWP seeks to avail itself of the incidental take exemption provided by the BOs, the coordinated long-term operation of the SWP would be subject to the BOs, including any reasonable and prudent measures, terms and conditions, or RPAs required by the BOs.

#### *1.2.4.1 Threatened and Endangered Species Considered in ESA Consultation for Coordinated Long-Term Operation of the CVP and SWP*

The following species, and their associated ESA and critical habitat listing rules, were considered in recent ESA consultations with USFWS and NMFS for the coordinated long-term operation of the CVP and SWP analysis in this document:

- Sacramento River winter-run Chinook Salmon (*Oncorhynchus tshawytscha*) Evolutionarily Significant Unit (ESU) was originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). They were re-classified as an endangered species on January 4, 1994 (59 FR 440).
- Central Valley spring-run Chinook Salmon (*O. tshawytscha*) ESU was listed as threatened on June 18, 2005 (70 FR 37160).
- Central Valley Steelhead (*O. mykiss*) Distinct Population Segment (DPS) was listed as threatened on January 5, 2006 (71 FR 834).
- Southern Oregon/Northern California Coast Coho Salmon (*O. kisutch*) ESU was reaffirmed as threatened on June 18, 2005 (70 FR 37160).
- Southern DPS of the North American Green Sturgeon (*Acipenser medirostris*) was listed as threatened on June 6, 2006 (71 FR 17757).
- Southern Resident DPS of Killer Whales (*Orcinus orca*) was listed as endangered on November 18, 2005 (70 FR 69903-69912).
- Delta Smelt (*Hypomesus transpacificus*) was listed as threatened on March 5, 1993 (58 FR 12854). The species was recently proposed for re-listing as endangered under the ESA.

Fall and late-fall runs of Chinook Salmon are currently Federal Species of Concern, but have not been formally listed.

Central California Coast Steelhead (*O. mykiss*) DPS was listed as threatened on January 5, 2006 (71 FR 834). The 2009 NMFS BO determined that the long-term operation of the CVP and SWP would not likely adversely affect Central California Coast Steelhead DPS and its critical habitat. Therefore, no further analysis of this DPS was performed for this EIS.

#### *1.2.4.2 Recent ESA Consultation Activities and Court Rulings*

Reclamation submitted a biological assessment to USFWS and NMFS for consultation on the long-term operation of the CVP and SWP in June 2004. Because SWP operations are coordinated with CVP operations, SWP operations are included in Reclamation's action. NMFS has responsibility for anadromous fish and marine mammals, and USFWS has jurisdiction over all other ESA listed species.

In July 2004, USFWS issued its BO "Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operations Criteria and Plan to Address Potential Critical Habitat Issues." In February 2005, USFWS issued the "Re-Initiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues."

On October 22, 2004, NMFS issued its "Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project."

On April 26, 2006, Reclamation requested that the NMFS consultation be re-initiated based on the new listing of the Southern DPS of the North American Green Sturgeon. On May 19, 2006, Reclamation requested that the USFWS consultation be re-initiated because of the potential for the re-initiation of the NMFS consultation to affect the Delta Smelt and because of recently compiled data related to the pelagic organism decline.

Following the issuance of the 2004 and 2005 BOs, litigation was filed against the Department of the Interior and the Department of Commerce challenging the validity of these BOs. Following a finding that the CVP/SWP operation analyzed in the 2005 BO jeopardized the continued existence of Delta Smelt, on December 14, 2007, the District Court issued an Interim Remedial Order in *Natural Resources Defense Council, et al. v. Kempthorne*, 1:05-cv-1207 OWW GSA (E.D. Cal. 2007), to provide additional protection for Delta Smelt pending completion of a new USFWS BO for the continued long-term operation of the CVP and SWP. The Interim Remedial Order remained in effect until USFWS issued a new BO for the continued long-term operation of the CVP and SWP on December 15, 2008.

On April 16, 2008, the District Court issued a Memorandum Decision and Order on the Cross-Motions for Summary Judgment filed in *Pacific Coast Federation of Fishermen's Associations, et al. v. Gutierrez*, 1:06-cv-245-OWW-GSA (E.D. Cal. 2008). The District Court found that the BO issued by NMFS in 2004 was invalid. An evidentiary hearing followed, resulting in a Remedies Ruling on July 18, 2008. The ruling concluded that the District Court needed further evidence to consider the Plaintiffs' proposed restrictions on the long-term coordinated CVP and SWP operation.

In August 2008, Reclamation submitted a biological assessment to USFWS and NMFS for consultation.

On December 15, 2008, USFWS issued a BO analyzing the effects of the coordinated long-term operation of the CVP and SWP on Delta Smelt and its designated critical habitat. The 2008 USFWS BO concluded that ‘‘the coordinated operation of the CVP and SWP, as proposed, [was] likely to jeopardize the continued existence of the Delta Smelt’’ and ‘‘adversely modify Delta Smelt critical habitat.’’ The BO included an RPA for long-term operation of the CVP and SWP designed to allow the projects to continue operating without causing jeopardy to Delta Smelt or adverse modification of designated critical habitat.

On December 15, 2008, Reclamation provisionally accepted and began implementing the USFWS RPA.

On June 4, 2009, NMFS issued a BO analyzing the effects of the coordinated long-term operation of the CVP and SWP on listed salmonids, Green Sturgeon, and southern resident Killer Whale and their designated critical habitats. The NMFS BO concluded that the long-term operation of the CVP and SWP, as proposed, was likely to jeopardize the continued existence of Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, Central Valley Steelhead, Southern DPS of North American Green Sturgeon, and Southern Resident Killer Whales. Further, the BO concluded that the proposed action would destroy or adversely modify critical habitat for Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, Central Valley Steelhead, and Southern DPS of North American Green Sturgeon.

The 2009 NMFS BO included an RPA designed to allow the CVP and SWP to continue operating without causing jeopardy to the analyzed species or adverse modification of their designated critical habitat. On June 4, 2009, Reclamation provisionally accepted and began implementing the NMFS RPA.

Several lawsuits were filed in the District Court challenging aspects of the 2008 USFWS BO and the 2009 NMFS BO and Reclamation’s acceptance and implementation of the associated RPAs. Many of the lawsuits were consolidated into two proceedings focused on each BO. The outcomes of the *Consolidated Delta Smelt Cases* and the *Consolidated Salmonid Cases* are summarized below.

- *Consolidated Delta Smelt Cases*
  - On November 16, 2009, the District Court ruled that Reclamation violated NEPA by failing to conduct a NEPA review of the potential impacts on the human environment before provisionally accepting and implementing the 2008 USFWS BO, including the RPA.
  - On December 14, 2010, the District Court found certain portions of the 2008 USFWS BO to be arbitrary and capricious in several respects and remanded those portions of the BO to USFWS without vacatur for further consideration. The District Court ordered Reclamation to review its decision to provisionally accept and implement the BO and RPA in accordance with NEPA.

- The decision of the District Court related to the USFWS BO was appealed to the United States Court of Appeals for the Ninth Circuit (Appellate Court). On March 13, 2014, the Appellate Court reversed the District Court and upheld the BO. However, the Appellate Court affirmed the judgment of the District Court with respect to the NEPA claims.
- The District Court amended the Judgement on September 30, 2014 consistent with the Appellate Court's decision. Petitions for Writ of Certiorari were submitted to the U.S. Supreme Court; however, the U.S. Supreme Court decided to not hear the cases.

- *Consolidated Salmonid Cases*
  - On March 5, 2010, the District Court ruled that Reclamation violated NEPA by failing to undertake a NEPA analysis of potential impacts on the human environment before provisionally accepting and implementing the 2009 NMFS BO and RPA.
  - On September 20, 2011, the District Court found the NMFS BO was arbitrary and capricious in several respects and remanded the 2009 NMFS BO to NMFS without vacatur for further consideration.
  - The decisions of the District Court related to the 2009 NMFS BO were appealed to the Appellate Court. On December 22, 2014, the Appellate Court reversed the District Court and upheld the BO.
  - The District Court issued the Final Order on May 5, 2015 consistent with the Appellate Court's Decision.

## 1.3 Need to Prepare this Environmental Impact Statement

Compliance with NEPA is a Federal responsibility and involves the participation of Federal, state, tribal, and local agencies, as well as concerned and affected members of the public in the planning process. NEPA requires that Federal agencies analyze and disclose the potential environmental impacts and possible mitigation for Federal actions and a reasonable range of alternatives to the proposed action. NEPA is required when a discretionary Federal action is proposed. The regulations [40 CFR 1508.18(a)] define a Federal action as including new and continuing activities, actions partly or entirely financed by Federal agencies (where some control and responsibility over the action remain with the Federal agency [43 CFR 46.100]), actions conducted by Federal agencies, actions approved by Federal agencies, new or revised agency rules or regulations, and proposals for legislation.

Section 102 of NEPA (42 U.S.C. 4332) indicates that a detailed analysis, such as an EIS, should be completed with proposals for Federal actions that substantially affect the quality of the human environment, including the natural and physical environment and the relationship of people with that environment (40 CFR 1508.14).

To comply with the District Court's 2010 orders regarding NEPA, Reclamation initiated preparation of this EIS in 2011. This EIS documents Reclamation's analysis of the effects of modifications to the coordinated long-term operation of the CVP and SWP that are likely to avoid jeopardy to listed species and destruction or adverse modification of designated critical habitat.

In accordance with the District Court's order in the *Consolidated Delta Smelt Cases*, the Final EIS and Record of Decision are to be completed on or before December 1, 2015. By order dated October 8, 2015, this date has been extended to January 12, 2016.

As described in Chapter 3, Description of Alternatives, many of the provisions of the RPAs, as set forth in the 2008 USFWS BO and the 2009 NMFS BO, require further study, monitoring, further consultation, implementation of adaptive management programs, and subsequent environmental documentation for future facilities to be constructed or modified. Specific actions related to these provisions are not known at this time. Therefore, this EIS assumes the completion of future actions, including provisions of the RPAs, in a manner that would be consistent with the ESA and does not address impacts during construction and startup phases of these actions.

## 1.4 Use of the Environmental Impact Statement

This EIS may be used by Reclamation or cooperating agencies that are participating in the preparation of this EIS to inform future decisions related to the ESA consultation and implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO. A cooperating agency is defined as any Federal agency, except the NEPA lead agency, that has jurisdiction by law or has special expertise with respect to any environmental issue that should be addressed in the EIS (40 CFR 1501.6). A cooperating agency also can include a governmental entity (state, tribal, or local) that has jurisdiction by law or special expertise with respect to any environmental impact associated with the action being considered. The cooperating agencies for this EIS are listed in Section 1.6.

## 1.5 Proposed Action and Preferred Alternative

The Notice of Intent identified an "initial Proposed Action" that included the operational actions of the 2008 USFWS BO and 2009 NMFS BO, without structural changes included in the RPA actions that would require future studies and environmental documentation to define recommended actions, including fish passage around the CVP dams. The initial Proposed Action is included in this EIS as Alternative 2.

Based upon the analysis of aquatic resources (see Chapter 9, Fish and Aquatic Resources), by 2030, climate change may result in substantially higher air temperatures than during recent conditions. Higher air temperatures would likely increase water temperatures in both the CVP reservoirs and in the rivers downstream of the CVP dams. Under these conditions, Reclamation may not be able to operate the reservoirs under the initial Proposed Action without fish passage in a manner that would meet water temperature objectives; and it may not be possible to avoid jeopardizing the continued existence of listed species and/or resulting in an adverse modification of critical habitat.

Based upon the results of the impact analyses presented in Chapters 5 through 21 of this EIS, the Preferred Alternative is the No Action Alternative. The No Action Alternative contains all of the RPA actions in the 2008 USFWS BO and 2009 NMFS BO, as amended, including the RPA actions to evaluate fish passage to upstream habitats that exhibit lower water temperatures. Further discussion of the selection of the Preferred Alternative will be included in the Record of Decision.

The Environmentally Preferred Alternative also will be identified and disclosed in the Record of Decision, as required by the Council of Environmental Quality regulations.

## 1.6 Project Area

The project area boundaries are defined by the locations of most of the CVP facilities and their service areas and all of the SWP facilities and the SWP service areas, as shown on Figure 1.1. The CVP facilities associated with Millerton Lake, including the Madera and Friant-Kern canals and their service areas, and the San Joaquin River Restoration Program are not part of the project area for this EIS because the operations of these facilities were not addressed in the 2008 USFWS BO and 2009 NMFS BO.

### 1.6.1 CVP Facilities

The CVP facilities evaluated in this EIS include reservoirs on the Trinity, Sacramento, American, and Stanislaus rivers; Mendota Pool on the San Joaquin River; rivers, streams, canals, and aqueducts used to convey CVP water; and the CVP service area that relies upon water from the following reservoirs (as described in Chapter 5, Surface Water Resources and Water Supplies, and Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations).

- A portion of the water from Trinity River is stored and re-regulated in Trinity Lake, Lewiston Lake, and Whiskeytown Reservoir and diverted through tunnels and power plants into the Sacramento River. Water is also stored and re-regulated in Shasta Lake and Folsom Lake. Water from these reservoirs and other reservoirs owned or operated by the CVP flows into the Sacramento River. The Red Bluff Pumping Plant on the Sacramento River lifts water into the Tehama Colusa Canal for delivery to CVP contractors. Water also is delivered from the Sacramento River, American River, and the Folsom South Canal to CVP contractors, water rights holders, and settlement contractors.

- The Sacramento River conveys water to the Delta for delivery through the Contra Costa Canal and Jones Pumping Plant. The Contra Costa Canal originates at Rock Slough near Oakley and extends to the Martinez Reservoir. Water from the Contra Costa Canal is delivered to the Contra Costa Water District. The Jones Pumping Plant at the southern end of the Delta lifts the water into the DMC. This canal delivers water to CVP contractors, who divert water directly from the DMC, and to San Joaquin River exchange contractors, who divert directly from the San Joaquin River and the Mendota Pool. CVP water is also conveyed to the San Luis Reservoir for deliveries to CVP contractors through the San Luis Canal. Water from the San Luis Reservoir is also conveyed through the Pacheco Tunnel to CVP contractors in Santa Clara and San Benito counties.
- The CVP provides water stored in New Melones Reservoir for water rights holders in the Stanislaus River watershed and CVP contractors in the northern San Joaquin Valley and to meet existing water right permit conditions to support fish and wildlife and water quality beneficial uses.

The project area includes portions of the watersheds upstream of the CVP reservoirs that support anadromous fish species, as addressed in the NMFS BO, and the service areas of CVP water users in the Trinity River Region, Sacramento and San Joaquin valleys in the Central Valley Region, and the San Francisco-Bay Area Region.

### 1.6.2 SWP Facilities

The SWP facilities evaluated in this EIS include Lake Oroville on the Feather River; rivers, streams, canals, and aqueducts used to convey SWP water; and the SWP service area that relies upon water from these reservoirs including:

- SWP water is stored and re-regulated in Lake Oroville and released into the Feather River, which flows into the Sacramento River. Water also is delivered from the Feather River to SWP contractors, water rights holders, and settlement contractors.
- SWP water flows in the Sacramento River to the Delta and is exported from the Delta at the Banks Pumping Plant. The Banks Pumping Plant pumps the water into the California Aqueduct, which delivers water to the SWP contractors and conveys water to the San Luis Reservoir for continued delivery in the California Aqueduct to the San Joaquin Valley, Central Coast Region, and southern California.
- The SWP provides water from the Delta to Solano and Napa counties through the North Bay Aqueduct and to Alameda and Santa Clara counties through the South Bay Aqueduct (including Lake Del Valle).

- The SWP provides water from the Delta to the Central Coast Region through the Coastal Branch Aqueduct.
- The SWP provides water from the Delta to southern California through the California Aqueduct (including Quail, Pyramid, Castaic, Silverwood, and Perris lakes).
- The SWP delivers water to the Cross-Valley Canal, when the systems have capacity, for CVP contractors.

The project area includes the service areas in the Sacramento and San Joaquin valleys in the Central Valley Region as well as the San Francisco-Bay Area, Central Coast, and Southern California regions.

## 1.7 Study Period

The coordinated long-term operation of the CVP and SWP, as described in this EIS, is assumed to continue to at least 2030 before CVP and SWP operations would change. These changes could include projects considered as part of the cumulative effects analyses, as described in Chapter 3, Description of Alternatives. Therefore, this EIS analyzes future conditions projected for 2030. It is recognized that many changes between existing conditions and 2030 conditions would occur without changes to CVP and SWP operations, including:

- Land use changes will occur in the Delta watershed as growth occurs as projected in local agency general plans. Much of this growth is expected in the service areas of water users with water rights that may be senior to the CVP and SWP or within the Sacramento Valley, and municipal and industrial CVP contractors will increase water demands for population growth as described in the general plans. These actions could reduce the available water supplies for use by the CVP and SWP. This EIS assumes that this growth will occur by 2030. Therefore, the effects of land use changes by 2030 will be similar in the comparison of all alternatives.
- Climate change could change CVP and SWP water supplies if the amount of snow decreases and the amount of rain either decreases or occurs within a shorter period and limits the amount of water captured in reservoirs. Sea-level rise would increase salinity in the western, central, and southern Delta, which could limit the time when CVP and SWP divert water. These actions could reduce the available water supplies for use by the CVP and SWP. Federal and state agencies have completed numerous studies that project future climate change and sea-level rise scenarios. The specific characteristics of climate change and sea-level rise are not defined at this time because this EIS includes only qualitative analyses. All of the alternatives, including the No Action Alternative, evaluated in this EIS include the same assumptions for climate change and sea-level rise. Therefore, the effects of climate change and sea-level rise will be similar in the comparison of all alternatives.

- Numerous studies are being prepared by Federal, state, and local agencies to evaluate implementation of storage projects in the Delta watershed, Delta conveyance, Delta ecosystem restoration, Delta water quality improvement through construction of treatment facilities for discharges into the Delta, and changes to the SWRCB Water Quality Control Plan. As described in Chapter 3, Description of Alternatives, most of those studies have not been completed. However, many of the facilities recommended by those studies are expected to be constructed and operational by 2030. Therefore, the effects of implementation of those facilities will be similar in the comparison of all alternatives.

As the changing conditions described above and other future changes occur, changes in long-term operation of the CVP and SWP may be required. This may require the re-initiation of consultation on the 2008 USFWS BO and 2009 NMFS BO. Therefore, because the above-described changes in conditions are likely to occur by 2030 and because new BOs would be required, this EIS considers a study period that concludes in 2030.

## 1.8 Participants in Preparation of the EIS

For this EIS, Reclamation is the Federal lead agency. The Federal cooperating agencies include USFWS, NMFS, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and Bureau of Indian Affairs.

Reclamation also provided non-federal agencies with the opportunity to participate in the NEPA process if they qualified under NEPA (as described above) as a cooperating agency. In August 2012, Reclamation invited 747 non-federal entities to be cooperating agencies for this EIS, including:

- DWR
- SWRCB
- California Department of Fish and Wildlife
- Agencies that have contracts with the CVP or SWP for water delivery, water service repayment, exchange or settlement, or use of CVP or SWP facilities for conveyance
- State and Federal Contractors Water Agency
- Cities and counties within the CVP and SWP service areas
- Federally recognized tribes within the CVP and SWP service areas or areas affected by long-term operation of the CVP and SWP

Non-federal entities that meet the specified criteria for cooperating agencies are required to enter into a Memorandum of Understanding (MOU) [43 CFR 46.225(d)] with Reclamation. The MOU provides a framework for cooperating agencies to agree to their respective roles, responsibilities, and limitations, including, as appropriate, target schedules.

Reclamation has signed cooperating agency MOUs with the following entities:

- Anderson-Cottonwood Irrigation District
- California Department of Water Resources
- California Valley Miwok Tribe
- City of Hesperia
- Contra Costa Water District
- East Bay Municipal Utility District
- Friant Water Authority
- Glenn-Colusa Irrigation District
- Metropolitan Water District of Southern California
- Oakdale Irrigation District
- Reclamation District 108
- San Diego County Water Authority
- San Juan Water District
- San Luis & Delta-Mendota Water Authority
- Santa Clara Valley Water District
- Tehama Colusa Canal Authority
- Stockton East Water District
- Sutter Mutual Water District
- Zone 7 Water Agency

Reclamation also received a request from an interested party to include the Federal Emergency Management Agency (FEMA) as a cooperating agency. However, Reclamation concluded that FEMA does not meet the requirements for being a cooperative agency in accordance with Section 1501.6 of NEPA for a "Federal agency which has special expertise related to environmental issues, which should be addressed in the statement" and beyond that which could not be addressed by other cooperating Federal agencies.

### 1.8.1 Stakeholder and Public Involvement during Preparation of the EIS

The scoping process was initiated on March 28, 2012, with the publication of the Notice of Intent in the Federal Register (FR) and continued through June 28, 2012. Initially, the public scoping process was to be completed on May 29, 2012. During the public scoping process, other agencies and interested persons requested an extension of the public scoping process to allow additional opportunities to provide scoping comments. In response to these requests, Reclamation published a notice on May 25, 2012, extending the public scoping period through June 28, 2012.

Scoping meetings were held to inform the public and interested stakeholders about the project and to solicit comments and input on the EIS. The scoping meetings were held in the following locations and resulted in the following level of public participation:

- Madera on April 25, 2012 (6 participants)

- Diamond Bar on April 26, 2012 (3 participants)
- Sacramento on May 2, 2012 (15 participants)
- Marysville on May 3, 2012 (2 participants)
- Los Banos on May 22, 2012 (230 participants)

Reclamation posted the scoping notices in the FR, on its website, and in newspapers that served areas where the scoping meetings were held. Reclamation also published press releases to news organizations and others that have requested notifications for all press releases.

Scoping comments were used in the development of a reasonable range of alternatives and identification of key issues that would require analysis in the Environmental Consequences sections of this EIS, as described in Chapter 3, Description of Alternatives, and Chapter 23, Consultation, Coordination, and Cooperation.

Reclamation also posted on its website an initial range of alternatives discussed at a stakeholders meeting on October 19, 2012. As described in Chapter 3, Description of Alternatives, comments received during that process were used to refine the description of the alternatives.

Project status meetings were held with cooperating agencies and other stakeholders during preparation of the Draft EIS, including meetings in Sacramento on January 16, May 29, and November 5, 2014; and February 20 and June 24, 2015.

### 1.8.2 Stakeholder and Public Involvement during Preparation of the Final EIS

The Draft EIS was published for public review in July 2015. The distribution list for the Public Draft EIS is included in Chapter 24. Reclamation posted notification of the availability of the Public Draft EIS and the location and timing of public hearing(s) on its website, in the FR, and through press releases.

Four public meetings were held during the public review period for the Draft EIS in the following locations, with the following level of participation:

- Sacramento on September 9, 2015 (9 participants)
- Red Bluff on September 10, 2015 (9 participants)
- Los Banos on Tuesday, September 15, 2015 (9 participants)
- Irvine on September 17, 2015 (2 participants)

Approximately 860 written and verbal comments were received on the Draft EIS. All of the comments received on the Draft EIS were considered in preparation of the Final EIS. Written responses to all substantive comments received are included in Appendices 1A through 1E of the Final EIS.

## 1.9 Related Projects and Activities

Because the EIS study area is large, many activities and studies that are currently ongoing or planned for the near future could be affected by the findings of the EIS or are related actions of long-term operation of the CVP and SWP. Preliminary information from these studies and projects has been used to describe the No Action Alternative or to assess cumulative impacts of implementing alternatives evaluated in this EIS. Some of these projects are adjacent to, but not specifically part of the Study Area (e.g., San Joaquin River Restoration Program). However, these projects have been included in the cumulative effects analysis because of indirect effects on the Study Area. The following studies and projects are summarized in Chapter 3, Description of Alternatives, as either part of the No Action Alternative or the cumulative effects analyses:

- Trinity River Restoration Program
- Continued Implementation of the Central Valley Project Improvement Act Provisions
- Clear Creek Mercury Abatement and Fisheries Restoration Project
- Iron Mountain Mine Superfund Site
- Mainstem Sacramento River, American River, and Stanislaus River Gravel Augmentation Program
- Nimbus Fish Hatchery Fish Passage Project
- Folsom Dam Water Control Manual Update
- FERC Relicensing for Middle Fork of the American River Project
- Lower Mokelumne River Spawning Habitat Improvement Project
- Dutch Slough Tidal Marsh Restoration
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation
- Tidal Wetland Restoration in the Delta and Suisun Marsh
- San Joaquin River Restoration Program
- Stockton Deep Water Ship Channel Dissolved Oxygen Project
- Grassland Bypass Project
- Central Valley Salinity Alternatives for Long-term Sustainability (CV-Salts)
- Long-term Water Transfers
- Municipal Water Supply Projects that are being implemented (including City of Stockton Delta Water Supply Project, Woodland-Davis Water Supply Project, water recycling programs, San Diego County Water Authority

Carlsbad Seawater Desalination Facility, groundwater bank and wellfield expansions)

- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan
- Bay-Delta Water Quality Control Plan Update
- California WaterFix (Bay Delta Conservation Plan)
- California EcoRestore
- Shasta Lake Water Resources Investigation
- North of Delta Offstream Storage Investigation
- Federal Energy Regulatory Commission (FERC) License Renewal Projects (including SWP Oroville Project, Yuba-Bear and Drum Spaulding Projects, Turlock Irrigation District and Modesto Irrigation District Don Pedro Project, and Merced Irrigation District Merced River Hydroelectric Project)
- El Dorado Water and Power Authority Supplemental Water Rights Project
- Northeastern San Joaquin County Groundwater Banking Authority
- Semitropic Water Storage District Delta Wetlands
- North Bay Aqueduct Alternative Intake
- Los Vaqueros Reservoir Expansion Phase 2
- Upper San Joaquin River Basin Storage Investigation
- Central Valley Regional Water Quality Control Board Irrigated Lands Regulatory Program
- San Luis Reservoir Low Point Improvement Project
- Future Water Supply Projects (including groundwater storage and recovery projects; major conveyance projects, including Sacramento River Water Reliability Project, water recycling, and desalination projects)
- Contra Loma Reservoir and Recreation Resource Management Plan
- San Luis Reservoir State Recreation Area Resource Management Plan/General Plan
- *Westlands Water District v. United States Settlement*
- Mill Creek Riparian Assessment
- Yolo County Habitat/Natural Community Conservation Plan
- North Delta Flood Control and Ecosystem Restoration Project
- Franks Tract Project
- Future Water Supply Projects (including groundwater storage and recovery, conveyance, water recycling, desalination, and water transfers).

## 1.10 Organization of the Environmental Impact Statement

The Final EIS was prepared by incorporating changes identified during the public review of the Draft EIS. Chapters 1 through 25 and the Executive Summary have been revised and included in the Final EIS in response to comments received on the Draft EIS. Changes to the Appendices 3A through 19B have been included in the Final EIS as Errata sheets placed in front of each appendix. Appendices 1A through 1E include the comments on the Draft EIS and their corresponding responses. Three additional appendices have been added to the Final EIS to provide more detailed information requested by several commenters (Appendices 5E, 9O, and 9P).

This EIS is organized as follows:

- The **Executive Summary** presents the purpose and intended uses of this EIS and summarizes the project background, need to prepare this EIS, project area and study period, an overview of the alternatives, and major conclusions of the environmental analysis. A table summarizing the environmental consequences, mitigation measures, and significant impacts for the alternatives is included.
- **Chapter 1, Introduction,** summarizes the project background, need to prepare this EIS, use of this EIS, project area and study period, stakeholder and public involvement in the preparation of the EIS, and related projects and activities.
- **Chapter 2, Purpose and Need for the Action,** summarizes the underlying purpose and need to which Reclamation is responding in proposing the alternatives for the action.
- **Chapter 3, Description of Alternatives,** summarizes the methods used for developing the alternatives considered in the EIS, describes the alternatives, and discusses the alternatives considered but eliminated from detailed analysis.
- **Chapter 4, Approach to Environmental Analyses,** describes the approach and terms used in the description of the regulatory setting, affected environment, environmental consequences, cumulative effects, and mitigation measures, if appropriate, for the resource topics identified in Chapters 5 through 21.
- **Chapters 5 through 21** include the regulatory setting, affected environment, and environmental consequences for 17 resource topics and discuss methods of analysis, environmental impacts, and mitigation measures for potential direct and indirect impacts. References for each resource are included within each of these chapters, as follows:
  - Chapter 5 – Surface Water Resources and Water Supplies
  - Chapter 6 – Surface Water Quality

- Chapter 7 – Groundwater Resources and Groundwater Quality
- Chapter 8 – Energy
- Chapter 9 – Fisheries and Aquatic Resources
- Chapter 10 – Terrestrial Biological Resources
- Chapter 11 – Geology and Soils
- Chapter 12 – Agricultural Resources
- Chapter 13 – Land Use
- Chapter 14 – Visual Resources
- Chapter 15 – Recreation Resources
- Chapter 16 – Air Quality and Greenhouse Gas Emissions
- Chapter 17 – Cultural Resources
- Chapter 18 – Public Health
- Chapter 19 – Socioeconomics
- Chapter 20 – Indian Trust Assets
- Chapter 21 – Environmental Justice

- **Chapter 22, Other NEPA Considerations,** summarizes the environmental effects of implementation of the alternatives related to growth-inducing indirect impacts, the relationship between short-term and long-term productivity, irreversible and irretrievable commitments of resources, and impacts on other Federal and non-federal projects and plans.
- **Chapter 23, Consultation, Coordination, and Cooperation,** summarizes public and stakeholder involvement activities under NEPA; Native American consultation; consultation with other Federal, state, regional, and local agencies; consultation with other entities and organizations; and unresolved issues.
- **Chapter 24, Distribution List for Draft EIS and Final EIS,** provides locations where the Draft EIS was available for review and provides an overview of governmental entities, organizations, and interested parties that received a copy of the Draft EIS. The Final EIS was distributed to the same distribution list.
- **Chapter 25, List of Preparers,** provides a list of individuals who participated in the preparation of the EIS.
- **Chapter 26, Index,** provides an index of key topics in Chapters 1 through 23.
- **Appendices** contain background information including modeling methodologies, assumptions, and results; and lists and statuses of species federally listed as threatened and endangered evaluated in this EIS.


**Figure 1.1 Study Area**

**Chapter 2**

# Purpose and Need for the Action

## 2.1 Introduction

National Environmental Policy Act (NEPA) regulations require a statement of "the underlying purpose and need to which the agency is responding in proposing the alternatives, including the proposed action" (40 Code of Federal Regulations 1502.13).

## 2.2 Purpose of the Action

The purpose of the action considered in this Environmental Impact Statement (EIS) is to continue the operation of the Central Valley Project (CVP), in coordination with operation of the State Water Project (SWP), for the authorized purposes, in a manner that:

- Is similar to historical operational parameters with certain modifications
- Is consistent with Federal Reclamation law; other Federal laws and regulations; Federal permits and licenses; and State of California water rights, permits, and licenses
- Enables the Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) to satisfy their contractual obligations to the fullest extent possible

## 2.3 Need for the Action

Continued operation of the CVP is needed to provide river regulation; improvement of navigation; flood control; water supply for irrigation and domestic uses; fish and wildlife mitigation, protection, and restoration; fish and wildlife enhancement; and power generation. The CVP and the SWP facilities also are operated to provide recreation benefits and in accordance with the water rights and water quality requirements adopted by the State Water Resources Control Board.

As described in Chapter 1, Introduction, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) concluded in their 2008 and 2009 Biological Opinions (BOs), respectively, that coordinated long-term operation of the CVP and SWP, as described in the 2008 Reclamation Biological Assessment, jeopardizes the continued existences of listed species and adversely modifies critical habitat. To remedy this, USFWS and NMFS provided Reasonable and Prudent Alternatives (RPAs) in their BOs.

The U.S. Court of Appeals for the Ninth Circuit confirmed the U.S. District Court for the Eastern District of California ruling that Reclamation must conduct a NEPA review to determine whether the RPA actions cause a significant impact on the human environment. Potential modifications to the coordinated operation of the CVP and SWP analyzed in the EIS process should be consistent with the intended purpose of the action, be within the scope of Reclamation's legal authority and jurisdiction, be economically and technologically feasible, and avoid the likelihood of jeopardizing listed species or resulting in the destruction or adverse modification of critical habitat in compliance with the requirements of Section 7(a)(2) of the Endangered Species Act.

Chapter 3

# Description of Alternatives

## 3.1 Introduction

This chapter describes the methodology used for development of all potential alternatives and the basis for selecting the reasonable range of alternatives which are evaluated in detail in this Environmental Impact Statement (EIS).

## 3.2 Approach to Identify Potential Alternatives

This EIS evaluates a range of alternatives to the No Action Alternative for the coordinated long-term operation of the Central Valley Project (CVP) and the State Water Project (SWP) in the Year 2030. The No-Action Alternative includes full implementation of the 2008 USFWS Biological Opinion (2008 USFWS BO) and the 2009 National Marine Fisheries Service (NMFS) Biological Opinion (2009 NMFS BO) Reasonable and Prudent Alternatives (RPAs), in addition to other ongoing and future programs that are reasonably foreseeable to occur by 2030.

Identification of the No Action Alternative and the range of action alternatives for this EIS were developed in response to the purpose and need for the action as well as comments received during the scoping process and during preparation of the Draft EIS, as summarized below.

### 3.2.1 Scoping Process

The scoping process was initiated on March 28, 2012, with the publication of the Notice of Intent in the Federal Register (FR) and continued through June 28, 2012. Five scoping meetings were held to inform the public and interested stakeholders about the project, and to solicit comments and input on the EIS. The scoping meetings were held in Madera, Diamond Bar, Sacramento, Marysville, and Los Banos, California, in April and May 2012. Many scoping comments addressed the definition and range of alternatives, as summarized below and in the Scoping Report (included as Appendix 23A of this EIS).

- Alternative South Delta operation criteria, including:
  - Changes to Old and Middle River (OMR) flow criteria from what was described in the 2008 USFWS BO and 2009 NMFS BO
  - Changes to operational criteria of CVP and SWP south Delta intakes relative to the ratio of San Joaquin River inflows to south Delta exports;
  - Changes to measurement methods for OMR flow criteria related to locations of measurements and inclusion of Contra Costa Water District intakes within the calculations of OMR flows.

- Measures to benefit the survival and recovery of listed aquatic species that do not involve modifications of long-term operation of the CVP and SWP, such as improved water quality, reduction of populations of predators of listed aquatic species in the Delta, regulation of small unscreened water diversions, restoration of floodplain habitat, and provisions for levee vegetation approaches.
- Measures to improve primary productivity and food supply for salmonids and smelts Smelt (both Delta Smelt and Longfin Smelt), including through increased spring outflow, reduced Delta diversions, and changes in Delta flow patterns resulting from channel modifications or changes in Delta exports that change Delta residence times for aquatic species.
- Measures to support federal and state fish population doubling mandates and goals.
- Measures to increase opportunities for transfer of water through the Delta.
- Measures to increase water supply availability from the CVP and SWP south Delta intakes.
- Measures to reduce reliance on Delta water supplies by reducing water supply availability from the CVP and SWP south Delta intakes.
- Complete cessation of long-term operation of the CVP and SWP, including benefits related to the operation of the CVP and SWP reservoirs, such as flood management and recreational benefits.
- Measures to prioritize CVP operations of the Trinity, Sacramento, American, and Stanislaus rivers to meet in-watershed water demands, not only in accordance with existing water rights and agreements, but also for CVP water contractors specifically located within the American and Stanislaus river watersheds.
- Measures to prioritize use of Central Valley Project Improvement Act (CVPIA) restoration funds within geographic locations collected from CVP water users in those locations.

### 3.2.2 Concepts Identified during Preparation of the Draft EIS

As described in Chapter 23, Consultation and Coordination, status meetings were held throughout preparation of the Draft EIS with stakeholders and interested parties between 2012 and 2015. Following the scoping process, the discussions were initially focused on identification of the No Action Alternative, other bases of comparisons, and alternative concepts to the RPAs. Based upon these discussions, the development of alternatives process initially focused on identification of the No Action Alternative, and subsequently, upon development of the range of alternatives to the No Action Alternative.

## 3.3 Identification of the Bases of Comparison

Council on Environmental Quality (CEQ) regulations require an EIS to include evaluation of a No Action Alternative (40 CFR 1502.14). The No Action Alternative is defined as the projections of current conditions and trends into the future without implementation of alternatives. These projected conditions are defined by CEQ as "'no change' from current management direction or level of management intensity." The No Action Alternative also can be defined as "no project" in cases where a new project is proposed for implementation. However, all of the alternatives evaluated in this EIS are to continue the coordinated long-term operation of the CVP and SWP. Therefore, the definition of the No Action Alternative used for this EIS is continuation of the current management direction and level of intensity.

For this EIS, the No Action Alternative is based upon the continued operation of the CVP and SWP in the same manner as was occurring at the time of the publication of the Notice of Intent in March 2012. Thus, the No Action Alternative consists of the coordinated long-term operation of the CVP and SWP, including full implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO, because Reclamation provisionally accepted the BOs in 2008 and 2009, respectively, began implementing the RPAs, and continues to implement the RPAs to date. The No Action Alternative also includes changes not related to the long-term operation of the CVP and SWP or implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO, as described in subsequent sections of this chapter.

Numerous scoping comments requested that the No Action Alternative not include the RPAs in the 2008 USFWS BO and 2009 NMFS BO because, at that time, the District Court had remanded the biological opinions (BOs) back to USFWS and NMFS. The comments indicated that the EIS should include a "basis of comparison" for the alternatives that was similar to conditions prior to implementation of the RPAs. Scoping comments also indicated that a "No Action Alternative scenario" without implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO could be used to analyze the effects of implementing the RPAs.

Determining an appropriate baseline without the 2008 USFWS BO and 2009 NMFS BO actions and yet continuing to meet all of Reclamation's statutory and regulatory requirements is a difficult task. Simply analyzing a No Action Alternative that is similar to the project description described in either the 2004 Biological Assessment or 2008 Biological Assessment is insufficient, as each was found to jeopardize listed species, the 2004 Biological Assessment by the District Court in 2007, and the 2008 Biological Assessment by USFWS and NMFS. Either of these operations would be inconsistent with Reclamation's existing policy and management direction.

Because the RPAs were provisionally accepted and the No Action Alternative, represents a continuation of existing policy and management direction, the No Action Alternative includes the RPAs. However, in response to scoping comments and subsequent comments from stakeholders and interest groups; and to provide a basis for comparison of the effects of implementation of the RPAs (per the District Court's mandate), this EIS includes a "Second Basis of Comparison" that represents a condition in 2030 without implementation of the 2008 USFWS BO and 2009 NMFS BO. All of the alternatives are compared to the No Action Alternative and to the Second Basis of Comparison to describe the effects that could occur by 2030 under both bases of comparison.

Several of the 2009 NMFS BO RPA actions had been initiated prior to issuance of the 2009 NMFS BO; and therefore, those actions are included in the Second Basis of Comparison, as described below. Reasonably foreseeable actions included in the No Action Alternative that are not related to the 2008 USFWS BO or 2009 NMFS BO are also included in the Second Basis of Comparison.

### 3.3.1 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to environmental justice factors that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section, including:

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the State Water Resources Control Board (SWRCB); and operational requirements of the 2008 USFWS BO and the 2009 NMFS BO.
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs.
- Implementation of existing and future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS.

#### *3.3.1.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the Coordinated Operation Agreement (COA). The CVP and SWP are also operated under State Water Resources Control Board (SWRCB) decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

The COA established the operating framework for the CVP and SWP based upon conditions in the 1980s, by setting forth: (1) definitions of the CVP and SWP facilities and their water supplies, (2) procedures for coordination of operations, (3) formulas for sharing joint responsibilities for meeting Delta standards and ensuring no injury to other legal uses of water, (4) criteria for sharing unstored flow in the Delta, (5) a framework for exchange of water and services between the SWP and CVP, and (6) provisions for periodic reviews. Coordinated operation by agreed-on criteria can increase the efficiency of both the CVP and the SWP.

Implementation of the COA has evolved continually since 1986 as CVP and SWP facilities, operational criteria, and physical and regulatory environment have changed. For example, adoption of the CVPIA in 1992 changed purposes and operations of the CVP, and ESA responsibilities have affected operation of the CVP and SWP. Since 1986, facilities operations have been modified in response to statutory and regulatory requirements that were not part of the original COA assumptions or requirements. In addition, water quality objectives have been revised by the SWRCB since 1986 in the 1995 and 2006 Water Quality Control Plans and implemented through SWRCB Decision 1641. DWR and Reclamation have operational arrangements to accommodate new facilities, water quality objectives, the CVPIA, other SWRCB criteria, and the ESA, but the COA has not been formally modified to address these newer operating conditions.

The ongoing operational management policies of the CVP and SWP are anticipated to continue under the No Action Alternative and Second Basis of Comparison. These operational assumptions are described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations, and summarized in Chapter 5, Surface Water Resources and Water Supplies.

#### *3.3.1.2 Actions included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Several actions included in the 2008 USFWS BO RPA and 2009 NMFS BO RPA are ongoing and others have been completed, including the following actions.

- 2008 USFWS BO RPA Component 4, Habitat Restoration. In 2014, Reclamation, California Department of Fish and Wildlife (CDFW), and USFWS adopted and initiated implementation of the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Suisun Marsh Management

Plan). The No Action Alternative assumes that the Suisun Marsh Management Plan will provide up to 7,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh with or without implementation of the 2000 USFWS BO. This would represent up to 87 percent (7,000 of 8,000 acres of this habitat type referenced in the 2008 USFWS BO.

- 2009 NMFS BO RPA Action I.1.3, Clear Creek Spawning Gravel Augmentation. This effort was initiated in 1996 under the CVPIA Section 3406(b)(12), and is assumed to continue under the No Action Alternative and Second Basis of Comparison. The Clear Creek fisheries habitat restoration program is being implemented by USFWS and Reclamation in accordance with CVPIA (Reclamation 2011a). By the year 2020 the overall goal is to provide 347,288 square feet of usable spawning habitat from Whiskeytown Dam downstream to the former McCormick-Saeltzer Dam, which is the amount that existed before construction of Whiskeytown Dam. Between 1996 and 2009, a total of approximately 130,925 tons of spawning gravel was added to the creek. The interim annual spawning gravel addition target is 25,000 tons per year, but due to a lack of funding, only an average of 9,358 tons has been placed annually since 1996 (Reclamation 2013a). In 2010, the first annual evaluation of spawning gravel implementation and monitoring was submitted to NMFS as required by the NMFS BO. In 2012, Reclamation placed 10,000 tons of spawning gravel at four locations: Guardian Rock/Below N.E.E.D. Camp, Placer Bridge, Clear Creek Crossing/Bridge, and Tule Backwater.

- 2009 NMFS BO RPA Action I.1.4, Spring Creek Temperature Control Curtain Replacement. This action was completed when the temperature control curtain was replaced in 2011, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

- 2009 NMFS BO RPA Action I.2.6, Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead. The Battle Creek Salmon and Steelhead Restoration Projects under construction to reestablish approximately 42 miles of salmon and steelhead habitat on Battle Creek and an additional 6 miles of habitat on tributaries. The Project is a collaborative effort between Reclamation, USFWS, NMFS, CDFW, Pacific Gas & Electric Company (PG&E), and other groups. Prior to 2030, elements of the project will be completed including removal of five dams, installation of new fish screens and fish ladders, provisions for increased instream flows in Battle Creek, improved access roads and trails, and decommissioned power plant canals that conveyed water between tributaries. The No Action Alternative assumes implementation of this project with or without implementation of the 2009 NMFS BO.

- 2009 NMFS BO RPA Action I.3.1, Operate Red Bluff Diversion Dam with Gates Out. This action was completed when the new Red Bluff Pumping Plant began operation in 2012, and the gates no longer block the flow of water in the Sacramento River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

- 2009 NMFS BO RPA Action I.5, Funding for CVPIA Anadromous Fish Screen Program. This effort was initiated over 20 years ago under the CVPIA Section 3406(b)(21), and is assumed to continue under the No Action Alternative with or without implementation of the 2009 NMFS BO. The No Action Alternative assumes continued implementation of the program to meet the program objectives by 2030.
- 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Habitat; and Action I.6.2, Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass; Action I.6.3, Lower Putah Creek Enhancements; Action I.6.4, Improvements to Lisbon Weir; and Action I.7, Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass. These actions are addressed in the ongoing Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan (Implementation Plan) that has been initiated by Reclamation and DWR. The No Action Alternative and Second Basis of Comparison assume completion of this Implementation Plan by 2030 with or without implementation of the 2009 NMFS BO. The Implementation Plan includes an operable gate at or near the Fremont Weir and modification of the Sacramento Weir to increase the frequency and extent of floodplain inundation in the Yolo Bypass; restoration of at least 20,000 acres of floodplain rearing habitat (excluding tidally-influenced areas); and habitat enhancements in the Yolo Bypass, including measures to avoid stranding or barriers to migration. The No Action Alternative and Second Basis of Comparison assume that an operable gate would be installed in or near the Fremont Weir that would allow for controlled flows from the Sacramento River into the Yolo Bypass when Sacramento River water elevations exceed approximately 17.5 feet (NAVD88). Other portions of Fremont Weir would continue to block flows into the Yolo Bypass until the Sacramento River water elevations exceed 32.8 feet (NAVD88).
- 2009 NMFS BO RPA Action II.1, Lower American River Flow Management. This effort was initiated in 2006 when Reclamation began operating in accordance with the American River Flow Management Standard (FMS), as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. The No Action Alternative and Second Basis of Comparison assume continued operations under the FMS.

#### *3.3.1.3 Future Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

The No Action Alternative and the Second Basis of Comparison include assumptions unrelated to implementation of the 2008 USFWS BO RPA actions and 2009 NMFS BO RPA actions, including: climate change and sea level rise; continued implementation of ongoing federal, state, and local regulations and policies; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects that have been approved and are anticipated to be implemented by 2030. The 2008 USFWS BO and the 2009 NMFS BO included assumptions for climate change and sea level rise; continued implementation of ongoing federal, state, and local regulations and policies; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects. Subsequent to the publication of the BOs, the assumptions for these items have been updated and are included in the No Action Alternative and the Second Basis of Comparison. The assumptions used in this EIS for these items are discussed below.

#### 3.3.1.3.1 Climate Change and Sea Level Rise

Under Section 9503 of the SECURE Water Act (Public Law 111-11, Subtitle F), Reclamation conducted a comprehensive assessment of current information on potential future climate change impacts and implications for long-term water management in the West, as described in Appendix 5A, Modeling Methodology. Projections of future climate in the Sacramento and San Joaquin River basins are summarized, with regard to temperature, precipitation, snowpack, and runoff. Results indicate that temperatures across both river basins may increase steadily, with the basin-average mean annual temperature projected to increase by roughly $5^{o}$ to $6^{o}$ Fahrenheit (F) during the 21st century. Annual precipitation in the basins should remain geographically variable over the next century, with current projections suggesting that annual basin-wide precipitation may initially stay steady to slightly increasing, to an eventual slight decrease over the region. With regard to snowpack, increased warming is expected to diminish snow accumulation during the cool season and reduce the availability of snowmelt to sustain runoff during the warm season. Reductions in annual runoff are predicted to occur by the latter half of the century. Changes in runoff seasonality are generally projected, with warming leading to more rainfall and runoff in the cool season and less runoff during the spring, affecting seasonal water supplies. One difficulty that arises in taking climate change into account in long-term water resources planning is that the natural variability is often greater than the magnitude of change expected over several decades.

Global and regional sea levels have been increasing steadily over the past century and are expected to continue to increase throughout this century (BCDC 2011). The National Research Council recently released a study of sea level rise on the west coast. Key results indicate that global sea level has risen about 7 inches in the 20th century and the rate of sea level rise is accelerating (NRC 2012). Relative to year 2000 levels, global sea level is projected to rise 3 to 9 inches by 2030, 7 to 19 inches by 2050, and 20 to 55 inches by 2100. Sea level rise along the California coast south of Cape Mendocino are projected to show even greater ranges of potential change. As a result, sea level rise associated with climate change will continue to threaten coastal lands and infrastructure, increase flooding at the mouths of rivers, place additional stress on levees and water resources in the Delta.

Additional information related to development of climate change and sea level rise projections by 2030 are presented in Section 5A.A.5 of Appendix 5A, Section A, CalSim II and DSM2 Modeling.

##### 3.3.1.3.2 Continued Implementation of Ongoing Federal, State, and Local Water Resources Policies

The No Action Alternative and Second Basis of Comparison assume continued implementation of ongoing water resources policies and programs that are not addressed in the 2008 USFWS BO and 2009 NMFS BO, including the following programs.

- Federal Clean Water Act, including completion of Total Maximum Daily Load programs, National Pollutant Discharge Elimination System permits, and Waste Discharge Permits, as described in Chapter 6, Surface Water Quality.
- SWRCB water rights and water quality policies and programs, as described in Chapter 5, Surface Water Resources and Water Supplies.
- Federal Safe Drinking Water Act and California Safe Drinking Water Act policies and programs related to drinking water treatment requirements, as described in Chapter 6, Surface Water Quality.
- Federal Clean Air Act and California Clean Air Act, including completion of the compliance programs in accordance with the State Implementation Plans, as described in Chapter 16, Air Quality and Greenhouse Gas Emissions.
- Flood management policies and programs established by the U.S. Army Corps of Engineers (USACE) except for removal of substantial vegetation from levees per recent USACE requirements (USACE 2009, 2010), Federal Emergency Management Agency, DWR, Central Valley Flood Protection Board, and local flood management agencies, as described in Chapter 5, Surface Water Resources and Water Supplies.

##### 3.3.1.3.3 General Plan Development in CVP and SWP Service Areas

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Preparation of general plans includes an environmental evaluation under the California Environmental Quality Act to identify adverse impacts to the physical environment and to provide mitigation measures to reduce those impacts to a level of less than significance. Most of the counties where CVP and SWP water supplies are delivered have adopted general plans following the environmental review of the plans and appropriate alternatives. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and Second Basis of Comparison assume that land uses, as described in Chapter 13, Land Use, will develop through 2030 in accordance with existing general plans.

#### 3.3.1.3.4 Other Reasonable and Foreseeable Projects and Programs

The No Action Alternative and Second Basis of Comparison assume continued implementation of existing projects and facilities, including water supply and wastewater management facilities, flood management facilities, and recreational facilities.

In addition, the No Action Alternative assumes implementation of the following ongoing projects by 2030. These project descriptions are organized geographically from north to south in the State of California.

*Trinity River Restoration Program*

The Trinity River Restoration Program is a conducted by eight partners that form the Trinity Management Council, including Reclamation, USFWS, NMFS, U.S. Forest Service, Hoopa Valley Tribe, Yurok Tribe, California Resources Agency, and Trinity County. The Trinity River Flow Evaluation Final Report was adopted in 1999 and the Trinity River Record of Decision (ROD) was signed in 2000 to implement restoration of the physical processes and rehabilitate the Trinity River as foundation for fisheries recovery. The ROD described four restoration methods (flow management through releases from Lewiston Dam, construction of channel rehabilitation sites, augmentation of gravels, and control of fine sediments); infrastructure improvements to accommodate high flow releases from Lewiston Dam; environmental compliance with improvements to riparian vegetation and wetlands, reduced turbidity, and improved water temperatures; and science-based adaptive management. The Trinity River Restoration Program 2011 Annual Report indicated that about half of the projects described in the Flow Evaluation Study had been completed and intensive assessments of the physical responses of the Trinity River and geomorphic assessments of the 40-mile restoration reach had been initiated (TRRP 2012). This project will improve conditions for aquatic species in the Trinity River.

*Continued Implementation of the Central Valley Project Improvement Act Provisions*

In 1992, the CVPIA (Title 34 of Public Law 102-575) was adopted to include fish and wildlife protection, restoration, enhancement, and mitigation as purposes of the CVP having equal priority with irrigation and domestic water supply uses, and power generation. The purpose of the CVPIA is expressed in six broad statements found in Section 3402 of the Act:

- To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California;
- To address impacts of the CVP on fish, wildlife, and associated habitats;
- To improve the CVP's operational flexibility;
- To increase water-related benefits provided by the CVP to the state through expanded use of voluntary water transfers and improved water conservation;

- To contribute to the state's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary;
- To achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal and industrial, and power contractors.

The Secretary of the Department of the Interior (DOI) assigned primary responsibility for implementing CVPIA's many provisions to Reclamation and USFWS. Reclamation and USFWS coordinate with other federal agencies, tribes, the State of California, and numerous partners and stakeholders during each fiscal year to plan and implement activities.

The current focus of the CVPIA Program is on fish and wildlife restoration, water management, and conservation activities, authorized in Sections 3406 and 3408 of the Act. These goals fit within four broad resource areas: Fisheries, Water Operations, Refuges and Other Resources (Reclamation 2013c).

The Fisheries Resource Area includes actions to implement the CVPIA "fish-doubling goal" for Chinook Salmon, Rainbow Trout (steelhead), Striped Bass, American Shad, White Sturgeon and Green Sturgeon. The 2001 Final Restoration Plan to implement the CVPIA included 289 actions and evaluations that were determined to be reasonable given numerous technical, legal and implementation considerations. Reclamation and USFWS are implementing these and related actions (Reclamation 2013c). In 2008, the CVPIA Program conducted an independent review of the status of actions to achieve the fish-doubling goal. Following the review, a revised plan was developed to emphasize managing all of the fisheries programs as one program instead of individual actions; utilize a science-based management framework to address problems at a system level; report accomplishments by watershed; and improve transparency by communicating the coordination and decision-making that occurs within the program. The No Action Alternative assumes that the CVPIA Program will continue to be implemented in 2030.

The Water Operations Resource Area includes provisions to supply CVP water to resource locations in flow, quantity, velocity, and timing patterns that would contribute to the biological resources in accordance with Section 3406(b) of CVPIA (Reclamation 2013c). The No Action Alternative assumes that water operations will continue to include measures identified in Section 3406(b).

The Refuges Resources Area includes actions to contribute to the maintenance, restoration and enhancements of wetlands and waterfowl habitat either directly or through contractual agreements with other appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on 19 federal, state and private lands. The CVPIA requires Reclamation to provide CVP water to meet "Level 2" water demands and to obtain water supplies to meet "Level 4" water demands (Reclamation 2013c). In 2009, the CVPIA Program conducted an independent review of the refuge water supply program. The report indicated that Level 2 water supplies had become more reliable under CVPIA; however, Level 4 water supplies were not fully obtained. In response, Reclamation entered into an agreement with USFWS and the National Fish and Wildlife Foundation to explore avenues to improve the effectiveness of the water acquisitions, including those for Incremental Level 4; assessed ways to increase the priority for pumping, conveyance and storage of Incremental Level 4 water supplies in CVP facilities; and continued planning for external storage and conveyance facilities to meet refuge water supply needs. The No Action Alternative assumes that refuge water supplies will continue to be provided in 2030.

The Other Resource Area actions are related to terrestrial habitat and species; and water quality and conservation. One of the programs implemented in this resource area includes the Section 3406(b)(1) “other” Habitat Restoration Program, which focuses on protecting native habitats that have been directly and indirectly affected by the CVP’s construction and operation (Reclamation 2013c). This is accomplished through the purchase of fee title or conservation easements on lands where threats are significant and restoring lands to native habitat. Another program is the Land Retirement Program, Section 3408 (h), to purchase and retire land from agricultural production to improve water quality and provide for terrestrial habitat restoration. The No Action Alternative assumes that these actions will continue in a manner similar to ongoing operations.

The DOI is continuing to implement CVPIA using an improved science-based decision making process using a scientific framework that connects restoration actions to environmental and population responses across watersheds (Reclamation 2013c). A system-wide science-based approach with performance indices, monitoring, and scientific review of results is used to provide direction as the CVPIA adapts to changing conditions.

*Clear Creek Mercury Abatement and Fisheries Restoration Project*

The Lower Clear Creek Aquatic Habitat and Waste Discharge Improvement Project was initiated to remove the long-term impacts of mercury contamination in Lower Clear Creek and to create over 5 acres of new wetlands. The mercury sources are dredge-mined tailings from more than 200 historic gold and gravel mines in the watershed. The tailings are located on the properties adjacent to Clear Creek and in gravels historically used for spawning gravel supplementation. This is being completed in accordance with CVPIA actions (WSRCD 2011). This project will improve conditions for aquatic species in Clear Creek and the upper Sacramento River.

*Iron Mountain Mine Superfund Site*

The Iron Mountain Mine Superfund Site on Spring Creek had discharged acid mine drainage into several creeks that are tributary to Keswick Reservoir and the Sacramento River since the late 1890s. The interim remedies include source control, acid mine drainage collection and treatment, and water management, including water diversions and coordinated releases of contaminated surface water from Spring Creek Debris Dam with dilution flows released from the Spring Creek power plant and Shasta Lake. In 2008, the U.S. Environmental Protection Agency indicated that the interim remedies were operational and had reduced metal loading discharges by 95 percent as compared to pre-project conditions. A final restoration plan for natural resources injured by Iron Mountain Mine operation was adopted in 2002 by USFWS, CDFW, National Oceanic and Atmospheric Administration, Bureau of Land Management, and Reclamation and those programs are being implemented (USEPA 2008). This project will improve water quality and conditions for aquatic species in Spring Creek and the upper Sacramento River.

*Mainstem Sacramento River, American River, and Stanislaus River Gravel Augmentation Programs*

The Mainstem Sacramento Gravel Augmentation Program is an ongoing Reclamation project that helps meet requirements of Section 3406 (b)(13) of the CVPIA to restore and replenish spawning gravel and rearing habitat for salmonid species. Reclamation began placing salmonid spawning gravel in the Sacramento River approximately 0.25 miles downstream of Keswick Dam in 1997 and subsequently in Salt Creek. The project will place approximately 5,000 tons of gravel into the river and implement riffle supplementation/side-channel excavation to help improve spawning habitat for Chinook Salmon and steelhead (Reclamation and USFWS 2012). This project will improve conditions for aquatic species in the upper Sacramento River.

The Lower American River Salmonid Spawning Gravel Augmentation and Side-Channel Habitat Establishment Program to increase and improve salmon and steelhead spawning and rearing habitat by replenishing spawning gravel and establishing additional side-channel habitat at new restoration sites along the lower American River between Nimbus Dam and Upper Sunrise Recreation Area and at Arden Rapids. Gravel augmentation, side channel excavation, and incorporation of woody material into the main channel to improve Chinook Salmon and steelhead spawning and rearing habitat (Reclamation 2008, 2014e).

Gravel restoration also has been implemented on the lower Stanislaus River since 2004 (Reclamation 2011c).

*Nimbus Fish Hatchery Fish Passage Project*

A fish passageway from the Nimbus Fish Hatchery to the stilling basin downstream of the Nimbus Dam will be constructed and the diversion weir will be removed. This project will create and maintain a reliable system for collecting adult fish to allow Reclamation to mitigate for loss of access to spawning areas following construction of Nimbus Dam and adequately protect Chinook Salmon and Central Valley steelhead. The project is scheduled to start in 2018 if adequate funding is appropriated. This project will improve conditions for aquatic species in the lower American River and lower Sacramento River.

*Folsom Dam Water Control Manual Update*

The USACE is developing and evaluating alternatives to change flood management operations of Folsom Dam and Folsom Lake to reduce flood risk to the Sacramento area. Currently, the USACE is completing construction of the new auxiliary spillway at Folsom Dam and is completing an in-depth analysis of recent hydrologic data for the American River watershed upstream of Folsom Dam. The study will result in an updated Water Control Manual following completion of an EIS and an engineering report (USACE et al. 2012). This project could change flow patterns in the American and Sacramento rivers and the Delta.

*Federal Energy Regulatory Commission Relicensing for Middle Fork of the American River Project*

The Federal Energy Regulatory Commission (FERC) completed a final EIS for the relicensing of the Placer County Water Agency existing 223,753 kilowatt Middle Fork American River Hydroelectric Project. The project is located on the Middle Fork of the American River, Rubicon River, and Duncan and North and South Fork Long Canyon creeks in Placer and El Dorado counties. The re-licensing will provide for continued operation of the project with increased pulse and minimum instream flow releases, defined ramping rates, whitewater boating flow releases, protection of sensitive species, maintenance and enhancement of recreation opportunities, erosion and sedimentation reduction measures, vegetation improvement plans, and recreation management plans (FERC 2012). This project will change flow patterns in the American River and improve conditions for aquatic species in portions of the American River watershed.

*Lower Mokelumne River Spawning Habitat Improvement Project*

The Mokelumne River is tributary to the Delta and supports five species of anadromous fish. The proposed project will initially include placement of 4,000 to 5,000 cubic yards of suitably sized salmonid spawning gravel annually for a 3-year period at two specific sites, and then provide annual supplementation of 600 to 1,000 cubic yards thereafter. Fall-run Chinook Salmon and steelhead are the primary management focus in the river. Availability of spawning gravel in this section of the Mokelumne River has been determined to be deficient because historic gold and aggregate mining operations removed gravel annually and upstream dams have reduced gravel transport to the area. This area was chosen because it is known to have supported fall-run Chinook Salmon and steelhead spawning in the past and because the substrate is suitable for habitat improvement (USFWS 2009).

This project will improve conditions for aquatic species in the Mokelumne and San Joaquin rivers.

*Dutch Slough Tidal Marsh Restoration*

The Dutch Slough Tidal Marsh Restoration Project, located near Oakley in Eastern Contra Costa County, will restore wetland and uplands, and provide public access to the 1,200-acre Dutch Slough property. The property is composed of three parcels separated by narrow man-made sloughs. The project is a cooperative partnership between DWR, State Coastal Conservancy, CDFW, City of Oakley, Ironhouse Sanitary District, Reclamation Districts 2137 and 799, Natural Heritage Institute, and landowners. The project will provide ecosystem benefits, including habitat for sensitive species, including winter-run Chinook Salmon Sacramento splittail, and many waterfowl species. It also will be designed and implemented to maximize opportunities to assess the development of those habitats and measure ecosystem responses so that future Delta restoration projects will be more successful. DWR approved the Final Environmental Impact Report (EIR) for the project in March 2010 (NMFS 2013). This project will improve conditions for aquatic and terrestrial species in the Delta through tidal marsh restoration.

*Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation*

On March 2, 1987, the Suisun Marsh Preservation Agreement (SMPA) was signed by DWR, CDFW, Reclamation, and the Suisun Resource Conservation District. The purpose of the agreement was to establish mitigation for impacts on salinity from the SWP, CVP, and other upstream diversions. The SMPA contains provisions for Reclamation and DWR to mitigate the adverse effects on Suisun Marsh channel water salinity from operation of the CVP and SWP and other upstream diversions. The Suisun Marsh Habitat Management, Preservation and Restoration Plan (SMP) was completed in 2014 under the direction of Reclamation, USFWS, CDFW, NMFS, Suisun Resource Conservation District, and CALFED Bay-Delta Program (the Principal Agencies). This group was assisted by regulatory agencies such as the USACE, Bay Conservation and Development Commission, SWRCB, and the San Francisco Bay Regional Water Quality Control Board. The following actions will be implemented under the plan (Reclamation 2014a).

- Restoration of up to 7,000 acres of tidal marsh and protection and enhancement of up to 46,000 acres of managed wetlands through dredging, erosion protection, and installation of fish screens.
- Increased frequency of currently implemented managed wetlands activities.
- Implementation of the Preservation Agreement Implementation Fund (PAI Fund) to improve managed wetland flood and drain capabilities to accommodate high salinity water while maintaining functions and values of managed wetland habitats.

The plan includes environmental commitments and mitigation measures, an adaptive management program, and reporting through annual reports over the 30-year time frame of the plan. This project will improve conditions for aquatic and terrestrial species in the Delta and Suisun Marsh.

*Tidal Wetland Restoration in the Delta and Suisun Marsh*

In addition to tidal wetlands restoration that would occur in the Suisun Marsh, several programs are being implemented in the Cache Slough portion of the Delta. The 2008 USFWS BO RPA required a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. As described above, up to 7,000 acres of tidal marsh restoration would occur under the SMP. Other programs have been initiated to restore or expand tidal wetlands, and could provide an additional 3,000 acres of tidal wetlands in the Delta and Suisun Marsh. This additional 3,000 acres could be completed in accordance with the 2008 USFWS BO requirements. The No Action Alternative includes the following restoration programs.

- Yolo Ranch (initial phase), Northwest Field Network 4, and Flyway Farms – 941 and 405 acres, respectively, of tidal influenced lands (SFWCA 2011, 2013).
- Northern Liberty Island Fish Restoration Project – 737 acres (RD 2093 2011).
- Prospect Island Restoration Project – 1,170 acres (based on maps included in CDFW and DWR 2013).
- Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project – 87 acres (CDFW 2015).

*San Joaquin River Restoration Program*

The San Joaquin River Restoration Program is a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River and restore a self-sustaining Chinook Salmon fishery in the river while reducing or avoiding adverse water supply impacts from restoration flows. The restoration program is the product of more than 18 years of litigation, which culminated in a Stipulation of Settlement on the lawsuit known as *NRDC, et al., v. Kirk Rodgers, et al*. The settling parties reached agreement on the terms and conditions of the settlement, which was subsequently approved by the District Court on October 23, 2006. The settling parties include the Natural Resources Defense Council, Friant Water Users Authority, and the U.S. Departments of the Interior and of Commerce. The settlement's two primary goals are to:

- Restore and maintain fish populations in "good condition" in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish, and
- Reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the settlement.

The settlement requires specific releases of water from Friant Dam to the confluence of the Merced River, which are designed primarily to meet the various life stage needs for spring- and fall-run Chinook Salmon. The release schedule assumes continuation of the current average Friant Dam release of 116,741 acre-feet, annually, with specific flow requirements depending on the year type. The project was authorized and funded with the passage of San Joaquin River Restoration Settlement Act, part of the Omnibus Public Land Management Act of 2009 (Public Law 111-11). Interim flows began in October, 2009. There are many physical improvements within and near the San Joaquin River that will be undertaken to fully achieve the river restoration goal. The improvements will occur in two separate phases that will focus on a combination of water releases from Friant Dam, as well as structural and channel improvements (Reclamation 2012). This project will improve conditions for aquatic and terrestrial species in the San Joaquin River and the Delta.

This EIS does not address the CVP facilities associated with Millerton Lake, including the Madera and Friant-Kern canals and their service areas, and the San Joaquin River Restoration Program because these facilities are not considered in the consultations related to the 2008 USFWS BO and 2009 NMFS BO.

*Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project*

The Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project is a multiple-year study of the effectiveness of elevating dissolved oxygen (DO) concentrations in the channel. The DO concentrations drop as low as 2 to 3 milligrams per liter (mg/L) during warmer and lower water flow periods in the San Joaquin River. The low DO levels can adversely affect aquatic life including the health and migration behavior of anadromous fish (e.g., salmon). The objective of the study is to maintain DO levels above the minimum recommended levels specified in the 2006 Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River basins, as described in Chapter 6, Surface Water Quality.

The project's full-scale aeration system includes two 200-foot-deep u-tube aeration tubes; two vertical turbine pumps capable of pumping over 11,000 gallons of water each; a liquid-to-gas oxygen supply system; and numerous pieces of ancillary equipment and control systems. The system has been sized to deliver approximately 10,000 pounds of oxygen per day into the Deep Water Ship Channel. The aeration system is anticipated to be operated only when channel DO levels are below the Basin Plan DO water quality objectives (approximately 100 days per year). The project study includes an on-going assessment of DO levels in the channel and vicinity and a study of potential adverse effects of low DO on salmon (DWR 2010a). This project will improve water quality in the central and south Delta as compared to historical conditions.

*Grasslands Bypass Project*

Reclamation is actively engaged with the Grassland Area Farmers who discharge subsurface agricultural drainage waters through the Grassland Bypass Project, which is a significant source of selenium to the San Joaquin River and to the Delta. Reclamation and the Grassland Area Farmers are continuing to reduce the amount of agricultural drainage water produced in the Grassland Drainage Area, preventing the discharge of this water into local Grassland wetland water supply channels, and improving the quality of water in the San Joaquin River. The Grassland Bypass Project is based upon an agreement between Reclamation and the San Luis and Delta-Mendota Water Authority to use a 28-mile segment of the San Luis Drain to convey agricultural subsurface drainage water from the Grassland Drainage Area to Mud Slough (North), a tributary of the San Joaquin River. An extensive monitoring program by the San Francisco Estuary Institute (2013) continues to document the effectiveness of actions such as source control and other measures being taken by the Grassland Area Farmers. These actions by the Grassland Area Farmers are described in Chapter 2 of SFEI (2013). Briefly, these activities have included the Grassland Bypass Project and the San Joaquin River Improvement Project, formation of a regional drainage entity, newsletters and other communication with the farmers, a monitoring program, using State

Revolving Fund loans for improved irrigation systems, installing and using drainage recycling systems to mix subsurface drainage water with irrigation supplies under strict limits, tiered water pricing and a tradable loads programs.

The purposes and objectives of the Grasslands Bypass Project, 2010–2019, are to: 1) extend the San Luis Drain Use Agreement in order to allow the Grassland Basin Drainers time to acquire funds and develop feasible drainwater treatment technology to meet revised Basin Plan objectives and Waste Discharge Requirements by December 31, 2019; 2) continue the separation of unusable agricultural drainage water discharged from the Grassland Drainage Area from wetland water supply conveyance channels for the period 2010–2019; and 3) facilitate drainage management that maintains the viability of agriculture in the project area and promotes continuous improvement in water quality in the San Joaquin River. All discharges of drainage water from the Grassland Drainage Area into wetlands and refuges have been eliminated. The selenium load discharged from the Grassland Drainage Area has been reduced by 61 percent (from 9,600 pounds to 3,700pounds) and the salt load has been reduced by 39 percent (from 187,300 tons to 113,600 tons). Prior to the project, the monthly mean concentration of selenium in Salt Slough was 16 parts per billion. Since implementation of this project, the concentration has been less than the water quality objective of 2 parts per billion. The drainage water is conveyed to Mud Slough. Grasslands Water District and others are currently evaluating alternative plans to comply with Central Valley Regional Water Quality Control Board water quality objectives for selenium and salinity in the San Joaquin River at the end of this project in 2019. One of the alternatives could be zero discharge with complete recycle of the drainwater to salinity-tolerant crops (Reclamation 2009). This project will improve water quality in the San Joaquin River and the central and south Delta.

*Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)*

In 2006, the Central Valley Regional Water Quality Control Board, the SWRCB, and stakeholders began a joint effort to address salinity and nitrate problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. This effort is referred to as the Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS) Initiative. The goal of CV-SALTS is to develop a comprehensive region-wide Salt and Nitrate Management Plan (SNMP) describing a water quality protection strategy that will be implemented through a mix of voluntary and regulatory efforts. The SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or basin plan revisions.

The SNMP and will serve as the basis for amendments to the three Basin Plans that cover the Central Valley Region (Sacramento River and San Joaquin River Basin Plan, the Tulare Lake Basin Plan and the Sacramento/San Joaquin Rivers Bay-Delta Plan). The basin plan "amendments" will likely establish a comprehensive implementation plan to achieve water quality objectives for salinity (including nitrate) in the Region's surface waters and groundwater. The

SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or basin plan revisions (CVRWQCB 2015). This project could change water quality and flow patterns in the San Joaquin River.

*Municipal Water Supply Projects*

Municipal water users in California are required to prepare Urban Water Management Plans (UWMPs) in accordance with the California Urban Water Management Planning Act of 1983. The State Water Conservation Act of 2009 (also known as SBx7-7) required the UWMPs to identify the water demands and water supplies for their service area through the year 2030, and to provide a plan to reduce statewide per capita water use by 20 percent by the year 2020. All of the UWMPs identify conservation measures to reduce water demands by 2020. Many of the UWMPs identify projects that are being planned or implemented to meet water demands in 2030. Water resources projects that have been approved and are being implemented are assumed to be complete by 2030 under the No Action Alternative. There are numerous projects considered in the study area to be included in the No Action Alternative, as described in Appendix 5D, Municipal and Industrial Water Demands and Supplies, including the following major water supply projects.

- Cambria Emergency Water Supply Project desalination project (CCSD 2014).
- Carlsbad Metropolitan Water District water recycling project (Carlsbad MWD 2012)
- Central Basin Municipal Water District Southeast Water Reliability Project (CBMWD 2011).
- City of Los Angeles Department of Water and Power groundwater recharge projects (City of Los Angeles 2011, 2013a).
- City of Oxnard GREAT Program Desalter (City of Oxnard 2013).
- Eastern Municipal Water District water recycling programs (EMWD 2014a, 2014b).
- Fresno Irrigation District groundwater recharge projects (FID 2015).
- Inland Empire Utilities Agency groundwater recharge projects (IEUA 2015).
- Kern County and Antelope Valley-East Kern Water Agency (AVEK 2011).
- Los Angeles County Sanitation Districts expansion of water recycling programs (LACSD 2005).
- San Benito County Water District expansion of water treatment plant to treat CVP water (SBCWD 2014).
- San Diego County Water Authority Carlsbad Seawater Desalination Facility (SDCWA 2014).
- Santa Barbara desalination water treatment plant (KEYT 2015).

- Santa Clara Valley Water District wastewater recycling projects (SCVWD 2012).
- City of Stockton Delta Water Supply Project (City of Stockton 2005).
- Victor Valley Wastewater Reclamation Authority water recycling programs (VVWRA 2015).
- Water Replenishment District Groundwater Reliability Improvement Program and water recycling programs (WRD 2012, 2015).
- West Basin Municipal Water District recycling water programs (WBMWD 2011).
- Western Development and Storage Antelope Valley Water Bank (Reclamation 2010).
- Western Municipal Water District Arlington Desalter Expansion to use saline groundwater (WMD 2015).
- Woodland-Davis Clean Water Agency water treatment plant (WDCWA 2013).

*Water Transfer Projects*

Water transfer programs have been used historically throughout California, especially among CVP water users to meet both irrigation and municipal water demands either during drought or to replenish stored surface water or groundwater during wet periods (Reclamation 2013b).

Implementation of CVPIA in 1992 facilitated water transfers between CVP water users and between CVP water users and non-CVP water users. The water can be transferred through CVP facilities in a manner that does not harm the operation of the CVP for other users and beneficial uses. CVP facilities also can be used to convey non-CVP water under the Warren Act of 1911. In the first 10 years following adoption of CVPIA, more than 4.3 million acre-feet of water was transferred for agricultural and municipal water uses and more than 396,000 acre-feet was transferred to the DOI for Level 4 Refuge Water Supplies (Reclamation 2004a). Water transfers also occur between the SWP water users and non-SWP water users. SWP facilities can be used to convey the transferred water, including non-SWP water, under DWR conveyance agreements.

Historically, water transfers primarily were in-basin transfers (e.g., Sacramento Valley water seller to Sacramento Valley water user) (Reclamation 2013b; DWR, Reclamation, USFWS and NMFS 2013). However, between 2001 and 2012, water transfers from the Sacramento Valley to the areas located south of the Delta of up to 298,806 acre-feet occurred (not including water transfers under the Environmental Water Account Program in the early 2000s) (DWR, Reclamation, USFWS and NMFS 2013). These transfers occurred in drier years. In 2012 and 2013, the following types of water transfers occurred (DWR and SWRCB 2014).

- Water transfers involving CVP and SWP water:
  - 2012: 47,420 acre-feet of water transfers (43 percent were between agricultural water users, 36 percent were between municipal water users, and 21 percent were between agricultural and municipal water users).
  - 2013: 63,790 acre-feet of water transfers (28 percent were between agricultural water users, and 72 percent were between agricultural and municipal water users).
- Water transfers involving non-CVP and SWP water:
  - 2012: 188,074 acre-feet of water transfers (72 percent were between agricultural water users, 14 percent were from agricultural water users to wildlife refuges, and 14 percent were between agricultural and municipal water users).
  - 2013: 268,370 acre-feet of water transfers (72 percent were between agricultural water users, 1 percent were from agricultural water users to wildlife refuges, and 27 percent were between agricultural and municipal water users).

Until recently, most of the water transfers extended for one or two years. In 2008, one of the first long-term water transfer agreements was approved by the SWRCB for the Lower Yuba River Accord. The plan was designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water users, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. In 2013, Reclamation approved an overall program for a 25-year period (2014 to 2038) to transfer up to 150,000 acre-feet/year of water from the San Joaquin River Exchange Contractors Water Authority to DOI for refuge water supplies or CVP and SWP water users (Reclamation 2013b). Reclamation is currently evaluating a long-term water transfer program (2015 to 2024) between water sellers in the Sacramento Valley and water users located in the San Francisco Bay Area and south of the Delta (Reclamation 2014b).

Transfer programs generally involve annual crop changes using temporary crop idling or shifting, release of stored water in reservoirs on different patterns for the purchasers' water demands, and/or groundwater substitution (DWR and Reclamation 2014). The transfers must be approved by the CVP and/or SWP if the transfer involves CVP or SWP water or utilizes CVP or SWP facilities. Except for water transfers among CVP water users, water transfers also require approval from the SWRCB. Environmental documentation is required for all water transfers involving CVP and/or SWP water supplies or facilities. Under State law, water transfers cannot result in injury to other legal users of water; unreasonable impacts on fish and wildlife and instream uses; and unreasonable economic or environmental impact on the county in which the transfer water originates.

It is assumed that transfers would continue under the No Action Alternative in a similar manner as have occurred for the past 10 years. It is anticipated that the number of long-term transfer agreements could increase to facilitate annual decisions for water transfers. However, the conditions for each water transfer would be determined on a case-by-case basis.

## 3.3.2 No Action Alternative

In addition to the common conditions described above, the No Action Alternative also would include existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would not occur by 2030 without implementation of the BOs and implementation of the USACE vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010.

### *3.3.2.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The actions related to the CVP and SWP operations are described in more detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

In addition to the operational actions, there are several actions that would not have been implemented by 2030 under the No Action Alternative without implementation of the 2008 USFWS BO and 2009 NMFS BO. These actions have not been fully defined at this time; and therefore, would require future engineering and environmental evaluation prior to implementation. These following actions are assumed to be completed under the No Action Alternative, and the objectives outlined in the 2008 USFWS BO and 2009 NMFS BO are assumed to be achieved by 2030.

- 2009 NMFS BO RPA Action I.2.5, Winter-Run Passage and Re-Introduction Program at Shasta Dam.
- 2009 NMFS BO RPA Action II.3, Structural Improvements for Temperature Management on the American River, including installation of a Folsom Dam temperature control device, methods to transport cold water through Lake Natoma, installation of a temperature control device on the El Dorado Irrigation District intake from Folsom Lake, and development of temperature management decision-support tools.
- 2009 NMFS BO RPA Action II.5, Fish Passage at Nimbus and Folsom Dams.
- 2009 NMFS BO RPA Action II.6, Implement Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations.
- 2009 NMFS BO RPA Action III.2.1, Increase and Improve Quality of Spawning Habitat with Addition of 50,000 Cubic Yards of Gravel by 2014 and with a Minimum Addition of 8,000 Cubic Yards per Year for the Duration of the Project Actions on Stanislaus River.

- 2009 NMFS BO RPA Action III.2.2, Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on One- to Three-Year Schedule on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.3, Restore Freshwater Migratory Habitat for Juvenile Steelhead by Implementing Projects to Increase Floodplain Connectivity and to Reduce Predation Risk During Migration on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.4, Fish Passage at New Melones, Tulloch, and Goodwin Dams.
- 2009 NMFS BO RPA Action IV.4, Tracy Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates.

#### *3.3.2.2 Vegetation Management along Levees*

The No Action Alternative also would include vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010. Historically, the USACE has allowed brush and small trees to be located on the waterside of federal flood management project levees if the vegetation would preserve, protect, and/or enhance natural resources, and/or protect rights of Native Americans, while maintaining the safety, structural integrity, and functionality of the levee (DWR 2011b). After Hurricane Katrina in 2005, the USACE issued a policy and draft policy guidance to remove substantial vegetation from these levees throughout the nation (USACE 2009). This policy requires federally authorized levee systems that have maintenance agreements with the USACE (including Delta levees along the Sacramento and San Joaquin rivers) and other levees that are eligible for the federal Rehabilitation and Inspection Program (Public Law 84-99) to remove vegetation in the following manner.

- Removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, or within 15 feet of the toe of the levee on the landside ("toe" is where the levee slope meets the ground surfaces).
- Removal of all vegetation over 2 inches in diameter on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface.

In 2010, the USACE issued a draft policy guidance letter, *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls—75 Federal Register 6364-68* (USACE 2010) that included procedures for State and local agencies to request variances on a site-specific basis. DWR has been in negotiations with USACE to remove vegetation on the upper third of the waterside slope, top, and landside of the levees, and continue to allow vegetation on the lower two-thirds of the waterside slope of the levee and along benches above the water surface (DSC 2011). By 2030, it is anticipated that much of the existing vegetation on the upper third of the waterside slopes, tops, landside slopes, and within 15 feet of the landside toe of the levees would be removed.

### 3.3.3 Second Basis of Comparison

Numerous comments received during the scoping process and subsequently during preparation of the Draft EIS requested that the No Action Alternative not include the 2008 USFWS BO RPA and 2009 NMFS BO RPA. The comments indicated that the EIS should include a "basis of comparison" for the alternatives that was similar to conditions prior to implementation of the RPAs. Scoping comments also indicated that a "No Action Alternative scenario" without implementation of the RPAs in the 2008 USFWS BO and 2009 NMFS BO could be used to analyze the effects of implementing the RPAs.

Determining an appropriate baseline without the 2008 USFWS BO and 2009 NMFS BO actions and yet continuing to meet all of Reclamation's statutory and regulatory requirements is a difficult task. Simply analyzing a No Action Alternative that is similar to the project description described in either the 2004 Biological Assessment or 2008 Biological Assessment is insufficient, as each was found to jeopardize listed species (the 2004 Biological Assessment by the District Court in 2007, and the 2008 Biological Assessment by USFWS and NMFS). Either of these operations would be inconsistent with Reclamation's existing policy and management direction.

Reclamation has provisionally accepted and implemented the 2008 USFWS BO and 2009 NMFS BO actions; therefore, the No Action Alternative, by definition, must include these actions because they represent a continuation of existing policy and management direction. In response to the comments and to provide a basis for comparison of the effects of implementation of the RPAs (per the District Court's mandate), this EIS includes a "Second Basis of Comparison" that does not include implementation of the RPAs. The Second Basis of Comparison can be used as a basis of comparison for the alternatives that do not include the RPAs. In this way, the action alternatives can be compared against both the No Action Alternative and the Second Basis of Comparison.

#### *3.3.3.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The Second Basis of Comparison conditions assume that climate change conditions would have changed between 2015 and 2030. It is anticipated that by 2030, there will be less snowfall over the long-term average conditions and higher mean sea level elevations.

The CVP and SWP operations would be in accordance with water rights permits and licenses issued by the SWRCB and biological opinions issued by the USFWS and NMFS in the early 2000s. The CVP and SWP operations would be closely coordinated through the COA. The ongoing operational management policies of the CVP and SWP under the Second Basis of Comparison would be similar to the operational assumptions described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations, except for the sections identified as "Implementation of the 2008 USFWS BO [and/or 2009 NMFS BO]" (see Section 3A.4.3.4.8) and New Melones Reservoir operations.

The Second Basis of Comparison includes implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the biological opinions (as described in Section 3.3.1.2). The Second Basis of Comparison also includes implementation of future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS (as described in Section 3.3.1.3).

The Second Basis of Comparison would not include implementation of future actions described in the 2008 USFWS BO and 2009 NMFS BO that would not occur by 2030 without implementation of the biological opinions, as described below, including operations RPA actions and the following actions.

- 2009 NMFS BO RPA Action I.2.5, Winter-Run Passage and Re-Introduction Program at Shasta Dam.
- 2009 NMFS BO RPA Action II.3, Structural Improvements for Temperature Management on the American River, including installation of a Folsom Dam temperature control device, methods to transport cold water through Lake Natoma, installation of a temperature control device on the El Dorado Irrigation District intake from Folsom Lake, and development of temperature management decision-support tools.
- 2009 NMFS BO RPA Action II.5, Fish Passage at Nimbus and Folsom Dams.
- 2009 NMFS BO RPA Action II.6, Implement Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations.
- 2009 NMFS BO RPA Action III.2.1, Increase and Improve Quality of Spawning Habitat with Addition of 50,000 Cubic Yards of Gravel by 2014 and with a Minimum Addition of 8,000 Cubic Yards per Year for the Duration of the Project Actions on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.2, Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on One- to Three-Year Schedule on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.3, Restore Freshwater Migratory Habitat for Juvenile Steelhead by Implementing Projects to Increase Floodplain Connectivity and to Reduce Predation Risk During Migration on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.4, Fish Passage at New Melones, Tulloch, and Goodwin Dams.

- 2009 NMFS BO RPA Action IV.4, Tracy Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates.

#### *3.3.3.2 Vegetation Management Along Levees*

The Second Basis of Comparison includes vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010.

#### *3.3.3.3 New Melones Reservoir Operations*

Under the Second Basis of Comparison, operations of New Melones Reservoir would be the same as under the No Action Alternative for flood management, water quality, San Joaquin River base flows and pulse flows at Vernalis, and water supply. Because the Second Basis of Comparison represents regulatory environment without the 2008 USFWS and 2009 NMFS BOs, fishery flows would be consistent with the 1997 New Melones Interim Plan of Operations (IPO) without implementation of the Vernalis Adaptive Management Program (VAMP), as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

## 3.4 Development of Reasonable Alternatives

The National Environmental Policy Act (NEPA) regulations and DOI NEPA regulations (43 CFR Section 46.415(b)) require an EIS to include a range of reasonable alternatives that meet the purpose and need of the proposed action, and address one or more significant issues related to the proposed action.

The DOI NEPA regulations also state that the lead agencies should include a consensus-based alternatives consistent with the purpose and need of the proposed project that are proposed by participating persons, organizations, or communities who may be interested in or affected by the proposed project when one exists. No alternatives or alternative concepts submitted to Reclamation during preparation of this EIS were identified as consensus-based.

The range of alternatives was developed for this EIS through the identification of screening criteria based upon the purpose of the action; comparison of alternative concepts identified by Reclamation, stakeholders, and agencies to the screening criteria; and review of the identified range of alternatives to determine if the range of alternatives addresses the significant issues.

### 3.4.1 Application of Screening Criteria to the Range of Alternative Concepts

The screening criteria developed for this EIS is based upon the purpose of the action, as described in Chapter 2, Purpose and Need for the Action. The purpose of the action is:

- To continue the operation of the CVP, in coordination with operation of the SWP, for the authorized purposes, in a manner that:
  - Is similar to historic operational parameters with certain modifications;
  - Is consistent with Federal Reclamation law; other Federal laws; Federal permits and licenses; State of California water rights, permits, and licenses; and
  - Enables Reclamation and DWR to satisfy their contractual obligations to the fullest extent possible.

A number of alternative concepts were identified during the scoping process and through meetings with stakeholders and agencies during preparation of this EIS. These concepts were compared to the purpose of the action, as summarized in Table 3.1. Most of the concepts were incorporated into alternatives to be evaluated in detail in this EIS. Further discussion of concepts not included in the alternatives evaluated in detail in this EIS is presented in Section 3.4.8, Alternatives Considered but Not Evaluated in Detail.

**Table 3.1 Application of Screening Criteria to Alternative Concepts Identified for Consideration in the EIS**

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 1.** CVP and SWP Operations without actions defined in the 2008 USFWS BO RPA and 2009 NMFS BO RPA | Possibly | Yes | Yes, included in Alternatives 1, 3, and 4 |
| **Concept 2.** Modify actions defined in the 2008 USFWS BO RPA and 2009 NMFS BO RPA in a manner that would increase CVP and SWP deliveries | Possibly | Yes | Yes, included in Alternatives 1, 3, and 4 |
| **Concept 3.** Modify actions defined in the 2008 USFWS BO RPA and 2009 NMFS BO RPA in a manner that would reduce reverse flows and increase Delta outflow in the spring. | Possibly | Yes | Yes, included in Alternative 5 |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 4.** Modify actions defined in the 2008 USFWS BO RPA and 2009 NMFS BO RPA in a manner that would increase primary productivity and flood supply for aquatic resources | Possibly | Yes | Yes, included in Alternatives 1, 3, 4, and 5 |
| **Concept 5.** Modify actions defined in the 2008 USFWS BO RPA and 2009 NMFS BO RPA in a manner that would modify the triggers for OMR criteria to protect Delta Smelt as follows:<br>a) Reduce OMR criteria to a level between -5,000 cfs and -3,500 cfs only when appropriate based on analysis of turbidity levels and normalized salvage data in the south Delta<br>b) Reduce OMR to no more negative than -5,000 cfs when more than 25 percent of the Delta Smelt collected in the spring kodiak or 20 mm trawl are located in the south Delta or the adult cumulative salvage index immediately preceding spawning is high; lift this restriction if Qwest is >12,000 cfs and/or secchi depth in the south Delta is >85 cm<br>Do not implement RPA actions in the 2008 USFWS BO or 2009 NMFS BO | Possibly | Yes | Yes, included in Alternative 3 |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 6.** Modify actions defined in the 2009 NMFS BO RPA related to the Interim Criteria for the San Joaquin River Inflow:Export ratio as follows for April 1 through May 30:<br>Flows in San Joaquin River at Vernalis (7-day running average shall not be less than 7 percent of the target requirement) shall be based on the New Melones Index (as described in 2009 NMFS BO RPA Action IV.2.1) as follows for January 1 through June 15:<br>a) If the Index is 999 TAF or less - no minimum flow requirement<br>b) If the Index is 1000-1399 TAF - minimum flow is the greater of the SWRCB D-1641 requirement or 1500 cfs<br>c) If the Index is 1400-1999 TAF - minimum flow is the greater of the SWRCB D-1641 requirement or 3000 cfs<br>d) If the Index is 2000-2499 TAF - minimum flow is 4500 cfs<br>e) If the Index is above 2499 TAF - minimum flow is 6000 cfs<br>Do not implement RPA actions in the 2008 USFWS BO or 2009 NMFS BO | Possibly | Yes | No, this criteria is not implementable following the completion of the Vernalis Adaptive Management Program.<br>Other flow criteria for the San Joaquin River at Vernalis are included in the range of alternatives, however this concept is informed the development of other alternative concepts evaluated in this EIS. |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 7.** Implement predator control programs for Black Bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:<br>a) Black Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10<br>b) Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5<br>c) Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish | Yes | Yes | Yes, included in Alternatives 3 and 4 |
| **Concept 8.** Restore or create at least 10,000 acres of tidally influenced seasonal or perennial wetlands.<br>Do not implement other wetlands restoration RPA actions in the 2008 USFWS BO or 2009 NMFS BO | Yes | Yes | Yes, included in Alternatives 3 and 4 |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 9.** Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:<br>a) Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River<br>b) "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.<br>c) Tag subset of fish in order to quantify effectiveness of the program<br>d) Attempt to capture 10 percent to 20 percent of outmigrating juvenile salmonids | Yes | Yes | Yes, included in Alternatives 3 and 4 |
| **Concept 10.** Work with Pacific Fisheries Management Council, CDFW, and NMFS to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced | Maybe | Yes | Yes, included in Alternative 3 |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 11.** Work with Pacific Fisheries Management Council, CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years | Maybe | Yes | Yes, included in Alternative 4 |
| **Concept 12.** Limiting floodplain development to protect salmonids and Delta Smelt by implementing the following actions:<br>a) Incorporate guidance into flood hazard mapping to help communities comply with the ESA<br>b) Require communities to demonstrate ESA compliance for all flood plain map revisions<br>c) Prioritize consideration of ESA listed species and critical habitat when selecting flood insurance studies<br>d) Develop and implement floodplain management criteria<br>e) Refine community rating system to provide credits for natural and beneficial functions<br>f) Prohibit new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway | Possibly | Yes | Yes, included in Alternative 4 |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 13.** Do not implement USACE requirements for vegetation on levees, and instead bar removal of vegetation from levees, require planting of trees and shrubs on levees, and armor levees with vegetation, woody material, and root re-enforcement material instead of riprap | Possibly | Yes | Yes, included in Alternative 4 |
| **Concept 14.** Advance the timing of upgrades at the Sacramento Regional Wastewater Treatment Plant to 2017; and implement advanced treatment technologies at the Fairfield-Suisun Sewer District treatment plant to reduce nutrients in the effluent | Yes | Yes | No, these actions are under construction and will be complete by 2030, per the requirements of the SWRCB and the related Regional Water Quality Control Boards |
| **Concept 15.** Expand the current period of time for water transfers addressed in the operations consulted on in the 2008 USFWS BO and 2009 NMFS BO from July through September to year-round | Possibly | Yes | Yes, included in Alternative 4 |
| **Concept 16.** Include measures to support Federal and state fish-doubling goals, including the goals of CVPIA | Yes | Yes | Yes, included in Alternatives 1, 2, 3, 4, and 5 as part of ongoing implementation of CVPIA |
| **Concept 17.** Operate the CVP and SWP to avoid “dead-pool” conditions in Shasta Lake, Folsom Lake, and Lake Oroville | Possibly | Yes | Yes, included in Alternatives 1, 2, 3, 4, and 5 as part of overall CVP and SWP operations |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 18.** Change CVP water operations to meet all in-basin water demands for the Trinity, Sacramento, American, and Stanislaus rivers watersheds before meeting other CVP water demands | No | Yes | No, this concept would not be consistent with the purpose for the action |
| **Concept 19.** Implement operations of the New Melones Reservoir in accordance with the 2012 Oakdale Irrigation District and South San Joaquin Irrigation District Operations Plan | Possibly | Yes | Yes, included in Alternative 3 |
| **Concept 20.** Reduce reliance of the CVP and SWP water users on water exported from the Delta through development of regional and local water supplies | Possibly | Yes | Yes, included in Alternatives 1, 2, 3, 4, and 5 as part of overall statewide water operations |
| **Concept 21.** Changes to methods used to monitor and predict OMR flow criteria, including exclusion of Contra Costa Water District diversions from the calculations | Possibly | Maybe | No, this EIS analyzes overall operational concepts for the CVP and SWP. Specific methods to monitor and predict operations will be developed under separate efforts by Reclamation |
| **Concept 22.** Prioritize use of CVPIA restoration funds within watersheds in accordance with the amount of restoration funds collected in each watershed (e.g., the most funds would be highest in the watershed that generates the highest CVPIA restoration fund based upon water sales) | No | No | No, would not be consistent with CVPIA |

| Alternative Concept | Consistent with Purpose for the Action | Addresses One or More Significant Issues | Include in One or More of the Alternatives Evaluated in the Draft EIS |
|---|---|---|---|
| **Concept 23.** Completely cease operations of the CVP and SWP facilities | No | No | No, this concept would not be consistent with the purpose for the action |

Note:
Concepts identified as "possibly consistent with the purpose of the action" would require development of additional details and evaluation to determine if the concept is consistent with the stated purpose for the action, as described in Chapter 2, Purpose and Need for the Action. Concepts identified as "possibly consistent with the purpose of the action" were integrated into one or more of the alternatives evaluated in this EIS.

Based upon the comparison of screening criteria to the alternative concepts developed by Reclamation 17 of the 23 alternative concepts would be included in one or more of the alternatives evaluated in this EIS. The next step in the development of the alternatives is to combine the alternative concepts into specific alternatives and determine if the range of alternatives is adequate to address the significant issues in implementing a program that supports the purpose of the action.

### 3.4.2 Identification of Alternatives

The 17 alternative concepts were compiled into five alternatives. Development of the alternatives was informed by comments received about the alternative concepts. For example, numerous comments were received to evaluate an alternative that included assumptions identical to the Second Basis of Comparison assumptions in which the 2008 USFWS BO and 2009 NMFS BO would not be implemented. One of the scoping comments identified specific alternatives that included several alternative concepts included in Table 3.1; however, some of the specified alternative concepts were not consistent with assumptions for the Year 2030 and were modified to reflect implementable concepts.

Several of the alternative concepts are consistent with the No Action Alternative assumptions related to actions that would have occurred with or without implementation of the 2008 USFWS BO and 2009 NMFS BO. Therefore, the following alternative concepts are included under the No Action Alternative, Second Basis of Comparison, and all other alternatives.

- Alternative Concept 8 to restore or create at least 10,000 acres of tidally-influenced seasonal or perennial wetlands.
- Alternative Concept 16 to support the fish-doubling goals under CVPIA and state ecosystem restoration programs.
- Alternative Concept 17 to operate the CVP and SWP to avoid dead-pool conditions in the CVP and SWP reservoirs, to the extent possible based upon hydrologic conditions.

- Alternative Concept 20 to increase regional and local water supplies that could be used when CVP and SWP water supplies are reduced due to hydrologic and regulatory restrictions.

Using these concepts, the alternative concepts were combined into Alternatives 1 through 5 in a manner to avoid conflicts between concepts within an alternative.

The range of alternatives in the EIS includes the No Action Alternative and Alternatives 1 through 5, as described below.

### 3.4.3 No Action Alternative

The No Action Alternative, the Preferred Alternative, is described in Section 3.3.2, of this chapter.

### 3.4.4 Alternative 1

Alternative 1 was created because many comments requested an alternative that reflected conditions without implementation of the 2008 USFWS BO and the 2009 NMFS BO. Since the Second Basis of Comparison is not a true alternative, in accordance with NEPA guidelines, Reclamation could not select Second Basis of Comparison as a preferred alternative. Therefore, Alternative 1 was defined as being identical to the Second Basis of Comparison, as defined in Section 3.3.2.

### 3.4.5 Alternative 2

Alternative 2 was first included in the Notice of Intent and identified as an initial proposed action that included the operational actions of the 2008 USFWS BO and 2009 NMFS BO. Alternative 2 does not include RPA actions that would require future studies and environmental documentation to define recommended actions (generally, structural actions).

The definition of Alternative 2 is based upon the following assumptions that are briefly described below.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB and implementation of the 2008 USFWS BO and 2009 NMFS BO, as described under the No Action Alternative.
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs, as described above for the No Action Alternative in Sections 3.4.1.2 and 3.4.1.3.
- Implementation of future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS.

Alternative 2 conditions assume that climate change conditions would have changed between 2015 and 2030. It is anticipated that by 2030, there will be less snowfall over the long-term average conditions and higher mean sea level elevations.

Alternative 2 would not include actions in the 2008 USFWS BO and 2009 NMFS BO that have not been fully defined at this time; and therefore, would require future engineering and environmental evaluation prior to implementation. These following actions are not included in Alternative 2.

- 2009 NMFS BO RPA Action I.2.5, Winter-Run Passage and Re-Introduction Program at Shasta Dam.
- 2009 NMFS BO RPA Action II.3, Structural Improvements for Temperature Management on the American River.
- 2009 NMFS BO RPA Action II.5, Fish Passage at Nimbus and Folsom Dams.
- 2009 NMFS BO RPA Action II.6, Implement Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations.
- 2009 NMFS BO RPA Action III.2.1, Increase and Improve Quality of Spawning Habitat with Addition of Gravel.
- 2009 NMFS BO RPA Action III.2.2, Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.3, Restore Freshwater Migratory Habitat for Juvenile Steelhead on Stanislaus River.
- 2009 NMFS BO RPA Action III.2.4, Fish Passage at New Melones, Tulloch, and Goodwin Dams.
- 2009 NMFS BO RPA Action IV.4, Tracy Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency.
- 2009 NMFS BO RPA Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates.

#### *3.4.5.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 2 would be identical to the operational assumptions described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

#### *3.4.5.2 Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Actions included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred with or without the BOs, would be identical under Alternative 2 as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.5.3 Future Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Alternative 2 also includes assumptions unrelated to implementation of the 2008 USFWS BO and 2009 NMFS BO, including: climate change and sea level rise; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects that have been approved and are anticipated to be implemented by 2030. These items included in Alternative 2 are identical as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.5.4 Vegetation Management Along Levees*

Alternative 2 includes vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010.

### 3.4.6 Alternative 3

Alternative 3 was developed based upon a scoping comment from the Coalition for a Sustainable Delta which identified “RPA Alternative 1,” and a scoping comment received from Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) (included in the Scoping Report in Appendix 23A of this EIS). The definition of Alternative 3 is based upon the following assumptions that are briefly described below.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; without the operational requirements of the 2008 USFWS BO and the 2009 NMFS BO; plus implementation of the 2012 operations plan for New Melones Reservoir proposed by OID and SSJID.
- Implementation of actions described in the Coalition for a Sustainable Delta scoping comment letter related to “RPA Alternative 1.”
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs, as described above for the No Action Alternative in Sections 3.4.1.2 and 3.4.1.3.
- Implementation of future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS.

Alternative 3 would not include implementation of actions described in the 2008 USFWS BO and 2009 NMFS BO that would not occur by 2030 without implementation of the BOs.

Alternative 3 conditions assume that climate change conditions would have changed between 2015 and 2030. It is anticipated that by 2030, there will be less snowfall over the long-term average conditions and higher mean sea level elevations.

#### *3.4.6.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 3 would be similar to the operational assumptions under the Second Basis of Comparison with the following changes to water demand assumptions, OMR criteria, and operations of New Melones Reservoir to meet SWRCB D-1641 flow requirements on the San Joaquin River at Vernalis.

Alternative 3 would include additional demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. The additional demands would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a long-term CVP water service contract with El Dorado County Water Agency. During the review of the numerical modeling analyses used in this EIS, it was discovered that the demands for these El Dorado Irrigation District and the El Dorado County Water Agency contracts were not included in the CalSim II modeling analysis for Alternative 3 as presented in Chapters 5 through 21. A sensitivity analysis using the CalSim II model to compare the results of the analysis with and without these demands is presented in Appendix 5B of this EIS for Alternative 3. The results of the sensitivity analysis have been used in conjunction with the results presented in Chapters 5 through 21 to analyze the effects of including the CVP water service contract for El Dorado County Water Agency in Alternative 3.

##### 3.4.6.1.1 Old and Middle River Criteria

The OMR flow criteria under Alternative 3 are based on concepts addressed in the 2008 USFWS BO and 2009 NMFS BO related to adaptive restrictions for temperature, turbidity, salinity, and presence of Delta Smelt. The OMR flow criteria in the Alternative 3 are similar to those of the No Action Alternative, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations, with the exception of the following changes:

- Reduce OMR criteria to a level between -5,000 cfs and -3,500 cfs only when appropriate based on analysis of turbidity levels and normalized salvage data in the south Delta
- Reduce OMR to no more negative than -5,000 cfs when more than 25 percent of the Delta Smelt collected in the spring kodiak or 20 mm trawl are located in the south Delta or the adult cumulative salvage index immediately preceding

spawning is high; lift this restriction if Qwest is >12,000 cfs and/or secchi depth in the south Delta is >85 cm

For the purpose of quantitative analysis in this EIS, the numerical model represented this concept with the following assumptions.

- Action 1 that protects the pre-spawning adult Delta Smelt from entrainment is modified to limit exports such that the average daily OMR flow is no more negative than -3,500 cfs for a total duration of 14 days, with a 5-day running average no more negative than -4,375 cfs (within 25 percent of the monthly criteria).
- Action 2 that protects adult Delta Smelt within the Delta from entrainment is modified to limit exports so that the average daily OMR flow is no more negative than -3,500 or -7,500 cfs depending on the previous month's ending X2 location (-3,500 cfs if X2 is east of Roe Island, or -7,500 cfs if X2 is west of Roe Island), with a 5-day running average within 25 percent of the monthly criteria (no more negative than -4,375 cfs if X2 is east of Roe Island, or -9,375 cfs if X2 is west of Roe Island).
- Action 3 that protects larval and juvenile Delta Smelt from entrainment is modified to limit exports so that the average daily OMR flow is no more negative than -1,250, -3,500, or -7,500 cfs, depending on the previous month's ending X2 location (-1,250 cfs if X2 is east of Chipps Island, -7,500 cfs if X2 is west of Roe Island, or -3,500 cfs if X2 is between Chipps and Roe Island, inclusively), with a 5-day running average within 25 percent of the monthly criteria (no more negative than -1,562 cfs if X2 is east of Chipps Island, -9,375 cfs if X2 is west of Roe Island, or -4,375 cfs if X2 is between Chipps and Roe Island).
- Temporal off-ramp for Action 3 is assumed to occur no later than June 15 (changed from June 30).
- An off-ramp based on QWest (westerly flow on the San Joaquin River past Jersey Point calculated as a combination of San Joaquin River at Blind Point, Three Mile Slough and Dutch Slough) is assumed. If Qwest is greater than 12,000 cfs, then the Action 3 is discontinued. Because Action 2 is defined to occur between Actions 1 and 3, the Qwest off-ramp also results in discontinuation of Action 2 if it happens before Action 3 is triggered. In monthly CalSim II modeling, previous month's QWest value is used for determining the off-ramp, therefore if the off-ramp occurs within the previous month, actions in that previous month are assumed to continue until the end of the month.

#### 3.4.6.1.2 New Melones Operations Criteria

Alternative 3 assumes that the flood control operations for the New Melones Reservoir would be the same as under the No Action Alternative. However, New Melones Reservoir would be operated for different fishery flows, water quality flows, and San Joaquin River base flows and pulse flows at Vernalis.

*Fishery*

In the Alternative 3 simulation, fishery flows are modeled per the OID and SSJID 2012 operations proposal, as summarized in Tables 3.2 through 3.4. These flows include an outmigration pulse flow from April 1 through May 15. Total annual volume dedicated to fishery flows vary from 174 to 318 TAF depending on the hydrologic conditions defined by the New Melones water supply forecast (the end-of-February New Melones Storage, plus the March - September forecast of inflow to the reservoir).

**Table 3.2 Annual Fishery Flow Allocation in New Melones**

| Melones Water Supply Forecast (TAF) | Fishery Base Flows (TAF) |
|---|---|
| 0 to 1,800 | 174 |
| 1,801 to 2,500 | 235 |
| >2,500 | 318 |

**Table 3.3 Monthly "Base" Flows for Fisheries Purposes Based on the Annual Fishery Volume**

| Annual Fishery Flow Volume (TAF) | Monthly Fishery Base Flows (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| 235 | 252 | 300 | 300 | 150 | 173 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 318 | 300 | 300 | 300 | 300 | 300 | 300 | 1,500 | 850 | 200 | 200 | 200 | 200 |

**Table 3.4 April 1 through May 31 "Pulse" Flows for Fisheries Purposes Based on the Annual Fishery Volume**

| Melones Water Supply Forecast (TAF) | Fishery Pulse Flows (CFS) April 1 –May 31 |
|---|---|
| 0 to 1,800 | 750 |
| 1,801 to 2,500 | 1,500 |
| >2,500 | 1,500 |

*Water Quality*

Alternative 3 assumes that no water is released from New Melones Reservoir to meet the SWRCB D-1641 water quality criteria in the San Joaquin River. Water is released to meet the SWRCB D-1422 DO criteria; however, the compliance point is moved from Ripon to the Orange Blossom Bridge under the Alternative 3.

*Bay-Delta Flows*

Alternative 3 assumes that no water is released from New Melones Reservoir to meet the SWRCB D-1641 Bay-Delta flow requirements on the San Joaquin River at Vernalis for base flows or pulse flows.

#### ***3.4.6.2 Actions Related to Predation Control, Wetlands Restoration, Juvenile Salmonid Trap and Haul Program, and Chinook Salmon Ocean Harvest***

Alternative 3 includes the following actions as described in "RPA Alternative 1" in the Coalition for a Sustainable Delta scoping comment.

- Implement predator control programs for Black Bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Restore or create at least 10,000 acres of tidally influenced seasonal or perennial wetlands. These conditions are the same as under the No Action Alternative and Second Basis of Comparison.
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of out-migrating juvenile salmonids
- Work with Pacific Fisheries Management Council, CDFW, and NMFS to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced.

Any changes in harvest limitations would require review and approval from the California Fish and Game Commission; and for some species, the Pacific Fisheries Management Council.

#### *3.4.6.3 Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Actions included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred with or without the BOs, would be identical under Alternative 3 as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.6.4 Future Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Alternative 3 also includes assumptions unrelated to implementation of the 2008 USFWS BO and 2009 NMFS BO, including: climate change and sea level rise; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects that have been approved and are anticipated to be implemented by 2030. These items included in Alternative 3 are identical as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.6.5 Vegetation Management Along Levees*

Alternative 3 includes vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010.

### 3.4.7 Alternative 4

Alternative 4 was developed based upon a scoping comment from the Coalition for a Sustainable Delta which identified "RPA Alternative 2" (included in the Scoping Report in Appendix 23A of this EIS). The definition of Alternative 4 is based upon the following assumptions that are briefly described below.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; without the operational requirements of the 2008 USFWS BO and the 2009 NMFS BO, as described under Second Basis of Comparison.
- Implementation of actions described in the Coalition for a Sustainable Delta scoping comment letter related to "RPA Alternative 2."
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs, as described above for the No Action Alternative in Sections 3.4.1.2 and 3.4.1.3.
- Implementation of future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS.

Alternative 4 would not include implementation of actions described in the 2008 USFWS BO and 2009 NMFS BO that would not occur by 2030 without implementation of the BOs.

The "RPA Alternative 2" also included a provision to "Advance the timing of upgrades at the Sacramento Regional Wastewater Treatment Plant to 2017; and implement advanced treatment technologies at the Fairfield-Suisun Sewer District treatment plant to reduce nutrients in the effluent." However, both of these actions would be complete by 2030, the study period considered in this EIS. The Sacramento Regional Wastewater Treatment Plant must comply with the National Pollutant Discharge Elimination System permit issued on December 9, 2010 by the Central Valley Regional Water Quality Control Board to reduce nutrients in the effluent discharged to the Sacramento River by 2020 (SRCSD 2012). The Fairfield Suisun Sewer District must comply with similar permit conditions issued by the San Francisco Bay Regional Water Quality Control Board in March 2015 (SFRRWQCB 2015). Because the Environmental Consequences analysis in this EIS is conducted as a "snapshot" in time at 2030, inclusion of a provision to require compliance with the discharge requirements prior to 2020 could not be evaluated.

Alternative 4 conditions assume that climate change conditions would have changed between 2015 and 2030. It is anticipated that by 2030, there will be less snowfall over the long-term average conditions and higher mean sea level elevations.

#### *3.4.7.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The ongoing operational management policies of the CVP and SWP under Alternative 4 would be identical to operations described under the Second Basis of Comparison.

#### *3.4.7.2 Actions Related to Floodplain Protection, Levee Vegetation, Predation Control, Wetlands Restoration, Juvenile Salmonid Trap and Haul Program, and Chinook Salmon Ocean Harvest*

Alternative 4 includes the following actions as described in "RPA Alternative 1" in the Coalition for a Sustainable Delta scoping comment.

- Limiting floodplain development to protect salmonids and Delta Smelt by implementing the following actions:
  - Incorporate guidance into flood hazard mapping to help communities comply with the ESA
  - Require communities to demonstrate ESA compliance for all flood plain map revisions
  - Prioritize consideration of ESA listed species and critical habitat when selecting flood insurance studies
  - Develop and implement floodplain management criteria
  - Refine community rating system to provide credits for natural and beneficial functions

  - Prohibit new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway

- Modify the requirements of the USACE related to removal of vegetation on levees. USACE requires removal of vegetation on levees. DWR and USACE have been working to develop a plan that would allow for the continuation of existing vegetation on levees until levee maintenance or repairs requires removal of the vegetation. Under Alternative 4, trees and shrubs would be planted along the levees; and vegetation, woody material, and root re-enforcement material would be installed on the levees instead of riprap for erosion protection.

- Implement predator control programs for Black Bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:

  - Black Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10

  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5

  - Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish

- Restore or create at least 10,000 acres of tidally influenced seasonal or perennial wetlands. These conditions are the same as under the No Action Alternative and Second Basis of Comparison.

- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:

  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River

  - "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.

  - Tag subset of fish in order to quantify effectiveness of the program

  - Attempt to capture 10 percent to 20 percent of outmigrating juvenile salmonids

- Work with Pacific Fisheries Management Council, CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years.

Any changes in harvest limitations would require review and approval from the California Fish and Game Commission; and for some species, the Pacific Fisheries Management Council.

#### ***3.4.7.3 Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions***

Actions included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred with or without the BOs, would be identical under Alternative 4 as under the No Action Alternative and the Second Basis of Comparison.

#### ***3.4.7.4 Future Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions***

Alternative 4 also includes assumptions unrelated to implementation of the 2008 USFWS BO and 2009 NMFS BO, including: climate change and sea level rise; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects that have been approved and are anticipated to be implemented by 2030. These items included in Alternative 4 are identical as under the No Action Alternative and the Second Basis of Comparison.

### 3.4.8 Alternative 5

Alternative 5 is similar to the No Action Alternative with positive OMR criteria in April and May which causes increased Delta outflow; and use of the SWRCB D-1641 pulse flow at Vernalis. Alternative 5 was developed considering comments from environmental interest groups during the scoping process. Alternative 5 also provides another method to operate the New Melones Reservoir as compared to the other alternatives.

The definition of Alternative 5 is based upon the following assumptions that are briefly described below.

- Continued long-term operation of the CVP and SWP in accordance with ongoing management policies, criteria, and regulations, including water right permits and licenses issued by the SWRCB; and the operational requirements of the 2008 USFWS BO and the 2009 NMFS BO.
- Implementation of existing and future actions described in the 2008 USFWS BO and 2009 NMFS BO that would occur by 2030 without implementation of the BOs, as described above for the No Action Alternative in Sections 3.4.1.2 and 3.4.1.3.
- Implementation of actions described in the 2008 USFWS BO and 2009 NMFS BO that would not occur by 2030 without implementation of the BOs.
- Implementation of future actions not described in the 2009 NMFS BO that would occur by 2030 without implementation of any alternatives considered in this EIS.

Alternative 5 conditions assume that climate change conditions would have changed between 2015 and 2030. It is anticipated that by 2030, there will be less snowfall over the long-term average conditions and higher mean sea level elevations.

#### *3.4.8.1 Continued Long-Term Operation of the CVP and SWP Facilities*

The CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 5 would be similar to the operational assumptions under the No Action Alternative with the following changes to water demand assumptions, OMR criteria, and operations of New Melones Reservoir to meet SWRCB D-1641 flow requirements on the San Joaquin River at Vernalis.

##### 3.4.8.1.1 Water Demands

Alternative 5 would include additional water demands for users of water from the American River watershed as compared to the No Action Alternative or Second Basis of Comparison. Under Alternative 5, up to 17 TAF/year would be provided to the El Dorado Irrigation District under a Warren Act Contract to allow water to be conveyed through Folsom Lake; and up to 15 TAF/year would be provided to El Dorado County Water Agency under a separate long-term CVP water service contract. During the review of the numerical modeling analyses used in this EIS, it was discovered that the demands for these El Dorado Irrigation District and the El Dorado County Water Agency contracts were not included in the CalSim II modeling analysis for Alternative 3 as presented in Chapters 5 through 21. A sensitivity analysis using the CalSim II model to compare the results of the analysis with and without these demands is presented in Appendix 5B of this EIS for Alternative 3. The results of the sensitivity analysis have been used in conjunction with the results presented in Chapters 5 through 21 to analyze the effects of including the CVP water service contract for El Dorado County Water Agency in Alternative 3.

##### 3.4.8.1.2 Old and Middle River Criteria

The OMR flow criteria under Alternative 5 is similar to the assumptions under the No Action Alternative and based on concepts addressed in the 2008 USFWS BO and 2009 NMFS BO plus a requirement for positive OMR (no reverse flows) in April and May of all water year types.

##### 3.4.8.1.3 New Melones Operations Criteria

Alternative 5 assumptions for New Melones Reservoir operations are similar to assumptions under the No Action Alternative except for SWRCB D-1641 requirements for the San Joaquin River pulse flows at Vernalis, as summarized in Table 3.5.

**Table 3.5 Bay-Delta Vernalis Flow Objectives (average monthly cfs)**

| 60-20-20 Index | Pulse Flow Required if X2 is West of Chipps Island | Pulse Flow required if X2 is East of Chipps Island |
|---|---|---|
| Wet | 8,620 | 7,330 |
| Above Normal | 7,020 | 5,730 |
| Below Normal | 5,480 | 4,620 |
| Dry | 4,880 | 4,020 |
| Critical | 3,540 | 3,110 |

#### *3.4.8.2 Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Actions included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred with or without the BOs, would be identical under Alternative 5 as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.8.3 Actions in the 2009 NMFS BO that Would Not Have Occurred without Implementation of the Biological Opinions*

Actions included in the 2008 USFWS BO and 2009 NMFS BO that would not have occurred without the BOs, would be identical under Alternative 5 as under the No Action Alternative.

#### *3.4.8.4 Future Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions*

Alternative 5 also includes assumptions unrelated to implementation of the 2008 USFWS BO and 2009 NMFS BO, including: climate change and sea level rise; development of lands in accordance with general plans in areas served by CVP and SWP water supplies; and reasonable and foreseeable projects that have been approved and are anticipated to be implemented by 2030. These items included in Alternative 5 are identical as under the No Action Alternative and the Second Basis of Comparison.

#### *3.4.8.5 Vegetation Management Along Levees*

Alternative 5 includes vegetation management operations along levees for flood management in accordance with policies issued by the USACE in 2009 and 2010.

### 3.4.9 Alternatives Considered but Not Evaluated in Detail

As described above, 6 of the 23 alternative concepts identified for inclusion in the alternatives to be evaluated in this EIS were eliminated for further evaluation for several reasons, as described below.

#### *3.4.9.1 Alternative Concept 6: Modify Flows in San Joaquin River at Vernalis*

The 2009 NMFS BO included two phases related to implementation of the San Joaquin River Inflow to Export Ratio. The first phase, to be implemented in 2010 and 2011, assumed CVP and SWP operations under the Vernalis Adaptive Management Plan (VAMP) which provided for Reclamation to purchase water from non-CVP water users in the San Joaquin River watershed. The second phase was designed to be implemented following the completion of VAMP when Reclamation could no longer purchase water to meet flow requirements of the SWRCB D-1641 in the Delta.

Alternative Concept 6 recommended an operations that CVP could not meet without VAMP authorizations. Therefore, Alternative Concept 6 did not meet the provision in the purpose of the action to be "consistent with Federal Reclamation law; other Federal laws; Federal permits and licenses; State of California water rights, permits, and licenses." Alternative Concept 6 was not retained for analysis in the EIS.

#### *3.4.9.2 Alternative Concept 14: Advance the Timing of Upgrades at Wastewater Treatment Plants*

Alternative Concept 14 would advance the timing of upgrades at the Sacramento Regional Wastewater Treatment Plant to 2017; and implement advanced treatment technologies at the Fairfield-Suisun Sewer District treatment plant to reduce nutrients in the effluent." However, both of these actions would be complete by 2030, the study period considered in this EIS. The Sacramento Regional Wastewater Treatment Plant must comply with the National Pollutant Discharge Elimination System permit issued on December 9, 2010 by the Central Valley Regional Water Quality Control Board to reduce nutrients in the effluent discharged to the Sacramento River by 2020 (SRCSD 2012). The Fairfield Suisun Sewer District must comply with similar permit conditions issued by the San Francisco Bay Regional Water Quality Control Board in March 2015 (SFRRWQCB 2015).

Because the Environmental Consequences analysis in this EIS is conducted as a "snapshot" in time at 2030, inclusion of a provision to require compliance with the discharge requirements prior to 2020 would not be evaluated. Therefore, Alternative Concept 14 was not retained for analysis in the EIS.

#### *3.4.9.3 Alternative Concept 18: Change to CVP Operations to Meet In-Basin Water Demands prior to Meeting other CVP Water Demands*

Alternative Concept 18 would require operations of the CVP to meet in-basin water demands in the Trinity, Sacramento, American, and Stanislaus rivers watersheds prior to use of the CVP water in other portions of the service area. However, the CVP is operated as integrated system to satisfy statutory, regulatory, and contractual obligations to the fullest extent possible, in accordance with the purpose of the action. Therefore, Alternative Concept 18 was not retained for analysis in the EIS.

#### *3.4.9.4 Alternative Concept 21: Change methods used to monitor and predict OMR criteria*

Alternative Concept 21 addresses an item that is related to methods to implement OMR monitoring and projections. The alternatives considered in this EIS address approaches to continued operation of the CVP and SWP. Methods to monitor and predict criteria used in CVP and SWP operations are considered by Reclamation as part of the operations of the CVP. Changes in methods used to monitor and predict OMR values can be applied to any of the alternatives considered in this EIS; and would not result in differentiations between alternatives. Therefore, Alternative Concept 21 was not retained for analysis in the EIS.

#### *3.4.9.5 Alternative 22: Prioritize Use of CVPIA Restoration Funds in the Watersheds that Generated the Funds*

As described above, the locations of CVPIA restoration activities are determined based upon scientific framework throughout the CVP service area that connects restoration actions to environmental and population responses across watersheds (Reclamation 2013c). A system-wide science-based approach with performance indices, monitoring, and scientific review of results is used to provide direction as the CVPIA adapts to changing conditions. Changing the approach from the current CVPIA implementation plan could be considered to be inconsistent with Federal law. Therefore, Alternative Concept 22 was not retained for analysis in the EIS.

#### *3.4.9.6 Alternative 23: Completely Cease Operations of the CVP and SWP*

Complete cessation of CVP and SWP operations would not be consistent with the requirement of the purpose of the action to operate the CVP and SWP in a manner that is similar to historic operational parameters with certain modifications; and it would not be consistent with Federal Reclamation law; other Federal laws; Federal permits and licenses; State of California water rights, permits, and licenses related to delivery of water by CVP and SWP to water rights holder and related to flood management operations at the CVP and SWP reservoirs. Therefore, Alternative Concept 23 was not retained for analysis in the EIS.

## 3.5 Assumptions for Cumulative Effects Analysis

The CEQ regulations define cumulative effects as the impact on environmental, human, and community resources that results from the incremental impact of the proposed project when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertakes such actions. Cumulative effects can result from individually minor but collectively significant actions taking place over time (40 CFR 1508.7, 1508.25.) Future cumulative impacts should not be speculative but should be based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The reasonably foreseeable future actions included in the cumulative effects analysis are summarized below. The projects and actions are organized into:

- Water Supply and Water Quality Projects and Actions potentially affected by long-term operation of the SWP and CVP (organized geographically from north to south)
- Ecosystem Improvement Projects and Actions potentially affected by long-term operation of the SWP and CVP or potentially affecting resources analyzed in this EIS (organized geographically from north to south)

### 3.5.1 Water Supply and Water Quality Projects and Actions

There are numerous water supply and water quality projects and actions that could be potentially affected by changes in the coordinated long-term operation of the CVP and SWP, or could affect the CVP and SWP operations. Major future water supply and water quality projects and actions are discussed below.

#### *3.5.1.1 Bay-Delta Water Quality Control Plan Update*

In accordance with the federal Clean Water Act and the Porter-Cologne Water Quality Control Act, basin plans must be developed for each hydrologic area. Each basin plan must contain water quality objectives to ensure the reasonable protection of beneficial uses, as well as a program of implementation for achieving those objectives. Federal regulations require each state to adopt water quality standards to protect the public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act. In California, the beneficial uses and water quality objectives form the basis of the water quality control standards. In the Sacramento-San Joaquin Bay Delta, water quality and flow objectives to meet water quality criteria are included in the Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (Bay-Delta WQCP) (SWRCB 2006). The SWRCB and the Central Valley and San Francisco Regional Water Quality Control Boards are in the process of updating the Bay-Delta WQCP. The updates, or amendments, are being prepared in two phases. Initially, the SWRCB and Regional Water Quality Control Boards are evaluating new flow objectives for the Lower San Joaquin River and the tributaries of Stanislaus, Tuolumne, and Merced rivers; and southern Delta salinity objectives. The second phase is evaluating changes to other portions of the Bay-Delta WQCP including Delta outflows, SWP and CVP export restrictions, and other requirements in the Bay-Delta to protect fish and wildlife beneficial uses. A third phase will consider and assign responsibility for implementing measures to achieve the water quality objectives established in the first two phases (SWRCB 2012).

Ongoing programs to adopt and implement total maximum daily loads are described in Chapter 6, Surface Water Quality.

#### *3.5.1.2 Bay Delta Conservation Plan and the California Water Fix*

The Bay Delta Conservation Plan (BDCP) and the California WaterFix are being developed by Federal and State agencies and other stakeholders to achieve the dual goals of a reliable water supply for California and a healthy California Bay Delta ecosystem that supports the State's economy. The program would construct a new conveyance facility and modify operation of existing CVP and SWP Delta facilities; and reduce ecological stressors that impair the function or the use of the Delta by aquatic and terrestrial resources.

The Recirculated Draft EIR/Supplemental Draft EIS (RDEIR/SDEIS) was issued by DWR and Reclamation. The RDEIR/SDEIS evaluated new alternatives in addition to the alternatives included in the Public Draft EIR/EIS that combined ecosystem restoration approaches and Delta conveyance approaches. During the last 50 years, several broad conveyance approaches have been studied to address urban water quality, water supply reliability, and environmental concerns in the Delta: physical barriers, hydraulic barriers, through-Delta facilities, and isolated facilities. Several alternative Delta conveyance facilities are being evaluated as part of the EIR/EIS process. These alternatives included use of an isolated facility that would convey water around or under the Delta for local supply and export through a hydraulically isolated channel or pipeline and with continual use of the existing south Delta intakes (dual conveyance alternatives); and continuation of the use of the through-Delta conveyance with channel modifications.

#### *3.5.1.3 Shasta Lake Water Resources Investigation*

The Shasta Lake Water Resources Investigation is currently being conducted by Reclamation to determine the type and extent of federal interest in a multiple purpose plan to modify Shasta Dam and Reservoir to increase the survival of anadromous fish populations in the upper Sacramento River; increase water supplies and water supply reliability for agricultural, municipal, industrial, and environmental purposes (Reclamation 2013d). To the extent possible through meeting these objectives, alternatives evaluated in the EIS included features to benefit other identified water and related resource needs including ecosystem conservation and enhancement, improve hydropower generation capability, flood damage reduction, maintain and increase recreation opportunities, and maintain or improve water quality conditions in the Sacramento River and the Delta consistent with the objectives of the CALFED Bay-Delta Program. Alternatives for expansion of Shasta Lake included, among other features, raising the dam from 6.5 to 18.5 feet above current elevation, which would result in additional storage capacity of 256,000 to 634,000 acre-feet, respectively. The increased capacity would improve water supply reliability and increase the cold water pool, which would provide improved water temperature conditions for anadromous fish in the Sacramento River downstream of the dam. The Final EIS, published in December 2014, identified the preferred alternative to include an 18.5 foot raise of Shasta Dam to provide an additional 634,000 acre-feet of storage with augmentation of spawning gravel programs and restoration of riparian, floodplain, and side channel habitat in the upper Sacramento River (Reclamation 2014g).

#### *3.5.1.4 North of Delta Offstream Storage Investigation*

The North-of-the-Delta Offstream Storage Investigation evaluates the feasibility of offstream storage in the northern Sacramento Valley for improved water supply and water supply reliability, improved water quality, and enhanced survival of anadromous fish and other aquatic species (DWR 2013). Specific primary planning objectives are to: 1) increase water supplies to meet existing contract requirements, including improved water supply reliability, and provide greater flexibility in water management for agricultural, environmental, and municipal and industrial users; 2) increase the survival of anadromous fish populations in the Sacramento River, as well as the survivability of other aquatic species; and 3) improve drinking water quality in the Delta. To the extent possible through meeting these objectives, alternatives include ecosystem conservation and enhancement, provide ancillary hydropower generation capability to the statewide power grid, and create incremental flood damage reduction opportunities in support of major northern California flood-control reservoirs consistent with the objectives of the CALFED Bay Delta Program. All alternatives include construction of a dam and reservoir near Sites, located to the west of Maxwell (California), with various facilities and configurations for conveyance into and out of the reservoir, which would result in additional storage capacity ranging from 1200 to 1900 TAF.

#### *3.5.1.5 Federal Energy Regulatory Commission License Renewals*

There are 22 hydroelectric generation FERC permits that will expire prior to 2030 (FERC 2015). Fifteen projects in the Sacramento River watershed include one on the Pit River (upstream of Shasta Lake), six on the Feather River, four on the Yuba River, one on the Bear River, one on the American River, and one each on Cow and Battle creeks. Projects in the San Joaquin River watershed include four on the San Joaquin River, one on the Stanislaus River, two on the Merced River, and one on the Tuolumne River. The FERC must complete analyses under NEPA and ESA to consider the effects of the hydropower operations on the environment, including flow regimes, water quality, fish passage, recreation, aquatic and riparian habitat, and special status species.

##### 3.5.1.5.1 Federal Energy Regulatory Commission License Renewal for SWP Oroville Project

The Oroville Facilities, as part of SWP, are also operated for flood management, power generation, water quality improvement in the Delta, recreation, and fish and wildlife enhancement. The objective of the relicensing process was to continue operation and maintenance of the Oroville Facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. The initial FERC license for the Oroville Facilities, issued on February 11, 1957, expired on January 31, 2007. The Final EIR/EIS were completed in 2007 (FERC 2007). At this time, the revised BOs and FERC license have not been issued.

##### 3.5.1.5.2 Federal Energy Regulatory Commission Relicensing for Yuba River Watershed Hydroelectric Projects

The Nevada Irrigation District is applying for a new license for the Yuba-Bear Project (FERC Project No. 2266), and PG&E are applying for the Drum-Spaulding Project (FERC Project No. 2310). The Yuba-Bear Project is located on the Middle and South Yuba rivers, Bear River, and Jackson and Canyon creeks (FERC 2013). Concurrently, PG&E is applying for a license renewal for the Drum-Spaulding Project which is located on the Bear and Yuba rivers. Operations of the two projects are coordinated in many factors. The FERC relicensing processes for these two projects in underway.

##### 3.5.1.5.3 FERC Relicense Renewal for Turlock Irrigation District and Modesto Irrigation District Don Pedro Project

The Don Pedro Project is located on the Tuolumne River in Tuolumne County. The initial license was issued for operations between 1971 and 1991 followed by requirements to evaluate fisheries water needs in the Tuolumne River.

In 1987, after the Turlock Irrigation District and Modesto Irrigation District applied to amend their license to add a fourth generating unit, FERC approved an amended fish study plan with possible changes in 1998. In 1996, FERC amended the license to implement amended minimum flow criteria and require fish monitoring studies for completion in 2005. In 2002, NMFS requested that FERC initiate formal consultation on the effects of the Don Pedro Project on Central Valley steelhead. The FERC approved the Summary Report on fisheries in 2008. In 2009, NMFS, USFWS, CDFW, and several environmental interest groups filed requests for rehearing on the license. FERC denied portions of the request but required instream flow studies to be conducted and required NMFS to be included for consultation on any authorized changes to minimum flow release schedules.

The FERC also directed the appointment of an administrative law judge to assist in assessing the need for and feasibility for interim measures prior to relicensing. A final report was completed in 2010. Following the completion of the report and a monitoring plan by the affected districts, FERC approved an order modifying and approving instream flow and monitoring study plans. A final license application, including an Environmental Report, was submitted to FERC in April 2014 (TID and MID 2014). The current license expires in 2016.

The objective of the relicensing process is to continue operation and maintenance of the Don Pedro Project facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license.

##### 3.5.1.5.4 FERC Relicense Renewal for Merced Irrigation District's Merced River Hydroelectric Project

The Merced River Hydroelectric Project is located on the Merced River in Mariposa County and includes both Lake McClure and McSwain Reservoir, two powerhouses (New Exchequer and McSwain), and recreation facilities. The initial FERC license expires on February 28, 2014. The objective of the relicensing process is to continue operation and maintenance of the Merced River Hydroelectric Project facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license (Merced ID 2013).

#### *3.5.1.6 El Dorado Water and Power Authority Supplemental Water Rights Project*

The El Dorado Water and Power Authority (EDWPA) proposes to establish permitted water rights allowing diversion of water from the American River basin to meet planned future water demands in the El Dorado Irrigation District and Georgetown Divide Public Utility District service areas and other areas located within El Dorado County that are outside of these service areas. The EDWPA filed petitions with the SWRCB for partial assignment of State Filed Applications 5644 and 5645, and accompanying applications allowing for the total withdrawal and use of 40,000 acre-feet per year, consistent with the diversion and storage locations allowed under the El Dorado-Sacramento Municipal Utility District Cooperation Agreement (EDWPA 2010).

#### *3.5.1.7 Semitropic Water Storage District Delta Wetlands*

In 1987, Delta Wetlands, a California Corporation, proposed a project for water storage and wildlife habitat enhancement on four privately owned islands in the Delta. The four islands were Bacon Island and Bouldin Island in San Joaquin County and Holland Tract and Webb Tract in Contra Costa County, encompassing approximately 23,000 acres. The Delta Wetlands Project would store water on two Reservoir Islands (Bacon Island and Webb Tract) for subsequent release into the Delta, and habitat enhancement to compensate for wetland and wildlife effects of the water storage operations with a Habitat Management Plan on two Habitat Islands (Bouldin Island and Holland Tract).

In 2007, the Delta Wetlands Project partnered with the Semitropic Water Storage District (Semitropic WSD) to: 1) provide water to Semitropic WSD to augment its water supply, and 2) bank water within the Semitropic Groundwater Storage Bank and Antelope Valley Water Bank. The designated places of use for Delta Wetlands Project water would include: Semitropic WSD; Member Agencies of the Metropolitan Water District of Southern California, the Western Municipal Water District of Riverside County, and select service areas of the Golden State Water Company. The project would include improvements of 27 miles of levees and screened diversions to divert water during high-flow periods in the winter months of December through March into Webb Tract (100,000 acre-feet of storage) and Bacon Island (115,000 acre-feet of storage). The water would not be diverted in a manner that would adversely affect senior legal water rights holders, including the SWP and CVP. Stored water would be discharged into False River (from Webb Tract) and Middle River (from Bacon Island) for export when excess SWP or CVP diversion capacity is available, in the summer and fall months of July through November. Any water that could not be exported from the Delta in a given year would be available to increase Delta outflow in the fall months of September through November. Semitropic WSD issued a Draft EIR in 2010 and a Final EIR in 2011 (SWSD 2011).

#### *3.5.1.8 North Bay Aqueduct Alternative Intake*

DWR is evaluating the implementation of an alternative intake on the Sacramento River upstream of the Sacramento Regional Wastewater Treatment Plant, and conveyance facility to connect the intake with the existing North Bay Aqueduct. The proposed alternative intake would be operated in conjunction with the existing North Bay Aqueduct intake at Barker Slough. The proposed project would be designed to improve water quality and to provide reliable deliveries of SWP supplies to its contractors, the Solano County Water Agency and the Napa County Flood Control and Water Conservation District (DWR 2011a).

The proposed project would include construction and operation of a 240 cfs capacity intake with state-of-the-art positive barrier fish screens, pumping plant, sediment basins, and ancillary support facilities located on the west side of the Sacramento River near south Sacramento. The conveyance facility would include an approximately 30 mile long, 72 to 84-inch diameter underground steel and/or concrete pipeline to convey the water from the alternate intake to the existing North Bay Aqueduct. Two options are proposed for the location of the alternate intake facility. Alternate intake site 1 is located on the outside edge of Garcia Bend of the Sacramento River (on the west bank), approximately 500 feet south of the boundary of the City of West Sacramento. Alternate intake site 2 is located immediately south of the outside edge of Garcia Bend of the Sacramento River (on the west bank), approximately 2,500 feet south of the boundary of the City of West Sacramento. The intake and pumping plant facility would be constructed on the water side of the Sacramento River levee and the remaining components would be constructed on the land side of the levee. The intake would extend about 100 feet from the top of the levee into the river. The exact amount of this extension would depend on the site option selected. A fish screen would be installed on the face of the intake structure to prevent fish from swimming or being drawn into the intake and it would be designed to meet CDFW, NMFS, and USFWS criteria. The dimensions of the fish screen would be based on an anticipated approach velocity of 0.2 feet per second at the fish screen. Flow-control louvers behind the screen would control flow rates through the screen to assure uniform water velocity across the screen. Normal operation would keep the top of the screen below low water elevation. A reduction in pumping would occur any time the screens are not submerged or the water velocities increased. Above the screen would be concrete panels which extend to the 200 year flood elevation. A log boom would be installed in front of the fish screen to block large debris from blocking or damaging the intake. The intake would be equipped with an automatic fish screen cleaning system.

#### *3.5.1.9 Los Vaqueros Reservoir Expansion Phase 2*

Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. The Los Vaqueros Reservoir initial construction was completed in 1997 as a 100 TAF off-stream storage reservoir owned and operated by Contra Costa Water District to improve delivered water quality and emergency storage reliability to their customers. In 2012, the Los Vaqueros Reservoir was expanded to a total storage capacity of 160,000 acre-feet (Phase 1) to provide additional water quality and supply reliability benefits, and to adjust the timing of its Delta water diversions to accommodate the life cycles of Delta aquatic species, thus reducing species impact and providing a net benefit to the Delta environment. As part of the Storage Investigation Program described in the CALFED Bay Delta Program Record of Decision, additional expansion up to 275 TAF (Phase 2) is being evaluated by Contra Costa Water District, DWR, and Reclamation. The alternatives considered in the evaluation also consider methods to convey water from Los Vaqueros Reservoir to the South Bay Aqueduct to provide water to Zone 7 Water Agency, Alameda County Water District, and Santa Clara Valley Water District (Reclamation, CCWD, and Western 2010).

#### 3.5.1.10 Upper San Joaquin River Basin Storage Investigation

The Upper San Joaquin River Basin Storage Investigation is being conducted by Reclamation and DWR to evaluate alternative plans to increase Upper San Joaquin River Storage to enhance the San Joaquin River restoration efforts and improve water supply reliability for agricultural, municipal and industrial, and environmental uses in the Friant Division, the San Joaquin Valley, and other regions of the state. The investigation is evaluating integration of conjunctive management and water transfer concepts into plan formulations. Additional storage is also expected to provide incidental flood damage reduction benefits (Reclamation 2014c).

Reclamation is analyzing alternatives for a new dam and a 1,260 TAF reservoir along the San Joaquin upstream of Millerton Lake in an area known as Temperance Flat. Primary planning objectives are to: 1) increase water supply reliability, and 2) enhance flow and temperature conditions to support the San Joaquin River Restoration Program. Operation variables include reservoir carryover, new or shifting water supply beneficiaries, and alternative conveyance routes.

#### 3.5.1.11 Central Valley RWQCB Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program regulates discharges from irrigated agricultural lands. Its purpose is to prevent agricultural discharges from impairing the waters that receive the discharges. The California Water Code authorizes the SWRCB and Regional Water Quality Control Boards to conditionally waive waste discharge requirements if this is in the public interest. On this basis, the Los Angeles, Central Coast, Central Valley, and San Diego regional water quality control boards have issued conditional waivers of waste discharge requirements to growers that contain conditions requiring water quality monitoring of receiving waters. In 2010, the Central Valley Regional Water Quality Control Board proposed to expand the requirements to groundwater especially for regulation of discharges with higher concentrations of nutrients (CVRWQCB 2011). Participation in the waiver program is voluntary; however, non-participant dischargers must file a permit application as an individual discharger, stop discharging, or apply for coverage by joining an established coalition group. The waivers must include corrective actions when impairments are found.

#### 3.5.1.12 San Luis Reservoir Low Point Improvement Project

The San Luis Reservoir Low Point Improvement Project is proposed by Reclamation, the Santa Clara Valley Water District, and the San Luis and Delta Mendota Water Authority. As part of this project, Reclamation is investigating three alternatives to address the water quality problems within the CVP's San Felipe Division (Santa Clara and San Benito counties) that arise when San Luis Reservoir levels drop below 300,000 acre-feet during late summer in dry water years, resulting in large algal blooms. The alternatives being considered are to 1) expand the 6,000 acre-feet Pacheco Reservoir to 80,000 acre-feet or 130,000 acre-feet, 2) lower the San Felipe Intake at San Luis Reservoir, or 3) implement a combination comprehensive plan. The combination comprehensive plan would involve increasing groundwater recharge and recovery capacity, implementing desalination measures, re-operating Santa Clara Valley Water District's raw- and treated-water systems, and implementing institutional measures. If Pacheco Reservoir were to be enlarged, the reservoir would be filled with Delta water; thus, additional impacts on Delta aquatic species (e.g., juvenile salmonids and Delta Smelt) could result from an increase in Delta exports. The environmental scoping report for the San Luis Reservoir Low Point Improvement Project was released in January 2009 and the plan formulation report was published in January 2011 (Reclamation et al. 2011).

#### *3.5.1.13 Westlands v. United States Settlement*

In August 2015, Westlands Water District and the United States agreed upon a settlement involving several litigations, as described below. The settlement is contingent upon Congressional authorization of enabling legislation (Reclamation 2015). The following information provides a summary from the Reclamation news release in October 2015.

In 2000, the court in *Firebaugh Canal Co v. United States*, issued an Order requiring the Secretary of the Interior to provide drainage service to lands served by the San Luis Unit of the Central Valley Project. In 2007 Reclamation signed a Record of Decision selecting a drainage plan and finding that the cost of providing drainage for lands served by the San Luis Unit. Reclamation began implementing the selected drainage plan in a portion of Westlands Water District in 2010 on a court-ordered schedule.

In 2011, individual landowners within Westlands Water District filed a takings claim against the United States alleging that failure to provide drainage service has caused a physical taking of their lands without just compensation in violation of the Fifth Amendment (*Etchegoinberry v. United States*). The Court of Federal Claims denied the government's motion to dismiss the complaint.

In January 2012, Westlands filed a breach of contract case alleging that the government's failure to provide drainage service to the Westlands Water District service area constituted a breach of Westlands Water District 1963 Water Service and 1965 Repayment contracts (including the interim renewal of those contracts). The case is currently pending.

Under the proposed terms of the Settlement, Westlands Water District will:

- Permanently retire not less than 100,000 acres of land from production. Westlands Water District will agree to permanently retire a total of not less than 100,000 acres of lands within its boundaries utilizing those lands only for the following purposes:
    - Management of drain water, including irrigation of reuse areas;
    - Renewable energy projects;
    - Upland habitat restoration projects; or
    - Other uses subject to the consent of the United States.

- Cap contract deliveries at 75 percent of its CVP contact amount (from 1.193 million acre-feet to 895 thousand acre-feet). Any water above this 75 percent cap, that would have been delivered to Westlands Water District, would instead be available to the United States for other public purposes under the CVP.
- Assume all responsibility for drainage in accordance with all legal requirements under state and federal law. Westlands Water District would become legally responsible for the management of drainage water within its boundaries, in accordance with federal and California law.
- Indemnify the United States for any damages and pay compensation for claims arising out of the *Etchegoinberry litigation*. Under the Settlement Westlands Water District will indemnify the United States for any claims (past, present and future) arising out of a failure to provide drainage service with Westlands Water District. Westlands Water District would also intervene in the *Etchigoinberry* case for Settlement purposes and would pay compensation to individual landowners.
- Continue to wheel water to Lemoore Naval Air Station. As part of the overall Settlement, CVP water will be made available to Lemoore Naval Air Station and Westlands Water District would agree to wheel all CVP water made available to Lemoore under the same terms and conditions as Westlands Water District wheels water to other Westlands Water District's contractors.
- Be relieved from potential drainage repayment. If the United States were to expend significant funds to provide a drainage solution, Reclamation would seek repayment from Westlands Water District (over 50 years, with no interest, commencing after completion of each separable element). By taking responsibility for drainage, Westlands Water District would also eliminate responsibility for repayment.

Under the Terms of the Settlement, the United States will:

- Be relieved of all statutory obligations to provide drainage. The Settlement Agreement would relieve the Department of the Interior from all drainage obligations imposed by the San Luis Act, including implementation of the 2007 ROD, which is estimated to cost approximately $3.5 billion ($513 million authorized). Westlands Water District will agree to dismiss with prejudice the *Westlands v. U.S.* breach of contract litigation and will join the U.S. in petitioning for vacatur of the 2000 Order Modifying Partial Judgment in the *Firebaugh* case directing implementation of drainage service and control schedules.
- Receive a waiver of claims for potential damages due to a failure to provide drainage service. Westlands Water District will agree to provide for the release, waiver and abandonment of all past, present and future claims arising from the government's failure to provide drainage service under the San Luis Act, including those by individual landowners within Westlands Water District's service area, and would further agree to indemnify the United States

for any and all claims relating to the provision of drainage service or lack thereof within the Westlands service area.

- Relieve Westlands Water District repayment obligation for CVP construction charges to date (approximately $375 million). Westlands Water District will be relieved of its current, unpaid capitalized construction costs for the CVP, the present value of which is currently estimated to be $375 million. Under the Settlement, Westlands Water District will still be responsible for Operation and Maintenance, the payment of restoration fund charges pursuant to the CVPIA, and for future CVP construction charges.
- Convert Westlands Water District water service contract into a repayment contract. The Secretary will convert Westlands Water District's current 9(e) water service contract to a 9(d) repayment contract consistent with existing key terms and conditions. As a "paid out" contractor, the benefit of this conversion is permanent right to a stated share of CVP water. However, the terms and conditions of the contract—including the so called "shortage clause" – will otherwise be the same as in the current 9(e) contract.
- Retain the right to cease water deliveries if Westlands Water District fails to meet its drainage obligation. Language in the Settlement makes the United States' obligation to provide water to Westlands under the 9(d) Repayment Contract conditional upon Westlands Water District's fulfillment of its obligations to manage drainage water within its service area.
- Issue a water service contract to Lemoore Naval Air Station. As part of the overall Settlement, the United States is authorized to enter into a water service contract with Lemoore Naval Air Station to provide a guaranteed quantity of CVP water to meet the needs of the Naval Air Station associated with air operations and Westlands Water District will agree to wheel all CVP water made available to Lemoore.

#### *3.5.1.14 Contra Loma Reservoir and Recreation Resource Management Plan*

The Contra Loma Recreation Resource Management Plan is a long-term plan to guide management of the resources on the federal lands within the 80-acre Contra Loma Reservoir and surrounding 661 acres of recreation areas in Contra Loma Regional Park and Antioch Community Park (Reclamation 2014f). The East Bay Regional Park District manages the federal lands and public recreation facilities under an agreement with Reclamation. The proposed plan is to expand recreational use and facilities to increase recreational demands, including establishment of an additional all-weather sports field, fishermen's shelter, playground structure, a disc golf course, and expanded swim lagoon and trails.

#### *3.5.1.15 San Luis Reservoir State Recreation Area Resource Management Plan/General Plan*

The Resource Management Plan addressed recreational plans for the San Luis Reservoir State Recreation Area and adjacent lands in Merced County that are owned by Reclamation and managed by the California Department Parks and

Recreation, DWR, and CDFW (Reclamation and CDPR 2013). The plan would focus on boating management, cultural resources management, vegetation management, enhanced trails management, expanded visitor experiences and education opportunities, and road and utility upgrades.

#### *3.5.1.16 Future Water Supply Projects*

Many of the future projects would directly increase regional and local water supplies through groundwater storage and recovery programs, improved conveyance that connects water supplies from different water agencies, recycled water projects, and desalination projects. Water resources projects that have been approved and are being implemented were previously described in this chapter under the No Action Alternative. The following major water supply projects are currently being evaluated and are considered under the Cumulative Effects analysis.

- Future Groundwater Storage and Recovery Projects
  - City of Roseville (City of Roseville 2012)
  - Mokelumne River Water & Power Authority (MORE 2015)
  - Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA 2011)
  - Stockton East Water District (SEWD 2012)
  - Madera Irrigation District (Reclamation 2011b)
  - Kings River Conservation District (KRCD 2012b)
  - Buena Vista Water Storage District and Rosedale Rio Bravo Water Storage District (BVWSD 2015)
  - City of Los Angeles (City of Los Angeles 2010, 2013b)
  - Los Angeles County (Los Angeles County 2013b)
  - City of San Diego (City of San Diego 2009a, 2009b)
  - Rancho California Water District (RCWD 2011, 2012)
  - Eastern Municipal Water District (EMWD 2014c)
  - Jurupa Community Services District (JCSD et al. 2010)
- Major Conveyance Projects
  - Bay Area Regional Water Supply Reliability (CCWD 2014, EBMUD 2014)
  - Friant-Kern Canal and Madera Canal Capacity Restoration Projects (SJRRP 2011, 2015)
  - Los Banos Creek Water Resources Management Plan (SJRECWA 2012)
  - Sacramento River Water Reliability Project (Reclamation 2004b)

- Major Recycle Water Projects (more than 10,000 acre-feet/year)
  - City of Fresno (City of Fresno 2011)
  - City of Los Angeles (City of Los Angeles 2005)
  - Central Basin Municipal Water District (CBMWD 2010)
  - Foothill Municipal Water District (MWDSC 2010)
  - Upper San Gabriel Valley Municipal Water District (USGVMWD 2013)
  - West Basin Municipal Water District (WBMWD 2011, 2015a)
  - Olivenhain Municipal Water District (OMWD 2015)
  - Eastern Municipal Water District (EMWD 2014c)
  - Inland Empire Utilities Agency (IEUA 2014)
  - Palmdale Water District (PWD 2010)
  - East Valley Water Reclamation Authority (Antelope Valley 2013)
- Major Future Coastal Desalination Water Projects
  - San Francisco Bay Area Regional Desalination Project (BARDP 2015)
  - City of Santa Barbara (City of Santa Barbara 2015)
  - Camrosa Water District (CWD 2015)
  - City of Long Beach (City of Long Beach 2015)
  - City of Huntington Beach (City of Huntington Beach 2010)
  - City of Oceanside (City of Oceanside 2012)
  - City of Carlsbad (City of Carlsbad 2006)
  - West Basin Municipal Water District (WBMWD 2015b)
  - Metropolitan Water District of Orange County (MWDOC 2015)
  - San Diego County Water Authority in the Southern California Region (SDCWA 2009, 2015)
- Long-term and short-term Water Transfers to provide water to municipal, agricultural, and ecosystem water users, including wildlife refuges including programs that transfer water from northern California to the San Joaquin Valley and southern California across the Delta (Reclamation and SLDMWA 2015; BWGWD 2015).

### 3.5.2 Ecosystem Improvement Projects and Actions

There are numerous ecosystem improvement projects and actions that could be potentially affected by changes in the coordinated long-term operation of the CVP and SWP, or could affect the CVP and SWP operations. Major future water supply and water quality projects and actions are discussed below.

#### *3.5.2.1 Mill Creek Riparian Assessment*

The need to restore and maintain riparian habitat in Mill Creek is identified in the Anadromous Fish Restoration Program and CALFED Bay-Delta Ecosystem Restoration Program goals, objectives, and targets. The AFRP is one of five CVPIA programs that have been integrated with the Ecosystem Restoration Plan. Both of these programs prioritize establishment, restoration, and maintenance of anadromous fish habitat on this stream, particularly in the arena of riparian habitat and flow enhancement. In response to this identified need, Reclamation and USFWS is implementing the Mill Creek Riparian Assessment. The project includes: 1) riparian habitat and condition mapping and vegetation classification of the Mill Creek watershed, 2) identifying and prioritizing areas that should be restored, enhanced, and/or preserved in addition to existing conservation easements, and 3) identifying the types of restoration actions that should occur at the prioritized sites (USFWS 2010).

#### *3.5.2.2 Yolo County Habitat/Natural Community Conservation Plan*

The Yolo County Habitat Joint Powers Authority, consisting of five local public agencies, launched the Yolo Natural Heritage Program in March 2007. This effort includes the continuing preparation of a joint Habitat Conservation Plan/ Natural Community Conservation Plan (HCP/NCCP). Member agencies include Yolo County and the cities of Davis, Woodland, West Sacramento, and Winters.

The HCP/NCCP describes the measures that local agencies will implement to conserve biological resources, obtain permits for urban growth and public infrastructure projects, and continue to maintain the agricultural heritage and productivity of Yolo County. The nearly 653,820-acre planning area provides habitat for covered species occurring within five dominant habitats/natural communities. The plan proposes to address 63 covered species, including seven state-listed species: palmate-bracted bird’s-beak, Colusa grass, Crampton’s tuctoria, giant garter snake, Swainson’s hawk, western yellow-billed cuckoo, and bank swallow. Interim conservation activities include acquiring permanent conservation easements for sensitive species habitat in the plan area (YNHP 2015).

#### *3.5.2.3 California EcoRestore*

California EcoRestore is an initiative by the California Natural Resources Agency to coordinate and advance habitat restoration for at least 30,000 acres by 2019 (CNRA 2015a, 2015b). This acreage includes 25,000 acres of habitat restoration identified in the 2008 USFWS BO and 2009 NMFS BO, and 5,000 acres of habitat enhancements. Some of these programs would be funded by federal and state water agencies that are required to mitigate impacts of the CVP and SWP. Other programs would be sponsored by a combination of funds from state bonds (Proposition 1 and 1E), Assembly Bill 32 Greenhouse Gas Reduction Fund, federal agencies, local agencies, and private investments. The California Delta Conservancy will lead implementation of identified restoration projects in collaboration with local governments and with a priority on using public lands in the Delta.

Many of the programs to be implemented under California EcoRestore in Suisun Marsh, Yolo Bypass, and Cache Slough are discussed separately under the No Action Alternative and cumulative effects in this EIS.

#### *3.5.2.4 North Delta Flood Control and Ecosystem Restoration Project*

The North Delta Flood Control and Ecosystem Restoration Project is proposed near the confluence of the Cosumnes and Mokelumne rivers by the DWR and encompasses approximately 197 square miles. Consistent with objectives contained in the CALFED Record of Decision, the project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern. These actions are focused on McCormack-Williamson Tract and Staten Island. The project would implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. Flood control improvements are needed to reduce damage to land uses, infrastructure, and the Bay-Delta ecosystem resulting from overflows caused by insufficient channel capacities and catastrophic levee failures in the 197 square-mile project study area. The proposed project as described in the Final EIR (DWR 2010b) included: portions of the levee system degraded to allow controlled flow across McCormack-Williamson Tract; levee modification to mitigate hydraulic impacts; channel dredging to increase flood conveyance capacity; an off-channel detention basin on Staten Island; ecosystem restoration where floodplain forests and marshes would be developed at McCormack-Williamson Tract and the Grizzly Slough property; setback levee on Staten Island to expand the floodway conveyance; and opening up the southern portion of McCormack-Williamson Tract to boating; improving Delta Meadows property; providing access and interpretive kiosks for wildlife viewing; and providing restroom, circulation, parking, and signage infrastructure to support such uses.

#### *3.5.2.5 Franks Tract Project*

Reclamation has conducted studies to evaluate the feasibility of modifying the hydrodynamic conditions near Franks Tract to improve Delta water quality and enhance the aquatic ecosystem. The results of these studies have indicated that modifying the hydrodynamic conditions near Franks Tract may substantially reduce salinity in the Delta and protect fishery resources, including populations of Delta Smelt. Reclamation evaluated installing operable gates to control the flow of water at key locations (Threemile Slough and/or West False River) to reduce sea water intrusion, and to positively influence movement of fish species of concern to areas that provide favorable habitat conditions. The project gates would be operated seasonally and during certain hours of the day, depending on fisheries and tidal conditions. Boat passage facilities would be included to allow for passing of watercraft when the gates are in operation. The Franks Tract Project is consistent with ongoing planning efforts for the Delta to help balance competing uses and create a more sustainable system for the future. By protecting fish resources, this project also could improve operational reliability of the CVP and SWP because curtailments in water exports (pumping restrictions) are likely to be less frequent. Franks Tract was previously evaluated as part of DWR's Flooded Island Pre-Feasibility Study Report (DWR 2007).

## 3.6 Summary of Environmental Consequences

Conditions in 2030 related to environmental and human resources that would occur with implementation of the No Action Alternative were compared to conditions under the Second Basis of Comparison; and conditions under

Alternatives 1 through 5 were compared to the conditions under the No Action Alternative and the Second Basis of Comparison, as described in Chapter 4, Approach to Environmental Analysis. The results of these analyses by alternative are described in Chapters 5 through 21 of this EIS and summarized in Tables 3.6 and 3.7.

The tables present summarize the results of both quantitative and qualitative impact analyses. The tables include relative quantitative differences for adverse impacts to provide a basis for consideration of mitigation measures. Potential mitigation measures were considered related to the comparison of Alternatives 1 through 5 to the No Action Alternative. Mitigation measures were not included to address adverse impacts of implementation of Alternatives 1 through 5 and the No Action Alternative as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in surface water conditions are provided as a basis for identifying the impacts as described in Aquatic, Terrestrial, and Recreation resources. Therefore, no mitigation measures are presented for Surface Water Resources.

Differences in the quantitative analyses of 5 percent or less are considered to be "similar" because the modeling analyses are based on CalSim II model output which operates with monthly time steps. Therefore, it was determined that changes in the model of 5 percent or less were related to the uncertainties in the model processing.

1 **Table 3.6 Comparison of Alternatives 1 through 5 to No Action Alternative**

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **SURFACE WATER** | | | | | |
| Trinity Lake | Water surface elevations similar.<br>Storage similar or increased. | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. |
| Trinity River at Lewiston Dam | Flows similar or increased. | No change. | Flows similar or increased. | Flows similar or increased. | Water surface elevations similar.<br>Storage similar. |
| Shasta Lake | Water surface elevations similar.<br>Storage similar or increased. | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage similar. |
| Sacramento River at Keswick Dam | Flows similar or increased except reduced in September and November (up to 44%). | No change. | Flows similar or increased except reduced in September and November (up to 42%). | Flows similar or increased except reduced in September and November (up to 44%). | Flows similar. |
| Sacramento River at Freeport | Flows similar or increased except reduced in September and November (up to 47%). | No change. | Flows similar or increased except reduced in September and November (up to 48%). | Flows similar or increased except reduced in September and November (up to 47%). | Flows similar. |
| Clear Creek near Igo | Flows same except reduced in May (41%). | No change. | Flows same except reduced in May (29%). | Flows same except reduced in May (41%). | No change. |
| Lake Oroville | Water surface elevations similar.<br>Storage reduced except in June (up to 22%). | No change. | Water surface elevations similar.<br>Storage similar or increased. | Water surface elevations similar.<br>Storage reduced except in June (up to 22%). | Water surface elevations similar.<br>Storage similar. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Feather River downstream of Thermalito Complex | Flows similar or increased except reduced in July-September and November-December (up to 65%). | No change. | Flows similar or increased except reduced in July-September and October-January (up to 70%). | Flows similar or increased except reduced in July-September and November-December (up to 65%). | Flows similar or increased except reduced in April-May (up to 27%). |
| Folsom Lake | Water surface elevations similar<br>Storage similar or increased except reduced in June-August in above normal and below normal years (up to 15%). | No change. | Water surface elevations similar<br>Storage similar or increased except reduced in July-August in above normal and August-September in below normal years (up to 10%). | Water surface elevations similar<br>Storage similar or increased except in reduced June-August in above normal and below normal years (up to 15%). | Water surface elevations similar.<br>Storage similar. |
| American River at Nimbus Dam | Flows similar or increased except reduced in September-November and June-July (up to 48%). | No change. | Flows similar or increased except reduced in August-November and June (up to 46%). | Flows similar or increased except reduced in September-November and June-July (up to 48%). | Flows similar or increased except reduced in September and April-May (up to 14%). |
| New Melones Reservoir | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar.<br>Storage reduced in July-September in above normal years (up to 6%); and all months in below normal, dry, and critical dry years (up to 19 percent). |
| Stanislaus River at Goodwin Dam | Flows similar or increased except reduced in July-August, December, and March (up to 18%). | No change. | Flows similar or increased except reduced in October and February-July (up to 73%). | Flows similar or increased except reduced in July-August, December, and March (up to 18%). | Flows similar or increased except reduced in June-August (up to 18%). |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| San Joaquin River at Vernalis | Flows similar or increased except reduced in October and April (up to 19%). | No change. | Flows similar or increased except reduced in October and May-June (up to 21%). | Flows similar or increased except reduced in October and April (up to 19%). | Flows similar or increased. |
| San Luis Reservoir | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased. | Water surface elevations similar<br>Storage similar or increased except in below normal years in June-July (up to 9%); in dry years in April-September (up to 17%); and in critical dry years in April-January (up to 18%). |
| Flows into Yolo Bypass | Flows similar or increased except in October in wet years (20%). | No change. | Flows similar or increased except in October in wet years (25%). | Flows similar or increased except in October in wet years (20%). | Flows similar. |
| Delta Outflow | Reduced flows in many months. Increased flows in some months, including in December, February-March, and June in wet years (up to 1,492 cfs); and similar or increased flows in June and September in dry years (up to 385 cfs). | No change. | Reduced flows in many months. Increased flows in some months, including in December-March, in wet years (up to 3.307cfs); and increased flows in January-February and June-July in dry years (up to 277 cfs). | Reduced flows in many months. Increased flows in some months, including in December, February-March, and June in wet years (up to 1,492 cfs); and similar or increased flows in June and September in dry years (up to 385 cfs). | Flows would be similar or increased. |
| Reverse Flows in Old and Middle Rivers | Increased negative flows except in July-September. | No change. | Increased negative flows except in July-September. | Increased negative flows except in July-September. | Increased positive flows except in July-August. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Water Supplies** | | | | | |
| Non-CVP and Non-SWP Deliveries | Deliveries similar.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. | Deliveries similar.<br>No mitigation needed. |
| CVP Water Deliveries<br>(including CVP agricultural and municipal and industrial water service contracts; Sacramento River Settlement Contracts, San Joaquin River Exchange Contracts, and Eastside Division Contracts) | Deliveries similar or increased.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased in wet to dry years.<br>Reduced deliveries in the Eastside Division Contractors in critical dry years (8%).<br>Potential Mitigation measure: Reclamation would support water transfers from other basin water rights holders. |
| SWP Water Deliveries<br>(In accordance with Table A contracts without Article 21 water) | Deliveries similar or increased.<br>No mitigation needed. | No change.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. | Deliveries similar or increased.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Surface Water Quality** | | | | | |
| Salinity in Northern Delta (near Emmaton) | Salinity increased in fall and winter months (up to 377%).<br>Reduced in June in wet to dry years (up to 30%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in fall and winter months in wet and above normal years (up to 378%).<br>Reduced in June of above normal years and September of below normal years (up to 8%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in the western Delta in fall and winter months (up to 377%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in January-February in all years (up to 8%).<br>Reduced in April-June in critical dry years (up to 15%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Salinity in Western Delta (near Port Chicago) | Salinity increased in Oct-March in below normal, dry, and critical dry years, and September wet and above normal years (up to 96%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-January, April-May, June, and September in wet and above normal years (up to 95%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in Oct-March in below normal, dry, and critical dry years, and September wet and above normal years (up to 96%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity similar in most months except reduced in April-May in dry and critical dry years (up to 8%).<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Salinity in Western Central Delta (near Antioch) | Salinity increased in fall and winter months (up to 265%).<br>Reduced in June in wet to below normal years (up to 14%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in fall and winter months (up to 262%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in fall and winter months (up to 265%).<br>Reduced in June in wet to below normal years (up to 14%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in February in critical dry years (7%).<br>Reduced in April-May in below normal to critical dry years, and in June in critical dry years (up to 20%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Salinity in Western Central Delta (near Contra Costa Water District Intakes) | Salinity increased in October-January and September in wet and above normal years (up to 65%).<br>Reduced in March-June in wet to below normal years (up to 32%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-December in all year types, and January in above normal to dry years, and in September in wet and above normal years (up to 76%).<br>Reduced in April-June (up to 34%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in October-January and September in wet and above normal years (up to 65%).<br>Reduced in March-June in wet to below normal years (up to 32%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in April-June in below normal to critical dry years (up to 40%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Salinity in Southern Delta (near CVP and SWP intakes) | Salinity increased in fall and early winter months (up to 65%).<br>Reduced in February-June (up to 22%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | No change.<br>No mitigation needed. | Salinity increased in October-December (up to 29% at Jones Pumping Plant intake and up to 41% at Clifton Court intake).<br>Reduced in June (up to 13% at Jones Pumping Plant intake and up to 19% at Clifton Court intake).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in fall and early winter months (up to 65%).<br>Reduced in February-June (up to 22%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. | Salinity increased in June in dry and critical dry years (up to 12%).<br>Potential Mitigation Measures: Continued coordination of CVP and SWP operations to reduce salinity to the extent possible. Other mitigation measures have not been identified at this time. |
| Mercury in Delta Fish | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | Mercury concentrations similar or reduced concentrations.<br>No mitigation needed. | Mercury concentrations similar concentrations.<br>No mitigation needed. |
| Selenium in Delta and Delta Fish | Selenium concentrations similar concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. | Selenium concentrations similar concentrations.<br>No mitigation needed. |
| **Groundwater Resources** | | | | | |
| Trinity River Region | Similar groundwater conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. |
| Central Valley Region: Sacramento Valley | Similar groundwater conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. | Similar groundwater conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Central Valley Region: San Joaquin Valley | Reduced groundwater pumping (8%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced groundwater pumping (6%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | Reduced groundwater pumping (8%); and higher groundwater elevations (2-200 feet).<br>Potentially improved groundwater quality.<br>Reduced subsidence potential.<br>No mitigation needed. | Similar groundwater pumping; and similar to higher groundwater elevations (2-25 feet).<br>Similar groundwater quality.<br>Similar subsidence potential.<br>No mitigation needed. |
| San Francisco Bay Area, Central Coast, and Southern California Region | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | No change.<br>No mitigation needed. | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | Potentially reduced groundwater pumping; and potentially higher groundwater elevations.<br>Potentially improved groundwater quality.<br>Less subsidence potential.<br>No mitigation needed. | Similar groundwater pumping; and groundwater elevations.<br>Potentially similar groundwater quality.<br>Similar subsidence potential.<br>No mitigation needed. |
| **CVP and SWP Energy Resources** | | | | | |
| Energy Generated and Used by CVP and SWP Water Users | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (41%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (27%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | Similar CVP net generation.<br>Decreased SWP net generation over the long-term (41%).<br>Potentially reduced energy use by CVP and SWP water users.<br>No mitigation needed. | Similar CVP and SWP net generation.<br>Similar reduced energy use.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Aquatic Resources** | | | | | |
| Trinity River: Coho Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Spring-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Steelhead | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Green Sturgeon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity Lake and Lewiston Reservoir: Reservoir Fish | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Pacific Lamprey | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Trinity River: Eulachon | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Winter-run Chinook Salmon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Spring-run Chinook Salmon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Improved conditions due to predator controls.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to reduced pulse flows along lower Clear Creek; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Late Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Steelhead | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030.<br>Potential mitigation measure: Implement fish passage around dams. | Similar conditions.<br>No mitigation needed. |
| Sacramento River System: Green Sturgeon and White Sturgeon | Likely to result in improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Likely to result in improved conditions.<br>No mitigation needed. | Likely to result in improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Delta: Delta Smelt | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta. No mitigation measures have been identified at this time. | Similar conditions. No mitigation needed. | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta. No mitigation measures have been identified at this time. | Reduced habitat conditions due to increased potential for entrainment during larval and juvenile stages, and increased salinity in the fall in the western Delta. No mitigation measures have been identified at this time. | Similar conditions. No mitigation needed. |
| Delta: Longfin Smelt | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices). No mitigation measures have been identified at this time. | Similar conditions. No mitigation needed. | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices). No mitigation measures have been identified at this time. | Reduced habitat conditions due to more negative Old and Middle River flows and other factors (as indicated by lower Longfin Smelt abundance indices). No mitigation measures have been identified at this time. | Similar conditions. No mitigation needed. |
| Delta: Sacramento Splittail | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Sacramento River System: Reservoir Fish | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Sacramento River System: Pacific Lamprey | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Sacramento River System: Striped Bass, American Shad, and Hardhead | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation measures have been identified at this time. | Similar conditions for Hardhead.<br>Reduced habitat conditions for Striped Bass and American Shad due to reduced survival in larval and juvenile stages and increased salinity in the spring in the western Delta.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |
| Stanislaus River: Fall-run Chinook Salmon | Similar conditions.<br>No mitigation needed. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain.<br>No mitigation needed. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Stanislaus River: Steelhead | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030; and lack of measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants.<br>Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain.<br>Potential mitigation measure: Implement fish passage around dams to reduce temperature impacts. No mitigation measures have been identified for remaining impacts. | Similar conditions.<br>No mitigation needed. |
| Stanislaus River: White Sturgeon | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Conditions may be similar; however, adverse impacts could occur due to higher water temperatures.<br>No mitigation measures have been identified at this time. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| New Melones Reservoir; Reservoir Fish | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Stanislaus River: Other Fish | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions for lampreys and Hardheads.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation needed for lamprey and Hardhead. No mitigation measures have been identified at this time for Striped Bass. | Similar conditions for lampreys and Hardheads.<br>Adverse conditions for Striped Bass due to changes in harvest limitations.<br>No mitigation needed for lamprey and Hardhead. No mitigation measures have been identified at this time for Striped Bass. | Similar conditions.<br>No mitigation needed. |
| Pacific Ocean: Killer Whale | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Terrestrial Resources** | | | | | |
| Terrestrial Resources along Shoreline of CVP and SWP Reservoirs | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Terrestrial Resources along Rivers Downstream of CVP and SWP Reservoirs | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | No change.<br>No mitigation needed. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along the Stanislaus River. | Similar or improved conditions along Trinity, Sacramento, American, and Feather rivers.<br>Improved conditions along Stanislaus River.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Terrestrial Resources in Yolo Bypass | Similar conditions in Yolo Bypass.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions in Yolo Bypass.<br>No mitigation needed. | Similar conditions in Yolo Bypass.<br>No mitigation needed. | Similar conditions in Yolo Bypass.<br>No mitigation needed. |
| Terrestrial Resources in Western Delta | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | No change.<br>No mitigation needed. | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | Increased extent of salt water in the fall months of wet and above normal years in western Delta which could adversely affect terrestrial resources that use freshwater habitat.<br>No mitigation measures identified at this time. | Similar habitat in western Delta.<br>No mitigation needed. |
| **Geology and Soils Resources** | | | | | |
| Geology and Soils Resources | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Agricultural Resources** | | | | | |
| Agricultural Production and Employment | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Land Use** | | | | | |
| Municipal and Industrial Land Use | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| **Visual Resources** | | | | | |
| Visual Resources of Land Irrigated with CVP and SWP Water | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Visual Resources at Reservoirs that Store CVP and SWP Water | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| **Recreation Resources** | | | | | |
| Recreation Resources at Reservoirs that Store CVP and SWP Water | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar or improved conditions.<br>No mitigation needed. | Similar conditions.<br>No mitigation needed. |
| Recreation Resources in Rivers downstream of CVP and SWP Reservoirs | Similar or improved conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or improved conditions.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing.<br>No mitigation measures identified at this time. | Similar or improved conditions.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing.<br>No mitigation measures identified at this time. | Similar conditions.<br>No mitigation needed. |
| **Air Quality and Greenhouse Gas Emissions** | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Improved air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Reduced air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Improved air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Similar air quality conditions in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions.<br>No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Increased Greenhouse Gas Emissions (GHG) due to Changes in Energy Resources Related to CVP and SWP Water Use | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase in the San Francisco Bay Area, Central Coast, and Southern California regions. |
| **Cultural Resources** | | | | | |
| Potential for Disturbance of Cultural Resources | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| **Public Health** | | | | | |
| Water Supply Availability for Wildland Firefighting | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Potential Exposure to Mercury in Fish in Delta | Similar or reduced concentrations. No mitigation needed. | No change. No mitigation needed. | Similar or reduced concentrations. No mitigation needed. | Similar or reduced concentrations. No mitigation needed. | Similar concentrations. No mitigation needed. |
| **Socioeconomics** | | | | | |
| Agricultural and Municipal and Industrial Employment | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Municipal and Industrial Water Supply Operating Expenses | Similar conditions. No mitigation needed. | No change. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. | Similar conditions. No mitigation needed. |
| Recreational Economics CVP and SWP Reservoirs | Similar or improved conditions. No mitigation needed. | No change. No mitigation needed. | Similar or improved conditions. No mitigation needed. | Similar or improved conditions. No mitigation needed. | Similar or improved conditions. No mitigation needed. |

| | Alternative 1 Compared to the No Action Alternative | Alternative 2 Compared to the No Action Alternative | Alternative 3 Compared to the No Action Alternative | Alternative 4 Compared to the No Action Alternative | Alternative 5 Compared to the No Action Alternative |
|---|---|---|---|---|---|
| Recreational Economics Related to Striped Bass Fishing in Delta | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced recreational opportunities and associated economics.<br>No mitigation identified at this time. | Reduced recreational opportunities and associated economics.<br>No mitigation identified at this time. | Similar conditions.<br>No mitigation needed. |
| Commercial and Sport Ocean Salmon Fishing | Similar conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced commercial and sport ocean salmon fishing and associated economics.<br>No mitigation identified at this time. | Reduced commercial and sport ocean salmon fishing and associated economics.<br>No mitigation identified at this time. | Similar conditions.<br>No mitigation needed. |
| **Indian Trust Assets** | | | | | |
| Potential for Disturbance of Indian Trust Assets | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. | No change.<br>No mitigation needed. |
| **Environmental Justice** | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Improved air quality conditions.<br>No mitigation needed. | No change.<br>No mitigation needed. | Reduced air quality conditions.<br>No mitigation needed. | Improved air quality conditions.<br>No mitigation needed. | Similar air quality conditions.<br>No mitigation needed. |
| Potential Exposure to Mercury in Fish in Delta | Similar or reduced concentrations.<br>No mitigation needed. | No change.<br>No mitigation needed. | Similar or reduced concentrations.<br>No mitigation needed. | Similar or reduced concentrations.<br>No mitigation needed. | Similar concentrations.<br>No mitigation needed. |

1 **Table 3.7 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **SURFACE WATER CONDITIONS** | | | | | | |
| Trinity Lake | Water surface elevations similar<br>Storage would be similar in most months, except reduced in November-December in above normal years (up to 6%) and all months in critical dry years (up to 10%). | No change. | Water surface elevations similar<br>Storage would be similar in most months, except reduced in November-December in above normal years (up to 6%) and all months in critical dry years (up to 10%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage would be similar in most months, except reduced in all months in critical dry years (up to 10%). |
| Trinity River at Lewiston Dam | Flows similar or increased except reduced in December-February in wet to below normal years (up to 30%). | No change. | Flows similar or increased except reduced in December-February in wet to below normal years (up to 30%). | Flows similar or increased. | No change. | Flows similar or increased except reduced in December-February in wet to below normal years (up to 21%). |
| Shasta Lake | Water surface elevations similar<br>Storage reduced in September-February in wet to dry years (up to 11%) and in all months in critical dry years (up to 14%). | No change. | Water surface elevations similar<br>Storage reduced in September-February in wet to dry years (up to 11%) and in all months in critical dry years (up to 14%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage reduced in September-February in most months of wet to dry years (up to 10%), and in all months in critical dry years (up to 17%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River at Keswick Dam | Flows reduced (up to 21%) except September and November. | No change. | Flows reduced (up to 21%) except September and November. | Flows similar or increased except reduced in August in below normal years (up to 6%). | No change. | Flows reduced (up to 16%) except September and November. |
| Sacramento River at Freeport | Flows similar or increased except reduced in May and June (up to 27%). | No change. | Flows similar or increased except reduced in May and June (up to 27%). | Flows similar or increased except reduced in June in below normal years (up to 13%). | No change. | Flows similar or increased except reduced in May and June (up to 28%). |
| Clear Creek near Igo | Flows similar or increased. | No change. | Flows similar or increased. | No change. | No change. | Flows similar or increased. |
| Lake Oroville | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). | No change. | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). | Water surface elevations similar<br>Storage similar. | No change. | Water surface elevations similar.<br>Similar in most months May-July in wet to dry years and in all months in critical dry years.<br>Reduced in many months from September-February in all year types (up to 18%). |
| Feather River downstream of Thermalito Complex | Flows similar or increased except reduced in August-June (up to 52%). | No change. | Flows similar or increased except reduced in August-June (up to 52%). | Flows similar or increased except reduced in August-June (up to 28%). | No change. | Flows similar or increased except reduced in August-June (up to 58%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Folsom Lake | Water surface elevations similar<br>Storage similar in many months except reduced flows in September-January (up to 12%) in wet to below normal years and July-September in critical dry years (up to 11%). | No change. | Water surface elevations similar<br>Storage similar in many months except reduced flows in September-January (up to 12%) in wet to below normal years and July-September in critical dry years (up to 11%). | Water surface elevations similar<br>Storage similar. | No change. | Water surface elevations similar<br>Storage similar in many months except reduced flows in August-January (up to 13%) in wet to below normal years and July in critical dry years (8%). |
| American River at Nimbus Dam | Flows similar or increased except reduced in June-August, December, February, and April (up to 25%). | No change. | Flows similar or increased except reduced in June-August, December, February, and April (up to 25%). | Flows similar or increased except reduced flows in June-August and April (up to 17%). | No change. | Flows similar or increased except reduced in December-February, April, June, and August (up to 25%). |
| New Melones Reservoir | Water surface elevations similar<br>Storage similar in wet, below normal, and dry years, and in most months in above normal and critical dry years. Storage reduced in October in above normal water years (6%) and in October-January and April-June in critical dry years (up to 7%). | No change. | Water surface elevations similar<br>Storage similar in wet, below normal, and dry years, and in most months in above normal and critical dry years. Storage reduced in October in above normal water years (6%) and in October-January and April-June in critical dry years (up to 7%). | Water surface elevations similar<br>Storage similar or increased. | No change. | Water surface elevations similar<br>Storage reduced in all months in all water year types (up to 23%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River at Goodwin Dam | Flows similar or increased except reduced in November-March and May-June (up to 25%). | No change. | Flows similar or increased except reduced in November-March and May-June (up to 25%). | Flows reduced in all months (up to 79%) except April and August. | No change. | Flows reduced in all months (up to 25%) except October, April, and May. |
| San Joaquin River at Vernalis | Flows similar or increased except reduced in November and May-June (up to 9%). | No change. | Flows similar or increased except reduced in November and May-June (up to 9%). | Flows similar or increased except reduced in May-June (up to 27%). | No change. | Flows similar or increased except reduced in November and June (up to 10%). |
| San Luis Reservoir | Water surface elevations reduced in all months in wet to below normal water years and in February-September in dry and critical dry years (up to 16%).<br>Storage reduced in October-June in most water years (up to 71%). | No change. | Water surface elevations reduced in all months in wet to below normal water years and in February-September in dry and critical dry years (up to 16%).<br>Storage reduced in October-June in most water years (up to 71%). | Water surface elevations similar except reduced in January-February in above normal years (up to 6%) and February-August in critical dry years (up to 7%).<br>Storage similar or increased in some months except in December-February and June in wet years (up to 16%), October-July in above normal and below normal years (up to 40%), January-September in dry years (up to 19%), and October-August in critical dry years (up to 29%). | No change. | Water surface elevations reduced in all months in all year types (up to 70%).<br>Storage would be reduced in October-August in wet to below normal years (up to 17%), in January-September in dry years (up to 14%), and in all months in critical dry years (up to 14%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Flows into Yolo Bypass | Flows similar or increased except reduced in November-December in wet years (up to 15%), January-March in above normal years (14%), December-March in below normal years (up to 25%), and December in dry years (6%). | No change. | Flows similar or increased except reduced in November-December in wet years (up to 15%), January-March in above normal years (14%), December-March in below normal years (up to 25%), and December in dry years (6%). | Flows similar except reduced in October of wet years (6%). | No change. | Flows similar or increased except reduced in November-January in wet years (up to 15%), January-March in above normal years (15%), December-March in below normal years (up to 24%), and December in dry years (7%). |
| Delta Outflow | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,590 cfs). | No change. | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,590 cfs). | Flows would increase in many months.<br>Reduced flows in some months, including October and March-June in wet years (up to 1,127 cfs), and October and May-June in dry years (up to 373 cfs). | No change. | Flows similar or increased in many months.<br>Reduced flows in some months, including in December, February-March, and June in wet years (up to 1,713 cfs), and June in dry years (526 cfs). |
| Reverse Flows in Old and Middle Rivers | Increased positive flows except in June-August in most years and March in wet years. | No change. | Increased positive flows except in June-August in most years and March in wet years. | Increased negative flows in June-August in most years and March in wet years. | No change. | Increased negative flows in July-August in most years and March and June in wet years. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Water Supplies** | | | | | | |
| Non-CVP and Non-SWP Deliveries | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. | Deliveries similar. |
| North of Delta CVP Water Deliveries: Agricultural Water Contractors | Deliveries reduced up to 16% over the long-term to 34% in critical dry years. | No change. | Deliveries reduced up to 16% over the long-term to 34% in critical dry years. | Deliveries similar over the long-term. Reduced up to 9% in dry years to 11% in critical dry years. | No change. | Deliveries reduced up to 16% over the long-term to 31% in critical dry years. |
| North of Delta CVP Water Deliveries: Municipal and Industrial Water Contractors | Deliveries similar. | No change. | Deliveries similar. | Deliveries similar. | No change. | Deliveries similar. |
| South of Delta CVP Water Deliveries: Agricultural Water Contractors | Deliveries reduced up to 23% over the long-term to 33% in critical dry years. | No change. | Deliveries reduced up to 23% over the long-term to 33% in critical dry years. | Deliveries similar over the long-term. Reduced up to 8% in dry years to 14% in critical dry years. | No change. | Deliveries reduced up to 24% over the long-term to 33% in critical dry years. |
| South of Delta CVP Water Deliveries: Municipal and Industrial Water Contractors | Deliveries reduced up to 10% over the long-term to 5% in critical dry years. | No change. | Deliveries reduced up to 10% over the long-term to 5% in critical dry years. | Deliveries similar. | No change. | Deliveries reduced up to 10% over the long-term to 8% in critical dry years. |
| CVP Water Deliveries: Eastside Division Contractors | Deliveries reduced up to 19% in critical dry years. | No change. | Deliveries reduced up to 19% in critical dry years. | Deliveries similar. | No change. | Deliveries reduced up to 19% in critical dry years. |
| North of Delta: SWP Water Deliveries under Table A without Article 21 water | Deliveries reduced up to 13% over the long-term to 20% in critical dry years. | No change. | Deliveries reduced up to 13% over the long-term to 20% in critical dry years. | Deliveries similar over the long-term and in dry years. Reduced by 10% in critical dry years. | No change. | Deliveries reduced up to 19% over the long-term to 21% in critical dry years. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| North of Delta: SWP Water Deliveries under Table A without Article 21 water | Deliveries reduced up to 18% over the long-term to 22% in critical dry years. | No change. | Deliveries reduced up to 18% over the long-term to 22% in critical dry years. | Deliveries similar over the long-term and in dry years. Reduced by 11% in critical dry years. | No change. | Deliveries reduced up to 19% over the long-term to 23% in critical dry years. |
| **Surface Water Quality** | | | | | | |
| Salinity in Northern Delta (near Emmaton) | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). | No change. | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). | Salinity increased in June in wet to dry years (up to 35%).<br>Reduced in fall and winter months in wet and above normal years (up to 24%). | No change. | Salinity increased in June in wet to dry years (up to 21%).<br>Reduced in fall and winter months in wet and above normal years (up to 79%). |
| Salinity in Western Delta (near Port Chicago) | Salinity reduced in September-May (up to 49%). | No change. | Salinity reduced in September-May (up to 49%). | Salinity increased in June in wet to below normal years (up to 9%).<br>Reduced in January-March (up to 25%). | No change. | Salinity reduced in September-May (up to 49%). |
| Salinity in Western Central Delta (near Antioch) | Salinity increased in June in wet to below normal years (up to 16%).<br>Reduced in fall and winter months (up to 73%). | No change. | Salinity increased in June in wet to below normal years (up to 16%).<br>Reduced in fall and winter months (up to 73%). | Salinity increased in May in wet years and June in wet to dry years (up to 20%).<br>Reduced in January-April (up to 40%). | No change. | Salinity increased in June in wet to below normal years (up to 14%).<br>Reduced in fall and winter months (up to 73%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Salinity in Western Central Delta (near Contra Costa Water District Intakes) | Salinity increased in March-June (up to 47%).<br>Reduced in October-January and September (up to 42%). | No change. | Salinity increased in March-June (up to 47%).<br>Reduced in October-January and September (up to 42%). | Salinity increased in March-April in dry and critical dry years (up to 16%).<br>Reduced in December-February in dry and critical dry years (up to 23%). | No change. | Salinity increased in March-June (up to 63%).<br>Reduced in October-January and September (up to 41%). |
| Salinity in Southern Delta (near CVP and SWP intakes) | Salinity increased in February-June (up to 23%).<br>Reduced in October-January (up to 28%). | No change. | Salinity increased in February-June (up to 23%).<br>Reduced in October-January (up to 28%). | Salinity increased in February-May in dry and critical dry years (up to 23%). | No change. | Salinity increased in February-June (up to 26%).<br>Reduced in October-January (up to 28%). |
| Mercury in Delta Fish | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Mercury concentrations increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |
| Selenium in Delta and Delta Fish | Selenium concentrations similar concentrations. | No change. | Selenium concentrations similar concentrations. | Selenium concentrations similar concentrations. | No change. | Selenium concentrations similar concentrations. |
| **Groundwater Resources** | | | | | | |
| Trinity River Region | Similar groundwater conditions. | No change. | Similar groundwater conditions. | Similar groundwater conditions. | No change. | Similar groundwater conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Central Valley Region: Sacramento Valley | Similar groundwater conditions. | No change. | Similar groundwater conditions. | Similar groundwater conditions. | No change. | Similar groundwater conditions. |
| Central Valley Region: San Joaquin Valley | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | Similar groundwater pumping; and similar to lower groundwater elevations (2-25 feet).<br>Similar groundwater quality.<br>Similar subsidence potential. | No change. | Increased groundwater pumping (8%); and lower groundwater elevations (2-200 feet).<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. |
| San Francisco Bay Area, Central Coast, and Southern California Region | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. | No change. | Potentially increased groundwater pumping; and potentially lower groundwater elevations.<br>Potentially reduced groundwater quality.<br>Increased subsidence potential. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **CVP and SWP Energy Resources** | | | | | | |
| Energy Generated and Used by CVP and SWP Water Users | Similar CVP net generation. Increased net generation over the long-term (29%). Potentially increased energy use by CVP and SWP water users. | No change. | Similar CVP net generation. Increased net generation over the long-term (29%). Potentially increased energy use by CVP and SWP water users. | Similar CVP net generation. Increased net generation over the long-term (10%). Potentially increased energy use by CVP and SWP water users. | No change. | Similar CVP net generation. Increased net generation over the long-term (30%). Potentially increased energy use by CVP and SWP water users. |
| **Aquatic Resources** | | | | | | |
| Trinity River: Coho Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Spring-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Fall-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Steelhead | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Green Sturgeon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity Lake and Lewiston Reservoir: Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Pacific Lamprey | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Trinity River: Eulachon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River System: Winter-run Chinook Salmon | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. | No change. | Similar conditions. | Improved habitat conditions due to improved escapement potential and predator controls. | Similar conditions. | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. |
| Sacramento River System: Spring-run Chinook Salmon | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. | No change. | Similar conditions. | Improved habitat conditions due to harvest limitations and predator controls. | Similar conditions. | Improved habitat conditions due to fish passage at dams and other actions to address high water temperatures caused by climate change by 2030. |
| Sacramento River System: Fall-run Chinook Salmon | Similar conditions. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Similar conditions. |
| Sacramento River System: Late Fall-run Chinook Salmon | Improved habitat conditions due to measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Improved habitat conditions due to measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Sacramento River System: Steelhead | Improved habitat conditions due to fish passage programs to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Similar conditions. | Similar conditions. | Improved habitat conditions due to fish passage programs to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |
| Sacramento River System: Green Sturgeon and White Sturgeon | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030 that are not improved by other actions. | No change. | Similar conditions. | Improved habitat conditions due to lower water temperatures. | No change. | Reduced habitat conditions due to lack of measures to address high water temperatures caused by climate change by 2030 that are not improved by other actions. |
| Delta: Delta Smelt | Improved habitat conditions due to reduced potential for entrainment during larval and juvenile stages, and reduced salinity in the fall in the western Delta. | No change. | Similar conditions. | Similar conditions. | No change. | Improved habitat conditions due to reduced potential for entrainment during larval and juvenile stages, and reduced salinity in the fall in the western Delta. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Delta: Longfin Smelt | Improved habitat conditions due to more positive Old and Middle River flows and other factors (as indicated by higher Longfin Smelt abundance indices). | No change. | Similar conditions. | Similar conditions. | No change. | Improved habitat conditions due to more positive Old and Middle River flows and other factors (as indicated by higher Longfin Smelt abundance indices). |
| Delta: Sacramento Splittail | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Pacific Lamprey | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Sacramento River System: Striped Bass, American Shad, and Hardhead | Similar conditions for Hardhead.<br>Improved habitat conditions for Striped Bass and American Shad due to improved survival in larval and juvenile stages and reduced salinity in the spring in the western Delta. | No change. | Similar conditions. | Similar habitat conditions for Hardhead, Striped Bass, and American Shad.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | No change in habitat conditions for Hardhead, Striped Bass, and American Shad.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions for Hardhead.<br>Improved habitat conditions for Striped Bass and American Shad due to improved survival in larval and juvenile stages and reduced salinity in the spring in the western Delta. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River: Fall-run Chinook Salmon | Similar or improved conditions. | No change. | Similar conditions. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain. | Potential improved habitat conditions due to predator controls, trap and haul operations, and harvest restrictions; however, the effectiveness of these measures is uncertain. | Similar or improved conditions. |
| Stanislaus River: Steelhead | Improved habitat conditions due to measures to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. | No change. | Similar conditions. | Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain. | Potential improved habitat conditions due to predator controls and trap and haul operations; however, the effectiveness of these measures is uncertain. | Improved habitat conditions due to measures to address high water temperatures caused by climate change by 2030; and measures to increase efficiency of fish handling facilities at Banks and Jones pumping plants. |
| Stanislaus River: White Sturgeon | Conditions may be similar; however, improved conditions could occur due to lower water temperatures. | No change. | Similar conditions. | Similar conditions. | No change. | Conditions may be similar; however, improved conditions could occur due to lower water temperatures. |
| New Melones Reservoir; Reservoir Fish | Similar conditions. | No change. | Similar conditions. | Improved conditions for black bass nest survival. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Stanislaus River: Other Fish | Similar conditions. | No change. | Similar conditions. | Similar conditions for lamprey and Hardhead.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions for lamprey and Hardhead.<br>Adverse conditions for Striped Bass due to changes in harvest limitations. | Similar conditions. |
| Pacific Ocean: Killer Whale | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Terrestrial Resources** | | | | | | |
| Terrestrial Resources along Shoreline of CVP and SWP Reservoirs | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Terrestrial Resources along Rivers Downstream of CVP and SWP Reservoirs | Similar or improved conditions along Trinity, Sacramento, American, and Stanislaus rivers.<br>Reduced conditions along Feather River.<br>No mitigation measures identified at this time for changes along Feather River. | No change. | Similar or improved conditions along Trinity, Sacramento, American, and Stanislaus rivers.<br>Reduced conditions along Feather River.<br>No mitigation measures identified at this time for changes along Feather River. | Similar or improved conditions along Trinity, Sacramento, Feather, and American rivers.<br>Reduced conditions along Stanislaus River.<br>No mitigation measures identified at this time for changes along Stanislaus River. | No change. | Similar or improved conditions along Trinity, American, and Stanislaus rivers.<br>Reduced conditions along Feather and Sacramento rivers.<br>No mitigation measures identified at this time for changes along Feather and Sacramento rivers. |
| Terrestrial Resources in Yolo Bypass | Similar conditions in Yolo Bypass. | No change. | Similar conditions in Yolo Bypass. | Similar conditions in Yolo Bypass. | No change. | Similar or reduced conditions in Yolo Bypass. |
| Terrestrial Resources in Western Delta | Increased extent of freshwater habitat in western Delta. | No change. | Increased extent of freshwater habitat in western Delta. | Similar conditions. | No change. | Increased extent of freshwater habitat in western Delta. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Geology and Soils Resources** | | | | | | |
| Geology and Soils Resources | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Agricultural Resources** | | | | | | |
| Agricultural Production and Employment | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Land Use** | | | | | | |
| Municipal and Industrial Land Use | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Visual Resources** | | | | | | |
| Visual Resources of Land Irrigated with CVP and SWP Water | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Visual Resources at Reservoirs that Store CVP and SWP Water | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 9%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Recreation Resources** | | | | | | |
| Recreation Resources at Reservoirs that Store CVP and SWP Water | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 6%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, and New Melones Reservoir.<br>Similar conditions at San Luis Reservoir in above normal to dry years.<br>Reduced conditions at San Luis Reservoir in wet and critical dry years (up to 9%).<br>Potentially reduced conditions in the San Francisco Bay Area, Central Coast, and Southern California regions (up to 18%). |
| Recreation Resources in Rivers downstream of CVP and SWP Reservoirs | Similar or improved conditions; except reduced conditions in June and August along the Feather and American rivers, and in May along the Feather River and Sacramento River near Freeport. | No change. | Similar or improved conditions; except reduced conditions in June and August along the Feather and American rivers, and in May along the Feather River and Sacramento River near Freeport. | Similar or improved conditions along rivers.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing. | No change along rivers.<br>Reduced opportunities for Striped Bass and sport ocean salmon fishing. | Similar or improved conditions; except reduced conditions in May and June and August along the Sacramento and Feather rivers, in August along the American River; and in June-August along Stanislaus River. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Air Quality and Greenhouse Gas Emissions** | | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. | Similar conditions. | No change. | Similar air quality conditions in the Trinity River Region and Sacramento Valley.<br>Potential increase in emissions (up to 18%) in the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions. |
| Increased Greenhouse Gas Emissions due to Changes in Energy Resources Related to CVP and SWP Water Use | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could be reduced in the San Francisco Bay Area, Central Coast, and Southern California regions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Cultural Resources** | | | | | | |
| Potential for Disturbance of Cultural Resources | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| **Public Health** | | | | | | |
| Water Supply Availability for Wildland Firefighting | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (6%). | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (6%). | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir (9%). |
| Potential Exposure to Mercury in Fish in Delta | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |
| **Socioeconomics** | | | | | | |
| Agricultural and Municipal and Industrial Employment | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |
| Municipal and Industrial Water Supply Operating Expenses | Similar conditions. | No change. | Similar conditions. | Similar conditions. | No change. | Similar conditions. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| Recreational Economics CVP and SWP Reservoirs | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. | Similar conditions. | No change. | Similar conditions at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Reduced potential at San Luis Reservoir and reservoirs that store CVP and SWP water in San Francisco Bay Area, Central Coast, and Southern California regions. |
| Recreational Economics Related to Striped Bass Fishing in Delta | Similar conditions. | No change. | Similar conditions. | Reduced recreational opportunities and associated economics. | Reduced recreational opportunities and associated economics. | Similar conditions. |
| Commercial and Sport Ocean Salmon Fishing | Similar conditions. | No change. | Similar conditions. | Reduced commercial and sport ocean salmon fishing and associated economics. | Reduced commercial and sport ocean salmon fishing and associated economics. | Similar conditions. |
| **Indian Trust Assets** | | | | | | |
| Potential for Disturbance of Indian Trust Assets | No change. | No change. | No change. | No change. | No change. | No change. |

| | No Action Alternative Compared to Second Basis of Comparison | Alternative 1 Compared to the Second Basis of Comparison | Alternative 2 Compared to the Second Basis of Comparison | Alternative 3 Compared to the Second Basis of Comparison | Alternative 4 Compared to the Second Basis of Comparison | Alternative 5 Compared to the Second Basis of Comparison |
|---|---|---|---|---|---|---|
| **Environmental Justice** | | | | | | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | Potential increase in emissions (up to 18%). | No change. | Potential increase in emissions (up to 18%). | Similar conditions. | No change. | Potential increase in emissions (up to 18%). |
| Potential Exposure to Mercury in Fish in Delta | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). | Similar conditions. | No change. | Increased near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough (up to 7%). |

## 3.7 References

Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan, Final, 2013 Update*.

AVEK (Antelope Valley-East Kern Water Agency). 2011b. *Water Supply Stabilization Project No. 2 Implementation Grant Proposal*. AVRWC (Apple Valley Ranchos Water Company). 2011. *2010 Urban Water Management Plan*. June 23.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html

BCDC (Bay Conservation and Development Commission). 2011. *Draft Staff Report, Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline, As Revised Through September 23, 2011*. September 23.

BWGWD (Biggs-West Gridley Water District). 2015. *Gray Lodge Water Supply Project*. Site accessed November 1, 2015. http://www.bwgwater.com/news-information/gray-lodge-water-supply-project

Carlsbad MWD (Carlsbad Metropolitan Water District). 2012. *Approval of a Mitigated Negative Declaration for Carlsbad Municipal Water District Phase III Recycled Water Project, Draft Initial Study/Mitigated Negative Declaration*. November 27.

CBMWD (Central Basin Municipal Water District). 2011. *Draft, 2010 Urban Water Management Plan*. March.

CBMWD (Central Basin Municipal Water District). 2011. *Initial Study, Central Basin Groundwater Storage Plan: A Blueprint for Future Reliability*. February.

CCSD (Cambria Community Services District). 2014. *Cambria Emergency Water Supply Project*. June.

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

CDFW (California Department of Fish and Wildlife Service). 2015. *CDFW Completes Drought Related Restoration Project at Lindsey Slough, Solano County*. Site accessed June 1, 2015. https://cdfgnews.wordpress.com/2014/12/19/cdfw-completes-drought-related-restoration-project-at-lindsey-slough-solano-county/

CDFW and DWR (California Department of Fish and Wildlife Service and California Department of Water Resources). 2013. *DRERIP Evaluation* *for Prospect Island Restoration Design Alternatives, Summary of a two-day workshop held at UC Davis, October 24-25, 2012*. February.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://www.lbwater.org/overview-long-beach-seawater-desalination-project

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

City of Los Angeles (Los Angeles Department of Water and Power). 2011. *Urban Water Management Plan, 2010*. May 3.

City of Los Angeles. 2013a. *Tujunga Spreading Grounds Enhancement Project, Final Environmental Impact Report*. April.

City of Los Angeles (Los Angeles Department of Water and Power). 2013b. *Initial Study, Los Angeles Groundwater Replenishment Project*. September.

City of Oxnard. 2013. *GREAT Program Update, City Council Report, December 10, 2013, Draft*. November 22.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2009a. *Mission Valley Basin*. September 11.

City of San Diego. 2009a. *San Pasqual Basin*. September 11.

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp

City of Stockton. 2005. *Draft – Volume I, Stockton Delta Water Supply Project, Program Environmental Impact Report*. April.

CNRA (California Natural Resources Agency). 2015a. *California EcoRestore, A Stronger Delta Ecosystem*. Site accessed November 1, 2015. http://resources.ca.gov/ecorestore.

CNRA (California Natural Resources Agency). 2015b. *Restoring the Sacramento-San Joaquin Delta Ecosystem*. April.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2011. *Irrigated Lands Regulatory Program, Program Environmental Impact Report*. March.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2015. *CV-SALTS, Central Valley Salinity Alternatives for Long-Term Sustainability*. Site accessed April 29, 2015. http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html

DSC (Delta Stewardship Council). 2011. *Draft Delta Plan Program Environmental Impact Report*. November.

DWR (California Department of Water Resources). 2007. *Value Engineering Study, Franks Tract Pilot Project, Final Report*. June.

DWR (California Department of Water Resources). 2010a. *Final Report, Stockton Deep Water Ship Channel, Demonstration Dissolved Oxygen Aeration Facility Project*. December.

DWR (California Department of Water Resources). 2010b. *Final Environmental Impact Report, North Delta Flood Control and Ecosystem Restoration Project*. October.

DWR (California Department of Water Resources). 2011a. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

DWR (Department of Water Resources). 2011b. Effects of U.S. Army Corps of Engineers' Policy on Levee Vegetation in California. Accessed September 26, 2011. water.ca.gov/floodsafe/leveeveg/.

DWR (California Department of Water Resources). 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper), Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR and SWRCB (California Department of Water Resources and State Water Resources Control Board). 2014. *2012/2013 Transfer Activity*. January 28.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

EBMUD (East Bay Municipal Utility District). 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

EDWPA (El Dorado Water and Power Authority). 2010. *Supplemental Water Rights Project, Acquisition of 40,000 Acre-Feet Per Year of New Consumptive Water Draft Environmental Impact Report*. July 15.

EMWD (Eastern Municipal Water District). 2014a. *Administrative Draft, Mitigated Negative Declaration, Temecula Valley Regional Water Reclamation Facility, 23 MGD Expansion*. January.

EMWD (Eastern Municipal Water District). 2014b. *San Jacinto Regional Water Reclamation Facility*. March.

EMWD (Eastern Municipal Water District). 2014c. *Indirect Potable Reuse Program*. January 8.

EMWD (Eastern Municipal Water District). 2014c. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

FERC (Federal Energy Regulatory Commission). 2007. *Final Environmental Impact Statement for Hydropower License, Oroville Facilities, FERC Project No. 2100-052*, California.

FERC (Federal Energy Regulatory Commission). 2012. *Draft Environmental Impact Statement for Hydropower License, Middle Fork American River Hydroelectric Project – FERC Project No. 2079-069*. July.

FERC (Federal Energy Regulatory Commission). 2013. *Draft Environmental Impact Statement for for the Drum-Spaulding Hydroelectric Project (Project No. 2310-193) and Yuba-Bear Hydroelectric Project (Project No. 2266-102)*. May.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

FID (Fresno Irrigation District). 2015. *FID Pond Measurement – State of California DWR LGA Grant*. Site accessed February 13, 2015. http://www.fresnoirrigation.com/index.php?c=36

IEUA (Inland Empire Utilities Agency). 2014. *Inland Empire Utilities Agency, 2013/14 Recycled Water Annual Report*.

IEUA (Inland Empire Utilities Agency). 2015. *Draft Fiscal Year 2015/16 Ten-Year Capital Improvement Plan*. January

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

KEYT (KEYT News). 2015. *Santa Barbara Desalination Plant Permit Approved*. Site accessed February 19, 2015.

http://www.keyt.com/news/santa-barbara-desal-plant-permit-approved/31055434

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP)*.

LACSD (Los Angeles County Sanitation District). 2005. *Final Palmdale Water Reclamation Plant 2025 Plan and Environmental Impact Report*. September.

Los Angeles County (County of Los Angeles). 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

Merced ID (Merced Irrigation District). 2015. *The Public Website for Relicensing of Merced Irrigation District's Merced River Hydroelectric Project, FERC Project No. 2179*. Site accessed January 13, 2015. http://www.eurekasw.com/mid/default.aspx?Paged=Next&p_StartTimeUTC=20131129T1

MID/TID (Modesto Irrigation District and Turlock Irrigation District). 2015. *Don Pedro Project Relicensing*. Site accessed January 13, 2015. http://www.donpedro-relicensing.com/default.aspx

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

NMFS (National Marine Fisheries Service). 2013. *Biological Opinion, Dutch Slough Tidal Marsh Restoration Project*. February 7.

NRC (National Research Council of the National Academies). 2012. *Sustainable Water and Environmental Management in the California Bay-Delta*. Washington D.C.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2011. *Eastern San Joaquin Basin Integrated Conjunctive Use Program Programmatic Environmental Impact Report*. February.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

RCWD (Rancho California Water District). 2012. *Agricultural Water Management Plan*. December 13.

RD 2093 (Reclamation District 2093). 2011. *Northern Liberty Island Fish Conservation Bank, Final Initial Study/Mitigated Negative Declaration, SCH#2010122078*. February 2011.

Reclamation (Bureau of Reclamation). 2004a. *Implementation of the Central Valley Project Improvement Act, 10 Years of Progress, Fiscal Years 1993-2002*. May.

Reclamation (Bureau of Reclamation). 2004b. *Sacramento River Water Reliability Study*. March 16.

Reclamation (Bureau of Reclamation). 2009. *Record of Decision, Grasslands Bypass Project, 2010-2019*. December.

Reclamation (Bureau of Reclamation). 2010. *Draft Environmental Assessment, Antelope Valley Water Bank Initial Recharge and Recovery Facilities Improvement Project*. January.

Reclamation (Bureau of Reclamation). 2011a. *Draft CVPIA Fiscal Year 2012 Annual Work Plan, Clear Creek Restoration – CVPIA Section 3406(b)(12)*. December 9.

Reclamation (Bureau of Reclamation). 2011b. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

Reclamation (Bureau of Reclamation). 2011c. *Finding of No New Significant Impact, 2011 CVPIA Gravel Replenishment Program, Stanislaus River at River Mile 58*. August.

Reclamation (Bureau of Reclamation). 2012. *Record of Decision San Joaquin River Restoration Program*. September 28.

Reclamation (Bureau of Reclamation). 2013a. *Clear Creek Restoration Program, Public Meeting*.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2013c. *2013 CVPIA Draft Annual Work Plans – Introduction*.

Reclamation (Bureau of Reclamation). 2013d. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2014a. *Record of Decision, Suisun Marsh Habitat Restoration, Preservation, and Management Plan*. April 21.

Reclamation (Bureau of Reclamation). 2014b. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014c. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation (Bureau of Reclamation). 2014d. *Santa Clara Valley Water District California Aqueduct Reverse Flow Project*. October.

Reclamation (Bureau of Reclamation). 2014e. *Lower American River Salmonid Spawning Gravel Augmentation and Side-Channel Habitat Establishment Program – 2014 Nimbus Project, Finding of No Significant Impact*. August.

Reclamation (Bureau of Reclamation). 2014f. *Contra Loma Reservoir and Recreation Area Final Resource Management Plan and Final Environmental Impact Statement.*

Reclamation (Bureau of Reclamation). 2014g. *Shasta Lake Water Resources Investigation Final Environmental Impact Statement*. December.

Reclamation (Bureau of Reclamation). 2015. *Westlands v. United States Settlement*. October.

Reclamation et al. (Bureau of Reclamation, Santa Clara Valley Water District, San Luis and Delta-Mendota Water Authority). 2011. *San Luis Low Point Improvement Project, Plan Formulation Report*. January.

Reclamation and CDPR (Bureau of Reclamation and California Department of Parks and Recreation). 2013. *San Luis Reservoir State Recreation Area Final Resource Management Plan/General Plan, Final Environmental Impact Statement/Environmental Impact Report.* June.

Reclamation and SLDMWA (Bureau of Reclamation and San Luis & Delta-Mendota Water Authority). 2015. *Long-term Water Transfers Environmental Impact Statement/Environmental Impact Report, Final*. March.

Reclamation and USFWS (Bureau of Reclamation and U.S. Fish and Wildlife Service). 2012. *Spawning and Rearing Habitat Restoration (gravel), CVPIA 3406b(13).*

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

SBCWD (San Benito County Water District). 2014. *West Hills Water Treatment Plant Project, Draft Environmental Impact Report*. January.

SCVWD (Santa Clara Valley Water District). 2012. *2012 Water Supply and Infrastructure Master Plan*. October.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

SDCWA (San Diego County Water Authority). 2014. *Fact Sheet, The Carlsbad Desalination Project*.

SDCWA (San Diego County Water Authority). 2015. *Seawater Desalination*. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

SFCWA (State and Federal Contractors Water Agency). 2011. Two Years Old: Walking and Talking – Poised to Run? Urban Water Institute: August 25, 2011. August 25, 2011.

SFCWA (State and Federal Contractors Water Agency). 2013. *Lower Yolo Restoration Project, Draft Environmental Impact Report*. April 2013.

SFEI (San Francisco Estuary Institute). 2013. *Grasslands Bypass Project, Prepared by San Francisco Estuary Institute, U.S. Bureau of Reclamation, U.S. Environmental Protection Agency, U.S. Fish and Wildlife, U.S. Geological Survey, Central Valley Regional Water Quality Control Board, California Department of Fish and Game, San Luis & Delta-Mendota Water Authority, Annual Report 2010-2011*. November.

SFRRWQCB (San Francisco Bay Region Regional Water Quality Control Board). 2015. *Staff Summary Report, Fairfield-Suisun Sewer District, Fairfield-Suisun Wastewater Treatment Plant and Wastewater Collection System, Fairfield, Solano County – Reissuance of NPDES Permit*. March 11.

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011. *Friant-Kern Canal Capacity Restoration, Draft*. June.

SJRRP (San Joaquin River Restoration Program). 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://restoresjr.net/activities/site_specific/madera-canal/index.html

SRCSD (Sacramento Regional County Sanitation District). 2012. *Notice of Preparation*. May 7.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2012. *Public Draft, Substitute Environmental Document in Support of Potential Changes to the Water*

*Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality*. December.

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

TID and MID (Turlock Irrigation District and Modesto Irrigation District). 2014. *Don Pedro Hydroelectric Project, FERC No. 2299, Final License Application, Exhibit E – Environmental Report*. April.

TRRP (Trinity River Restoration Program, including Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service, Hoopa Valley Tribe, Yurok Tribe, California Department of Water Resources, California Department of Fish and Wildlife, and Trinity County). 2012. *Trinity River Restoration Program 2011 Annual Report*. May.

TRRP (Trinity River Restoration Program, including Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service, Hoopa Valley Tribe, Yurok Tribe, California Department of Water Resources, California Department of Fish and Wildlife, and Trinity County). 2014. *Typical Releases*. Site accessed September 4, 2014 http://www.trrp.net/restore/flows/typical/.

USACE (U.S. Army Corps of Engineers). 2009. *ETL 1110-2-571 Guidelines For Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*. April 10.

USACE (U.S. Army Corps of Engineers). 2010. *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls--75 Fed. Reg. 6364-68*. February 9.

USACE et al. (U.S. Army Corps of Engineers, Bureau of Reclamation, Sacramento Area Flood Control Agency, and California Central Valley Flood Protection Board). 2012. Folsom Dam Modification Project Approach Channel, *Final Supplemental Environmental Impact Statement/ Environmental Impact Report*. December.

USEPA (U.S. Environmental Protection Agency). 2008. *Five-Year Review Report, Fourth Five-Year Review Report for Iron Mountain Mine Superfund Site, Redding, California*. July.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

USFWS (U.S. Fish and Wildlife Service). 2009. *Finding of No Significant Impact for the Lower Mokelumne River Spawning Habitat Improvement Project*. September 3.

USFWS (U.S. Fish and Wildlife Service). 2010. *Notice of Availability of Federal Assistance 2010 Request for Proposals, Mill Creek.*

VVWRA (Victor Valley Wastewater Reclamation Authority). 2015. *Apple Valley Subregional Water Recycling Plant*. Site accessed January 25, 2015. http://vvwra.com/index.aspx?page=122

WBMWD (Western Basin Municipal Water District). 2011. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

WBMWD (West Basin Municipal Water District). 2015a. *Water Recycling Satellite Facilities*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/recycled-water/satellite-facilities

WBMWD (West Basin Municipal Water District). 2015b. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview

WDCWA (Woodland-Davis Clean Water Agency). 2013. *The Project*. Site accessed February 5, 2013. http://www.wdcwa.com/the_project

WMWD (Western Municipal Water District). 2015. *Arlington Desalter*. Site accessed January 19, 2015. http://wmwd.com/index.aspx?nid=301&PREVIEW=YES

WRD (Water Replenishment District). 2012. *Notice of Intent to Adopt a Negative Declaration for Leo J. Vanders Lans Water Treatment Facility Expansion Project, Revised March 9, 2012*. March 9.

WRD (Water Replenishment District). 2015. *Recirculated Draft Environmental Impact Report, Groundwater Reliability Improvement Program (GRIP), Recycled Water Project*. April.

WSRCD (Western Shasta Resource Conservation District). 2011. *Lower Clear Creek Aquatic Habitat and Waste Discharge Improvement Project*.

YNHP (Yolo County Natural Heritage Program). 2015. *Yolo Natural Heritage Plan*. Site accessed June 3, 2015. http://www.yoloconservationplan.org/

This page left blank intentionally.

**Chapter 4**

# Approach to Environmental Analysis

This chapter describes the organization of the remaining chapters in the Environmental Impact Statement (EIS). It also defines the scope, extent, and framework of the environmental analysis, including a description of resources areas evaluated and not evaluated.

The resource chapters in this EIS (Chapters 5 through 21) describe the affected environment and the impact analysis for each resource associated with implementation of the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5. Potential mitigation measures (if necessary and available) to avoid, reduce, or otherwise minimize potential adverse impacts to the environment due to implementation of Alternatives 1 through 5 as compared to conditions under the No Action Alternative are discussed within each resource section. Potential cumulative effects that would occur with implementation of the alternatives are described in each resource chapter.

## 4.1 Basis of the Environmental Analysis

The impact analysis is focused on the coordinated long-term operation of the Central Valley Project (CVP) and the State Water Project (SWP). This EIS addresses conditions that would result from the long-term operation of Alternatives 1 through 5 as compared to the long-term conditions that would occur under the No Action Alternative and the Second Basis of Comparison in the Year 2030. This EIS does not address interim changes that would occur between now and 2030.

This EIS does not address the impacts that could occur between now and 2030 due to the construction of projects that are assumed to be implemented under the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5. As described in Chapter 3, Description of Alternatives, there are several ongoing projects that are assumed to be implemented in 2030, including facilities that require construction. The 2030 conditions assume the projected long-term conditions for each ongoing project as described in their respective environmental documents. This EIS does not address the construction activities of each ongoing project because those impacts are addressed in separate environmental documents for each project.

Implementation of the No Action Alternative and Alternatives 1, 3, 4, and 5 also could result in construction of facilities (e.g., fish passage facilities around dams or across the Delta under these alternatives). Because, at this time, it is not known if construction will be required to implement these provisions or the nature of future facilities, this EIS does not address the construction activities of the future facilities. Impacts of future facilities will be addressed in separate environmental documents for each project. It is assumed that the provisions in the alternatives, including construction activities, would be implemented in 2030.

## 4.2 Resources Considered for Environmental Analysis

The resources and issues included in Chapters 5 through 22 were identified through a review of scoping comments and subsequent comments received from agencies and the public during preparation of this EIS, as described in Chapter 3, Description of Alternatives. The resources and issues are described and analyzed in the following chapters of this EIS.

- Chapter 5 – Surface Water Resources and Water Supplies
- Chapter 6 – Surface Water Quality
- Chapter 7 – Groundwater Resources and Groundwater Quality
- Chapter 8 – Energy
- Chapter 9 – Fish and Aquatic Resources
- Chapter 10 – Terrestrial Biological Resources
- Chapter 11 – Geology and Soils Resources
- Chapter 12 – Agricultural Resources
- Chapter 13 – Land Use
- Chapter 14 – Visual Resources
- Chapter 15 – Recreation Resources
- Chapter 16 – Air Quality and Greenhouse Gas Emissions
- Chapter 17 – Cultural Resources
- Chapter 18 – Public Health
- Chapter 19 – Socioeconomics
- Chapter 20 – Indian Trust Assets
- Chapter 21 – Environmental Justice
- Chapter 22 – Other National Environmental Policy Act (NEPA) Considerations
- Chapter 23 – Consultation and Coordination
- Chapter 24 – Distribution of Draft EIS
- Chapter 25 – List of Preparers
- Chapter 26 – Index

As described above, this EIS only addresses long-term operational impacts. It is assumed that the coordinated long-term operation of the CVP and SWP would not result in substantial impacts to transportation, noise, hazards and hazardous materials, infrastructure related to public services and utilities, and paleontological resources because there would not be ongoing construction activities and the operation and maintenance activities would be similar to conditions under the No Action Alternative or the Second Basis of Comparison.

Scoping comments were received related to potential impacts to transportation on highways and airports due to dust generated from noncultivated agricultural lands. The potential for changes in dust generation is addressed in Chapter 16, Air Quality and Greenhouse Gas Emissions; based upon the impact assessment, it does not appear that the amount of noncultivated land would change substantially between the alternatives and result in substantial change in dust generation.

It is recognized that the ability to fund some public services and utilities could be affected through implementation of the alternatives evaluated in this EIS. These potential changes related to water supply costs are addressed in Chapter 19, Socioeconomics.

Chapter 23 includes a discussion of comments received during scoping and meetings that were held throughout preparation of the EIS with stakeholders. Chapter 24 includes a list of recipients of this Draft EIS. Chapter 25 includes a list of preparers of this Draft EIS.

## 4.3 Methodology for the Environmental Analysis

This EIS assesses the potential impacts of changes that could result on the resources identified above from implementation of each of the alternatives as compared to the No Action Alternative and the Second Basis of Comparison. The impact analysis includes an evaluation of potential direct, indirect, and cumulative effects by resource.

### 4.3.1 Geographic Range of Analysis

The project area that could be affected varies by resource. As described in Chapter 1, Introduction, the project area includes most of the CVP facilities and CVP service areas, and all of the SWP facilities and the SWP service areas. For the analysis purposes, the project area was divided into five regions, as shown in Figure 4.1 at the end of this chapter. The geographic extent for each resource is described by applicable regions in Chapters 5 through 21. The geographic range of the project area encompasses 35 counties. The locations of CVP and SWP water supply facilities, locations of CVP and SWP water users, and areas potentially affected by the long-term coordinated operation of the CVP and SWP, are summarized in Table 4.1.

**Table 4.1 Geographic Range of the EIS Analysis**

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Trinity River | Trinity | CVP Facilities: Trinity Lake, and Lewiston and Whiskeytown reservoirs<br>Trinity River downstream of Lewiston Dam |
| | Humboldt | Trinity River to confluence of lower Klamath River<br>Lower Klamath River from Trinity County border to Del Norte County border |
| | Del Norte | Lower Klamath River from Humboldt County border to Pacific Ocean |
| Central Valley | Shasta | CVP Facilities: Shasta Lake and Keswick Reservoir<br>Sacramento River downstream of Keswick Dam to Tehama County border |
| | | CVP Water Users:<br>Anderson-Cottonwood Irrigation District<br>Bella Vista Water District<br>Centerville Community Services District<br>City of Redding<br>City of Shasta Lake<br>Clear Creek Community Services District<br>Mountain Gate Community Services District<br>Redding Rancheria Tribe<br>Shasta Community Services District<br>Shasta County Service Area No. 25<br>Shasta County Water Agency<br>U.S. Forest Service<br>Multiple Contracts with Individuals and Businesses |
| | Plumas | SWP Facilities: Antelope Lake, Lake Davis, and Frenchman Lake |
| | | SWP Water Users: Plumas County Flood Control and Water Conservation District |
| | Tehama | CVP Facilities: Portion of the Tehama Colusa Canal and Corning Canal<br>Sacramento River within Tehama County |
| | | CVP Water Users:<br>Corning Water District<br>Kirkwood Water District<br>Thomes Creek Water District<br>Proberta Water District<br>Lake California Property Owners Association<br>Multiple Contracts with Individuals and Businesses |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Valley (continued) | Glenn | CVP Facilities: Portion of the Tehama Colusa Canal<br>Sacramento River within Glenn County |
| | | CVP Water Users:<br>4-E Water District<br>Elk Creek Community Services District<br>Glenn-Colusa Irrigation District<br>Glide Water District<br>Kanawha Water District<br>Orland-Artois Water District<br>Provident Irrigation District<br>Stony Creek Water District<br>U.S. Forest Service<br>Portion of Sacramento National Wildlife Refuge |
| | Colusa | CVP Facilities: Portion of the Tehama Colusa Canal<br>Sacramento River within Colusa County |
| | | CVP Water Users:<br>4-M Water District<br>Cachil Dehe Band of Wintu Indians of the Colusa Indian Community<br>Carter Mutual Water Company<br>Colusa County Water District<br>Colusa Drain Mutual Water Company<br>Cortina Water District<br>County of Colusa<br>County of Colusa (Stonyford)<br>Davis Water District<br>Glenn Valley Water District<br>Holthouse Water District<br>La Grande Water District<br>Maxwell Irrigation District<br>Myers-Marsh Mutual Water Company<br>Princeton-Codora-Glenn Irrigation District<br>Reclamation District No. 1004<br>Reclamation District No. 108<br>Roberts Ditch Irrigation Company<br>Sartain Mutual Water Company<br>Westside Water District<br>Colusa National Wildlife Refuge<br>Delevan National Wildlife Refuge<br>Portion of Sacramento National Wildlife Refuge<br>Multiple Contracts with Individuals and Businesses |
| | Butte | SWP Facilities: Lake Oroville and Thermalito Reservoir<br>Sacramento River within Butte County |
| | | CVP Water User:<br>Gray Lodge Wildlife Area |
| | | SWP Water User:<br>Butte County Water and Resources Conservation District |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Valley (continued) | Sutter | Sacramento River within Sutter County |
| | | CVP Water Users:<br>Feather Water District<br>Meridian Farms Water Company<br>Natomas Basin Conservancy<br>Pleasant Grove Verona Mutual Water Company<br>Sutter Mutual Water Company<br>Tisdale Irrigation and Drainage Company<br>Sutter National Wildlife Refuge |
| | | SWP Water Users:<br>City of Yuba City |
| | Yuba | Sacramento River within Yuba County |
| | | Water Supplies from Yuba County Water Agency are available to CVP and SWP |
| | Nevada | Water Supplies from Nevada County flow in the Bear River into CVP facilities on the American River |
| | Placer | CVP Water Facilities: Portion of Folsom Lake |
| | | CVP Water Users:<br>Placer County Water Agency<br>City of Roseville<br>San Juan Water District |
| | El Dorado | CVP Water Facilities: Portion of Folsom Lake |
| | | CVP Water Users:<br>El Dorado Irrigation District<br>El Dorado County Water Agency |
| | Sacramento | CVP Water Facilities: Portion of Folsom Lake, Lake Natoma, and Folsom South Canal<br>American River downstream of Nimbus Dam to confluence with Sacramento River<br>Sacramento River and Delta within Sacramento County |
| | | CVP Water Users:<br>City of Folsom<br>City of Sacramento<br>Natomas Central Mutual Water Company<br>Reclamation District No. 1000<br>Regional Water Authority<br>Sacramento County<br>Sacramento County Water Agency<br>Sacramento Municipal Utility District<br>Sacramento Suburban Water District<br>San Juan Water District<br>Natomas Basin Conservancy |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Valley (continued) | Yolo | CVP Facilities: Portion of the Tehama Colusa Canal<br>Sacramento River and Delta within Yolo County<br>Yolo Bypass |
| | | CVP Water Users:<br>City of West Sacramento<br>Conaway Preservation Group<br>Dunnigan Water District<br>Eastside Mutual Water Company<br>Pelger Mutual Water Company<br>Reclamation District No. 900<br>Multiple Contracts with Individuals and Businesses |
| | Solano<br>(included in San Francisco Bay Area Region in some chapters) | SWP Facilities: Portion of the North Bay Aqueduct<br>Sacramento River and Delta within Solano County<br>Yolo Bypass |
| | | SWP Water Users:<br>Solano County Water Agency |
| | Stanislaus | CVP Facilities: New Melones Reservoir and portion of the Delta Mendota Canal<br>Stanislaus River downstream of New Melones Dam to confluence with San Joaquin River<br>San Joaquin River within Stanislaus County |
| | | SWP Facilities: Portion of the California Aqueduct |
| | | CVP Water Users:<br>Del Puerto Water District<br>Oakdale Irrigation District<br>Patterson Irrigation District<br>West Stanislaus Irrigation District<br>Portion of San Luis National Wildlife Refuge |
| | | SWP Water Users:<br>Oak Flat Water District |
| | Merced | CVP Facilities: San Luis and O'Neill reservoirs, portions of Delta-Mendota Canal and San Luis Canal<br>San Joaquin River within Merced County |
| | | SWP Facilities: San Luis and O'Neill reservoirs and portion of California Aqueduct |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Valley (continued) | Merced (continued) | CVP Water Users:<br>Centinella Water District<br>Central California Irrigation District<br>City of Dos Palos<br>Del Puerto Water District<br>Eagle Field Water District<br>Grasslands Water District<br>Laguna Water District<br>Oro Loma Water District<br>San Luis Canal Company<br>San Luis Water District<br>Turner Island Water District<br>U.S. Department of Veterans Affairs, San Joaquin Valley National Cemetery<br>Widren Water District<br>Merced National Wildlife Refuge<br>Portion of San Luis National Wildlife Refuge<br>Kesterson National Wildlife Refuge<br>Los Banos and Volta Wildlife Areas, Grasslands Resources Conservation District |
| | Madera | CVP Facilities: Madera Canal |
| | San Joaquin | San Joaquin River and Delta within San Joaquin County |
| | | CVP Water Users:<br>Banta-Carbona Irrigation District<br>Byron-Bethany Irrigation District<br>Central San Joaquin Water Conservation District<br>City of Tracy<br>Del Puerto Water District<br>South San Joaquin Irrigation District<br>Stockton-East Water District<br>The West Side Irrigation District<br>West Stanislaus Irrigation District |
| | Fresno | CVP Facilities: Portions of Delta-Mendota Canal and San Luis Canal, Friant Dam and Millerton Lake<br>San Joaquin River within Fresno County |

| Region | County | Reasons for Inclusion of County in Project Area |
| --- | --- | --- |
| Central Valley (continued) | Fresno (continued) | CVP Water Users:<br>Broadview Water District<br>California Department of Fish and Wildlife<br>Central California Irrigation District<br>City of Avenal<br>City of Coalinga<br>City of Huron<br>Coelho Family Trust<br>Columbia Canal Company<br>County of Fresno<br>Eagle Field Water District<br>Firebaugh Canal Company<br>Fresno Slough Water District<br>Hills Valley Irrigation District<br>James Irrigation District<br>Laguna Irrigation District<br>Mercy Springs Water District<br>Meyers Farm<br>Pacheco Water District<br>Panoche Water District<br>Pleasant Valley Water District<br>Reclamation District No. 1606<br>San Luis Water District<br>Tranquility Irrigation District<br>Tranquility Public Utility District<br>Tri-Valley Water District<br>Westlands Water District<br>Widren Water District |
| | | SWP Water Users:<br>Dudley Ridge Water District |
| | Kings | SWP Facilities: Portion of the California Aqueduct |
| | | CVP Water Users:<br>Angiola Water District<br>Atwell Island<br>City of Avenal |
| | | SWP Water Users:<br>County of Kings<br>Empire West Side Irrigation District<br>Tulare Lake Basin Water Storage District |
| | Tulare | CVP Water Users:<br>County of Tulare<br>Tranquility Public Utility District<br>Pixley National Wildlife Refuge |
| | Kern | CVP Facilities: Cross Valley Canal and portion of the California Aqueduct |
| | | SWP Facilities: Portion of the California Aqueduct |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Valley (continued) | Kern (continued) | CVP Water Users:<br>Kern National Wildlife Refuge<br>Kern Tulare Water District<br>Pixley Irrigation District |
| | | SWP Water Users:<br>Kern County Water Agency |
| San Francisco Bay Area | Alameda | CVP Facilities: Jones Pumping Plant and northern reaches of Delta-Mendota Canal |
| | | SWP Facilities: Banks Pumping Plant, Bethany Reservoir, Lake Del Valle, and portions of the South Bay Aqueduct and California Aqueduct |
| | | CVP Water Users:<br>East Bay Municipal Utility District |
| | | SWP Water Users:<br>Alameda County Water District<br>Zone 7 Water Agency |
| | Contra Costa | CVP Facilities: Contra Costa Pumping Plant, Contra Loma Reservoir, and Contra Costa Canal<br>Delta within Contra Costa County |
| | | SWP Facilities: Clifton Court Forebay |
| | | CVP Water Users:<br>Byron-Bethany Irrigation District<br>Contra Costa Water District |
| | Santa Clara | CVP Facilities: Santa Clara Conduit |
| | | SWP Facilities: Portion of the South Bay Aqueduct |
| | | CVP and SWP Water Users:<br>Santa Clara Valley Water District |
| | San Benito | CVP Water Facilities: Pacheco Conduit, San Justo Reservoir, and Hollister Conduit |
| | | CVP Water Users:<br>San Benito County Water District |
| | Napa | SWP Facilities: Portion of the North Bay Aqueduct |
| | | SWP Water Users:<br>County of Napa |
| Central Coast | San Luis Obispo | SWP Facilities: Portion of Coastal Branch Aqueduct |
| | | SWP Water Users:<br>Central Coast Water Authority<br>San Luis Obispo County Flood Control and Water Conservation District |

| Region | County | Reasons for Inclusion of County in Project Area |
|---|---|---|
| Central Coast (continued) | Santa Barbara | SWP Facilities: Portion of Coastal Branch Aqueduct |
| | | SWP Water Users:<br>Central Coast Water Authority<br>Santa Barbara County Flood Control and Water Conservation District |
| Southern California | Ventura | SWP Water Users:<br>Ventura County Watershed Protection District |
| | Los Angeles | SWP Facilities: Portion of California Aqueduct |
| | | SWP Water Users:<br>Antelope Valley-East Kern Water Agency<br>Castaic Lake Water Agency<br>Littlerock Creek Irrigation District<br>Metropolitan Water District of Southern California<br>Palmdale Water District<br>San Gabriel Valley Municipal Water District |
| | Orange | SWP Water Users:<br>Metropolitan Water District of Southern California |
| | San Diego | SWP Water Users:<br>Metropolitan Water District of Southern California |
| | Riverside | SWP Facilities: Portion of California Aqueduct |
| | | SWP Water Users:<br>Desert Water Agency<br>Coachella Valley Water District<br>Metropolitan Water District of Southern California<br>San Gorgonio Pass Water Agency |
| | San Bernardino | SWP Facilities: Portion of California Aqueduct |
| | | SWP Water Users:<br>Crestline Lake Arrowhead Water Agency<br>Metropolitan Water District of Southern California<br>Mojave Water Agency<br>San Bernardino Valley Municipal Water District |

### 4.3.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS that are located on Federal or state lands, or actions that are implemented, funded, or approved by Federal and state agencies, need to be compliant with appropriate Federal and state agency policies and regulations. Federal and state policies and regulations that could be relevant to implementation of the alternatives evaluated in this EIS are summarized in Appendix 4A.

### 4.3.3 Affected Environment

The Affected Environment portions of Chapters 5 through 21 provide an adequate level of detail for the quantitative and qualitative impact analyses presented in this EIS. Changes in CVP and SWP operations could result in changes to:

- Water elevations in reservoirs that store CVP and SWP water supplies, including reservoirs owned by regional and local water agencies that use CVP and/or SWP water, and associated use of the reservoir or surrounding areas to support biological resources, visual resources, recreation, and cultural resources
- Flow rates and water quality in rivers downstream of CVP and SWP reservoirs, and associated use of the rivers to support biological resources, protection of soils from erosion along the rivers, and recreation
- Flows and water quality in the Delta, including Delta outflow and reverse flows, and associated use of the rivers to support beneficial uses including biological resources and food and water supplies for human consumption
- CVP and SWP deliveries, and associated changes in groundwater use, CVP and SWP energy use and generation, and land use which could affect air quality, human health, soil erosion, and cultural resources.

References are provided for each chapter and not compiled for the entire EIS.

### 4.3.4 Impact Analysis

In accordance with the Council on Environmental Quality regulations, an EIS must evaluate the effects of implementation of the alternatives on the environment, any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment and long-term productivity, and any irreversible or irretrievable commitments of resources if the alternatives are implemented. The impact analyses sections address direct, indirect, and cumulative effects of the alternatives in each resource chapter (Chapters 5 through 21), and are organized in the following manner to describe the approach and present the results of the impact assessment.

- Potential Mechanisms for Change and Analytical Tools
- Conditions in Year 2030 without Implementation of Alternatives 1 through 5
- Evaluation of Alternatives
  - Comparison of the No Action Alternative to the Second Basis of Comparison
  - Comparison of Alternatives 1 through 5 to the No Action Alternative
  - Comparison of Alternatives 1 through 5 to the Second Basis of Comparison
  - Summary of Impact Analysis
  - Potential Mitigation Measures
  - Cumulative Effects Analysis

The impact analysis includes quantitative and qualitative analyses depending upon the availability of acceptable numerical analytical tools and available information. The quantitative analyses include numerous analytical tools, as summarized in Figure 4.2.

An EIS must identify relevant, reasonable mitigation measures that are not already included in the proposed action or alternatives to the proposed action that could avoid, minimize, rectify, reduce, eliminate, or compensate for the project's adverse environmental effects (40 Code of Federal Regulations [CFR] 1502.14, 1502.16, 1508.8). Mitigation measures are presented for each resource to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

The cumulative effects of implementation of reasonably foreseeable projects and the alternatives as compared to conditions under the No Action Alternative and Second Basis of Comparison are discussed for each resource in Chapters 5 through 21. Cumulative effects are impacts on the environment that result from the incremental impacts of an alternative when added to other past, present, and reasonably foreseeable future actions of Federal, state, or local agencies or individual entities or persons (40 CFR 1508.7). Such impacts can result from individually minor, but collectively significant, actions taking place over time (40 CFR 1508.8).

### 4.3.5 Other NEPA Considerations

The irreversible and irretrievable commitments of resources, and the relationship between short-term uses of the environment and long-term productivity are discussed in Chapter 22, Other NEPA Considerations.

### 4.3.6 Consultation and Coordination

Public outreach and agency involvement efforts related to preparation of the Draft EIS and Final EIS are presented in Chapter 23, Consultation and Coordination. A listing of the agencies, other entities, and interest groups that received a copy of the Draft EIS and Final EIS is presented in Chapter 24, Distribution of Draft EIS. A list of preparers of the EIS is presented in Chapter 25.


**Figure 4.1 Study Area**

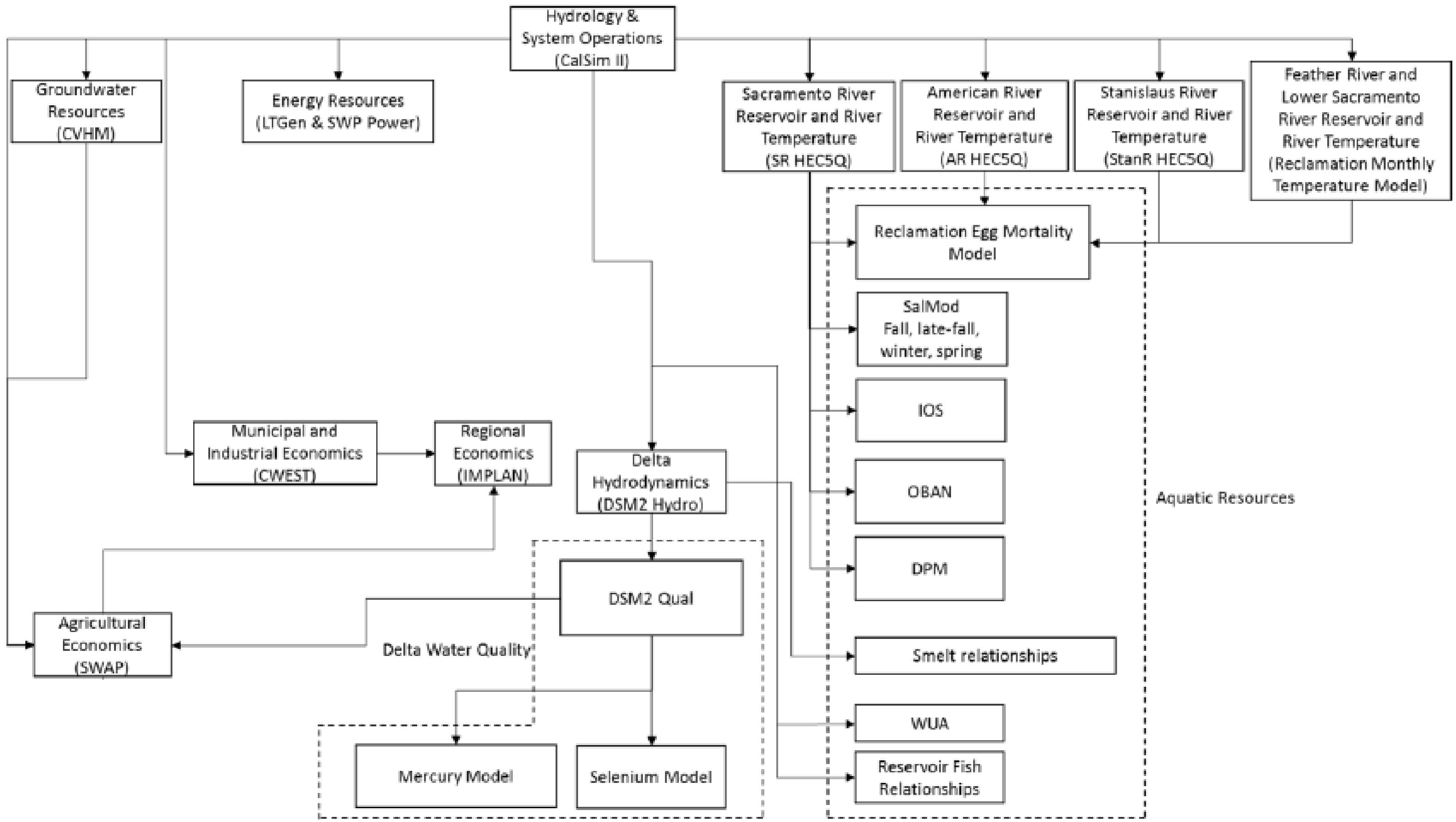



**Figure 4.2 Analytical Framework Used to Evaluate Impacts of the Alternatives**

This page left blank intentionally.

**Chapter 5**

# Surface Water Resources and Water Supplies

## 5.1 Introduction

This chapter describes the surface water resources and water supplies in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration components of the long-term operation of the CVP and SWP.

## 5.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect surface water resources, including rivers and reservoirs directly or indirectly impacted by changes in the operations of the CVP or SWP water facilities and users of CVP and SWP water supplies. Actions located on public agency lands or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analysis.

## 5.3 Affected Environment

This section describes the surface water resources and water supplies that could be potentially affected by the implementation of the alternatives considered in this EIS, including:

- **Surface Water Hydrology:** Changes in surface water hydrology may occur in the rivers within the Trinity River and Central Valley regions due to changes in CVP and SWP operations as some rivers in these regions are used to convey CVP and/or SWP water supplies. Changes in reservoir elevations may occur within the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions due to changes in CVP and SWP operations. The ongoing CVP and SWP facilities and operations are described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

- **Summaries of the Water Supplies used by CVP and SWP Water Users:** The water users which may be affected by changes in CVP and SWP operations are located in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

## 5.3.1 Overview of California Water Supply and Water Management Facilities

### *5.3.1.1 Sources of Water in California*

Variability and uncertainty are the dominant characteristics of California's water resources. Precipitation is the source of 97 percent of California's water supply (DWR 2009a). It varies greatly from year to year, as well as by season and location within the state. The unpredictability and geographic variation in precipitation that California receives make it challenging to manage the available runoff to meet urban, agricultural, and environmental water needs. With climate change, precipitation patterns are expected to become even more unpredictable, as described in Appendix 5A, CalSim II and DSM2 Modeling.

In an average water year, precipitation provides California with approximately 200 million acre-feet (MAF) of water falling as either rain or snow (DWR 2009a), including up to 10 MAF from surface water flows entering California due to precipitation falling in the Klamath River and Lost River watersheds in Oregon; and the Colorado River watershed in Wyoming, Colorado, Utah, Nevada, New Mexico, and Arizona, and northwestern Mexico. The total volume of water the state receives can vary dramatically between dry and wet years. California may receive less than 100 MAF of water during a dry year and more than 300 MAF in a wet year (Western Regional Climate Center 2011).

The majority of California's precipitation occurs between November and April, while most of the state's demand for water is in the summer months (Western Regional Climate Center 2011). In addition, most of the precipitation falls in the northern portion of the state and much of the state water demand comes from the central and southern portions of the state where the major agricultural and population centers are located on the Central Valley floor and in Southern California. In some years, the northern regions of the state can receive 100 inches or more of precipitation, while the southern regions receive only a few inches.

Over time, annual precipitation trends have been changing and continue to change, as shown on Figure 5.1. From 1906 to 1960, 33 percent of the water years in California were classified by the California Department of Water Resources (DWR) as "dry" or "critically dry" and that percentage increased to 36 percent from 1961 to 2013 (DWR 2014a). From 1906 to 1960, 45 percent of the water years in California were classified by DWR as "above normal" or "wet" and that percentage increased to 49 percent from 1961 to 2013. Additionally, the 1906 to 1960 period had 42 percent of water years classified as extreme ("critically dry" or "wet") and that percentage increased to 51 percent after 1960.

Although there were more extreme water year classifications in the later period, the overall precipitation averages in pre-1960 years and post-1960 years have little differences.

Despite having similar precipitation averages, the year to year variation and patterns of extreme condition occurrences are significantly different between the time periods. The year to year statewide precipitation variation is larger and more frequent from 1961 to 2013 than 1906 to 1960. Also, the occurrence of a year to year change of more than 10 inches of precipitation is 3 times higher in the post-1960 time period as compared to the pre-1960 time period. There are also more occurrences of sequential "critically dry" years and sequential "wet" years after 1960.

Approximately 50 percent of the precipitation that California receives evaporates, is used consumptively by native vegetation and crops (not including irrigation water supplies), is used by managed wetlands, flows into streams within Oregon or Nevada, flows into saline water bodies (such as Salton Sea), or percolates into saline groundwater aquifers (DWR 2013a). Therefore, less than 50 percent of the water that enters California, or less than 100 MAF per year, is available for use by urban, agricultural, and other environmental uses, collectively.

#### *5.3.1.2 Development of Major California Water Management Facilities*

Due to the hydrologic variability that ranges from dry summers and fall months to floods in winter and spring, water from precipitation in the winter and spring must be stored for use in the summer and fall. During an average hydrological year, approximately 15 MAF of water is stored in the Sierra Nevada snowpack (DWR 2013a). However, not all of the snowpack becomes available in a timely manner for uses throughout the state. Therefore, Federal, state, and local agencies and private entities have constructed reservoirs, aqueducts, pipelines, and water diversion facilities to capture and use the rainfall and the subsequent snowmelt.

##### 5.3.1.2.1 Water Facilities Development through the Early 1900s

Spanish settlements were initially established in the late 1700s in southern California, including conveyance systems to bring water to the pueblos. The first water storage and diversion project in California was constructed in 1772, including a 12-foot high dam on the San Diego River and 6 miles of canals to deliver water to the San Diego Mission (Reclamation 1997). Over the next 80 years, other irrigation systems were constructed to provide water for communities and irrigated lands. The major levee was constructed in the Delta in 1840 along Grand Island to protect agricultural lands from floods.

After California became a state in 1850, the state legislature adopted English Common Law, which included the doctrine of riparian rights to provide water supplies to lands adjacent to rivers and streams (Reclamation 1997). The California legislature at this time also recognized "pueblo water rights" that were granted under both Spanish and Mexican governments, including water rights on the Los Angeles and San Diego rivers. Water rights also were influenced by the practice of miners of "posting notice" at their points of diversion to substantiate water rights as an "appropriative right" for areas not adjacent to the rivers and streams. This set of appropriative rights was catalogued with respect to "first in time, first in right." Appropriative water rights were given statutory recognition in 1872.

Between the 1850s and early 1900s, numerous dams and canals were constructed by miners, agricultural water users, and communities (Reclamation 1997). In the 1870s, the first wells were constructed with wood-burning engines. By the late 1890s, natural gas engines and electricity became available to power pumps. Between 1906 and 1910, over 4,000 natural gas or electric groundwater pumps were installed in the San Joaquin Valley. Substantial use of groundwater caused extensive groundwater aquifer depletions and land subsidence in some areas of the Central Valley. The availability of electricity to communities also resulted in more hydroelectric generation facilities and associated dams being constructed throughout the Sierra Nevada.

#### 5.3.1.2.2 Conceptual Development of the Central Valley Project and State Water Project

The need for coordinated water development was evaluated in the 1870s when Congress authorized the Alexander Commission to evaluate water supply concepts in the Sacramento and San Joaquin rivers watersheds, including reservoirs and large-scale irrigation water supply projects (Reclamation 1997).

*1919 Marshall Plan*

In 1919, Colonel Robert Marshall, chief geographer for the U.S. Geological Survey, proposed a major water storage and conveyance plan to irrigate lands in the Central Valley and San Francisco Bay Area and provide water to communities in the San Francisco Bay Area and southern California (Marshall 1919). The Marshall Plan recommended two major dams on the San Joaquin River near Friant and Stanislaus River between the present locations of Tulloch and Goodwin dams to serve the eastern San Joaquin Valley and reduce groundwater overdraft in Tulare and Kern counties; four dams on Kern River to serve the Los Angeles area; and dams on the Sacramento River near Red Bluff, Klamath River downstream of Klamath Falls, and dams along the Sacramento River tributaries to provide stored water into two canals along the western and eastern sides of the Central Valley to provide exchange water to San Joaquin River water rights holders affected by the San Joaquin River dam, water to other San Joaquin Valley users, and water to communities in Contra Costa, Alameda, Santa Clara, and San Francisco counties.

*1930s State Water Plan*

During the 1920s, the California state legislature commissioned a series of investigations to further evaluate the Marshall Plan (DPW 1930; Reclamation 1997). The 1930 Division of Water Resources Bulletin No. 25 outlined a statewide water plan, including the concept that became the CVP and SWP. The plan included 37 water supply and flood management reservoirs, including a dam on the San Joaquin River near Friant and canals to distribute the water along the eastern San Joaquin Valley to reduce groundwater overdraft in Tulare and Kern counties; 14 dams along the Trinity River, Sacramento River, and Sacramento River tributaries to provide water to the San Joaquin River water rights contractors affected by the dam on the San Joaquin River and water users on the west side of the San Joaquin Valley and in Contra Costa County; and eight dams on San Joaquin Valley rivers to provide water to the San Joaquin Valley. These dams included recommended facilities near the present CVP Trinity, Shasta, Folsom, New Melones, and Friant dams and the present SWP Oroville Dam. The recommendations also included a Delta Cross Channel canal to improve south Delta water quality; a canal from a south Delta pumping plant to a regulating reservoir and pumping plant near Mendota; canals from Mendota to the San Joaquin Valley; a canal from the Delta into Contra Costa County; and expansion of the San Joaquin River and associated channels with five operable barriers along the San Joaquin River.

The study also addressed use of aquifer storage, improved navigation along the Sacramento and San Joaquin rivers, flood management, salt water barrier along the western Delta, recycled wastewater and stormwater in Southern California, and importation of Colorado River water to Southern California.

In 1933, the state authorized the Central Valley Project Act. However, during the 1930s depression, the state could not raise the funds. The state appealed to the Federal Government for assistance. The overall SWP was approved by the State Legislature in 1941.

As described above, six of the 37 dams in the SWP were included in the CVP and SWP facilities (Reclamation 1997). However, most of the recommended dams were constructed by the U.S. Army Corps of Engineers (USACE), local or regional water supply and/or flood management agencies, and hydropower entities on the Yuba, Bear, Feather, American, Mokelumne, Calaveras, Chowchilla, Fresno, Merced, Tuolumne, Stanislaus, Kings, Kaweah, Tule, and Kern rivers. Dams on the Fresno and Chowchilla rivers were initially developed by the USACE; however, the Hidden and Buchanan dams, respectively, were integrated into the CVP to supply water to portions of the eastern side of the San Joaquin Valley (DPW 1930; Reclamation 1997).

#### 5.3.1.2.3 Overview of the Central Valley Project

With the passage of the Rivers and Harbors Act of 1935, Congress appropriated funds and authorized construction of the CVP by the USACE (Reclamation 1997; Reclamation 2011a). When the Rivers and Harbors Act was reauthorized in 1937, the construction and operation of the CVP was assigned to Reclamation, and the CVP became subject to Reclamation Law (as defined in the Reclamation Act of 1902 and subsequent legislation).

The CVP facilities were initiated in the late 1930s (Reclamation 1997, 2011a). The CVP facilities, as shown on Figure 5.2, include:

- Trinity and Lewiston dams on the Trinity River.
- Shasta and Keswick dams on the Sacramento River.

- Red Bluff Pumping Plant on the Sacramento River to deliver water into the Tehama-Colusa Canal and the Corning Canal.
- Folsom and Nimbus dams on the American River and the Folsom-South Canal.
- Delta Cross Channel in the Delta.
- Rock Slough Intake to deliver water into the Contra Costa Canal, Contra Costa Pumping Plant, and Contra Loma Reservoir.
- Friant Dam along the San Joaquin River to deliver water into the Friant-Kern and Madera.
- C.W. Jones Pumping Plant (Jones Pumping Plant) (previously known as the Tracy Pumping Plant) in the south Delta to deliver water into the Delta-Mendota Canal and Mendota Pool.
- Delta-Mendota Canal/California Aqueduct Intertie downstream of the CVP Jones Pumping Plant and the SWP Banks Pumping Plant.
- San Luis Reservoir-related facilities, including the CVP facilities consisting of the O'Neill Forebay, Pumping Plant, and Canal; Coalinga Canal, Pleasant Valley Pumping Plant, and San Luis Drain. The O'Neill Forebay is operated in coordination with the SWP. The SWP facilities operated in coordination with the CVP include the B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants.
- Pacheco Tunnel and Conduit to deliver water from the San Luis Reservoir into the San Justo Dam and Reservoir, Hollister Conduit, and Santa Clara Tunnel and Conduit.
- New Melones Dam along the Stanislaus River.

The CVP reservoirs are listed in Table 5.1 and shown on Figures 5.3 through 5.5. Table 5.1 also includes reservoirs of the Bureau of Reclamation Orland Project (which are not part of CVP) because these reservoirs also affect hydrology of Stony Creek, a tributary to the Sacramento River.

**Table 5.1 Major Central Valley Project and Orland Project Reservoirs**

| Project | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| CVP | Millerton Lake | Friant | San Joaquin River | 1942 | 524,000 |
| CVP | Shasta Lake | Shasta | Sacramento River | 1945 | 4,552,000 |
| CVP | Keswick Reservoir | Keswick | Sacramento River | 1950 | 23,772 |
| CVP | Trinity Lake | Trinity | Trinity River | 1962 | 2,447,650 |
| CVP | Lewiston Reservoir | Lewiston | Trinity River | 1963 | 14,660 |
| CVP | Spring Creek Reservoir | Spring Creek Debris Dam | Spring Creek (tributary of Sacramento River) | 1963 | 5,874 |
| CVP | Whiskeytown Lake | Whiskeytown | Clear Creek (tributary of Sacramento River) | 1963 | 241,100 |
| CVP | Folsom Lake | Folsom | American River | 1956 | 967,000 |
| CVP | Lake Natoma | Nimbus | American River | 1955 | 9,000 |
| CVP | Contra Loma Reservoir | Contra Loma | Off-Stream | 1967 | 2,627 |
| CVP | Martinez Reservoir | Martinez | Wildcat Creek | 1938 | 268 |
| CVP | San Luis Reservoir | B.F. Sisk | San Luis Creek | 1967 | 2,041,000 |
| CVP | O'Neill Forebay | O'Neill | San Luis Creek | 1967 | 56,400 |
| CVP | Los Banos Creek Reservoir | Los Banos Detention | Los Banos Creek | 1965 | 34,600 |
| CVP | Little Panoche Creek Reservoir | Little Panoche Detention | Little Panoche Creek | 1966 | 5,580 |
| CVP | San Justo Reservoir | San Justo | Offstream | 1985 | 10,300 |
| CVP | Funks Reservoir | Funks | Funks Creek | 1976 | 2,460 |
| CVP | New Melones Reservoir | New Melones | Stanislaus River | 1979 | 2,400,000 |
| CVP | Hensley Lake | Hidden | Fresno River | 1975 | 90,000 |
| CVP | H.V. Eastman Lake | Buchanan | Chowchilla River | 1975 | 150,000 |
| Orland | East Park Reservoir | East Park | Little Stony Creek (tributary of Sacramento River) | 1910 | 51,000 |
| Orland | Stony Gorge Reservoir | Stony Gorge | Stony Creek (tributary of Sacramento River) | 1928 | 50,350 |

Sources: DWR 2014b; Reclamation 1994, 2014a, 2014b.

Note: CVP is Central Valley Project; Orland is Orland Project

Detailed information describing the CVP facilities and operations is presented in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

#### 5.3.1.2.4 Overview of the State Water Project

As the CVP facilities were being constructed after World War II, the state began investigations to meet additional water needs through development of the California Water Plan. In 1957, DWR published Bulletin Number 3 that identified new facilities to provide flood control in northern California and water supplies to the San Francisco Bay Area, San Joaquin Valley, San Luis Obispo and Santa Barbara counties in the Central Coast Region, and southern California (DWR 1957, 2012; Reclamation 2011a). The study identified a seasonal deficiency of 2.675 MAF/year in 1950 that resulted in groundwater overdraft throughout many portions of California. The report described facilities to meet the water demands and reduce groundwater overdraft, including facilities that would become part of the SWP.

In 1960, California voters authorized the Burns-Porter Act to construct the initial SWP facilities. The SWP facilities, as shown on Figure 5.2, include:

- Antelope Lake, Lake Davis, and Frenchman Lake on the upper Feather River upstream of Oroville Dam.
- Oroville Dam and Thermalito Diversion Dam on the Feather River.
- Barker Slough Pumping Plant in the north Delta which delivers water to the North Bay Aqueduct.
- Clifton Court Forebay and Harvey O. Banks Pumping Plant (Banks Pumping Plant) in the south Delta, which delivers water into the Bethany Forebay and California Aqueduct.
- South Bay Pumping Plant to deliver water from Bethany Forebay to the South Bay Aqueduct and Lake Del Valle.
- San Luis Reservoir-related facilities, including the SWP facilities B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants, and the CVP O'Neill Forebay. These facilities are operated in coordination between the SWP and CVP.
- California Aqueduct to deliver water to the San Joaquin Valley, Central Coast, and southern California. The California Aqueduct extends from the Banks Pumping Plant to San Luis Reservoir and continues to Lake Perris in Riverside County. The California Aqueduct reach in southern California also includes Quail Lake, Pyramid Lake, Castaic Lake, Silverwood Lake, Crafton Hills Reservoir, and Lake Perris.
- The Coastal Branch of the California Aqueduct to deliver water from the California Aqueduct to San Luis Obispo and Santa Barbara counties.

Major SWP reservoirs are listed in Table 5.2 and shown on Figures 5.3 through 5.6.

**Table 5.2 State Water Project Reservoirs**

| Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|
| Frenchman Lake | Frenchman | Little Last Chance Creek (tributary of Feather River) | 1961 | 55,477 |
| Antelope Lake | Antelope | Indian Creek (tributary of Feather River) | 1964 | 22,566 |
| Lake Davis | Grizzly Valley | Big Grizzly Creek (tributary of Feather River) | 1966 | 83,000 |
| Oroville Reservoir | Oroville | Feather River | 1968 | 3,537,577 |
| Thermalito Pool | Thermalito Diversion | Feather River | 1967 | 13,328 |
| Thermalito Forebay | Thermalito Forebay | Cottonwood Creek (tributary of Feather River) | 1967 | 11,768 |
| Thermalito Afterbay | Thermalito Afterbay | Feather River | 1967 | 57,041 |
| Clifton Court Forebay | Clifton Court Forebay | Old River | 1970 | 29,000 |
| Bethany Forebay | Bethany Forebay | Italian Slough | 1961 | 5,250 |
| Patterson Reservoir | Patterson | Offstream | 1962 | 98 |
| Lake Del Valley | Del Valle | Arroyo Valle | 1968 | 77,100 |
| Quail Lake | No dam | Offstream | Historic | 5,654 |
| Pyramid Lake | Pyramid | Piru Creek | 1973 | 180,000 |
| Castaic Lake | Castaic | Castaic Creek | 1973 | 323,700 |
| Silverwood Lake | Cedar Springs | Mojave River (West Fork) | 1971 | 78,000 |
| Crafton Hills Reservoir | Crafton Hills | Yucaipa Creek | 2001 | 130 |
| Lake Perris | Perris | Bernasconi Pass | 1973 | 131,452 |

Sources: DWR 2014b, 2014c.

Detailed information describing the SWP is presented in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

#### 5.3.1.2.5 Other Major Water Supply and Flood Management Reservoirs

During the past 100 years, numerous water supply, flood management, and hydroelectric generation reservoirs were constructed throughout California. Many of these projects were constructed on tributaries to the Sacramento and San Joaquin rivers and tributaries to the Tulare Lake Basin. Operations of these non-CVP and non-SWP reservoirs affect flow patterns into the Sacramento and San Joaquin rivers and the Delta. However, implementation of the alternatives evaluated in this EIS would not result in changes in operations in most of these reservoirs, except on the lower Stanislaus River.

Major non-CVP and non-SWP reservoirs in the Sacramento Valley and San Joaquin Valley watersheds, generally with storage capacities greater than 100,000 acre-feet, which could affect operations of CVP or SWP reservoirs or Delta facilities or could be affected by implementation of the alternatives evaluated in this EIS, are listed in Tables 5.3 and 5.4.

**Table 5.3 Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Sacramento Valley Watershed Considered in this EIS**

| Owner | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| U.S. Army Corps of Engineers | Black Butte Reservoir | Black Butte | Stony Creek (tributary of Sacramento River) | 1963 | 143,700 |
| Yuba County Water Agency | Bullards Bar Reservoir | New Bullards Bar | Yuba River (North Fork) | 1970 | 969,600 |
| U.S. Army Corps of Engineers | Englebright Reservoir | Englebright | Yuba River | 1941 | 70,000 |
| South Sutter Water District | Camp Far West Reservoir | Camp Far West | Bear River | 1963 | 104,500 |
| Pacific Gas & Electric Company | Bucks Lake | Bucks Storage | Bucks Creek (tributary of Feather River) | 1928 | 103,000 |
| Pacific Gas & Electric Company | Lake Almanor | Lake Almanor | Feather River (North Fork) | 1927 | 1,308,000 |
| South Feather Water And Power Agency | Little Grass Valley Reservoir | Little Grass Valley | Feather River (South Fork) | 1961 | 93,010 |
| Pacific Gas & Electric Company | Salt Springs Reservoir | Salt Springs | Mokelumne River (North Fork) | 1931 | 141,900 |
| East Bay Municipal Utility District | Pardee Lake | Pardee | Mokelumne River | 1929 | 209,950 |
| East Bay Municipal Utility District | Camanche Lake | Camanche | Mokelumne River | 1963 | 417,120 |
| Sacramento Municipal Utility District | Union Valley Reservoir | Union Valley | Silver Creek (tributary of American River) | 1963 | 230,000 |
| Placer County Water Agency | French Meadows Reservoir | L. L. Anderson | American River (Middle Fork) | 1965 | 136,400 |
| Placer County Water Agency | Hell Hole Reservoir | Lower Hell Hole | Rubicon River (tributary of American River) | 1966 | 208,400 |

Sources: DWR 2014b, 2014c.

**Table 5.4 Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Joaquin Valley Watersheds Considered in this EIS**

| Owner | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| Southern California Edison Company | Lake Thomas A. Edison | Vermilion Valley | Mono Creek (tributary of San Joaquin River) | 1954 | 125,000 |
| Southern California Edison Company | Shaver Lake | Shaver Lake | Stevenson Creek (tributary of San Joaquin River) | 1927 | 135,283 |
| Merced Irrigation Dist | Lake McClure | New Exchequer | Merced River | 1967 | 1,032,000 |
| San Francisco Public Utilities Commission | Cherry Lake | Cherry Valley | Cherry Creek (tributary of Tuolumne River) | 1956 | 273,500 |
| San Francisco Public Utilities Commission | Hetch Hetchy Reservoir | O' Shaughnessy | Tuolumne River | 1923 | 360,000 |
| Turlock Irrigation District | New Don Pedro Reservoir | New Don Pedro | Tuolumne River | 1971 | 2,030,000 |
| Calaveras County Water District | New Spicer Meadow Reservoir | New Spicer Meadow | Highland Creek (tributary of Stanislaus River) | 1989 | 190,000 |
| Tri-Dam Project | Donnells Reservoir | Donnells | Stanislaus River (Middle Fork) | 1958 | 56,893 |
| Tri-Dam Project | Beardsley Reservoir | Beardsley | Stanislaus River (Middle Fork) | 1957 | 77,600 |
| Tri-Dam Project | Tulloch Reservoir | Tulloch | Stanislaus River | 1958 | 68,400 |
| Oakdale Irrigation District and South San Joaquin Irrigation District | Goodwin Diversion | Goodwin | Stanislaus River | 1912 | 500 |
| South San Joaquin Irrigation District | Woodward Reservoir | Woodward | Simmons Creek (tributary of Stanislaus River) | 1918 | 35,000 |
| U.S. Army Corps of Engineers | New Hogan Lake | New Hogan | Calaveras River | 1963 | 317,000 |

Sources: DWR 2014b, 2014c.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions are shown on Figures 5.5 and 5.6 and listed in Tables 5.5, 5.6, and 5.7.

**Table 5.5 Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Francisco Bay Area Region Used to Store Central Valley Project and/or State Water Project Water**

| Owner | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| Contra Costa Water District | Los Vaqueros Reservoir | Los Vaqueros | Kellogg Creek | 1997 | 160,000 |
| East Bay Municipal Utility District | Briones Reservoir | Briones | Bear Creek | 1964 | 67,520 |
| East Bay Municipal Utility District | San Pablo Reservoir | San Pablo | Bear Creek | 1964 | 38,600 |
| East Bay Municipal Utility District | Lafayette Reservoir | Lafayette | Marsh Creek | 1963 | 4,250 |
| East Bay Municipal Utility District | Upper San Leandro Reservoir | Upper San Leandro | San Leandro Creek | 1977 | 37,960 |
| East Bay Municipal Utility District | Chabot Reservoir | Chabot | San Leandro Creek | 1892 | 10,281 |

Sources: DWR 2014b, 2014c; East Bay Municipal Utility District (EBMUD) 2011; City and County of San Francisco (CCSF) 2009; Santa Clara Valley Water District (SCVWD) 2011.

Note:
a. Anderson Reservoir capacity is restricted due to California Department of Safety and Dams (SCVWD 2011).

**Table 5.6 Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Central Coast Region Used to Store State Water Project Water**

| Owner | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| Bureau of Reclamation | Cachuma Lake | Bradbury | Santa Ynez River | 1953 | 205,000 |

Sources: DWR 2014b; Reclamation 2014c.

**Table 5.7 Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Southern California Region Used to Store State Water Project Water**

| Owner | Reservoir | Dam | Stream | Year Initiated | Capacity (acre-feet) |
|---|---|---|---|---|---|
| United Water Conservation District | Lake Piru | Santa Felicia | Piru Creek | 1955 | 100,000 |
| Metropolitan Water District Of Southern California | Diamond Valley Lake | Diamond Valley Lake | Domenigoni Valley Creek | 2000 | 800,000 |
| Metropolitan Water District Of Southern California | Lake Skinner | Robert A Skinner | Tucalota Creek | 1973 | 43,800 |
| Rancho California Water District | Vail Lake | Vail | Temecula Creek | 1949 | 51,000 |
| City of Escondido | Dixon Lake | Dixon | Escondido Creek | 1970 | 2,500 |
| San Diego County Water Authority | Olivenhain Reservoir | Olivenhain | Escondido Creek | 2003 | 24,900 |
| City of San Diego | Lake Hodges | Lake Hodges | San Dieguito River | 1918 | 37,700 |
| City of San Diego | San Vincente Reservoir | San Vicente | San Vicente Creek | 1943 | 146,994 |
| City of San Diego | El Capitan Reservoir | El Capitan | San Diego River | 1934 | 112,800 |
| Helix Water District | Lake Jennings | Chet Harritt | Quail Canyon Creek | 1962 | 9,790 |
| Sweetwater Authority | Sweetwater Reservoir | Sweetwat er | Sweetwater River | 1888 | 27,700 |
| City of San Diego | Murray Reservoir | Murray | Off-stream | 1918 | 4,818 |
| City of San Diego | Morena Reservoir | Morena | Cottonwood Creek | 1912 | 50,694 |
| City of San Diego | Lower Otay Reservoir | Savage | Otay River | 1919 | 49,849 |

Sources: DWR 2014b, 2014c; City of San Diego 2014a, 2014b, 2014c, 2014d; SDCWA and USACE 2008.

### 5.3.2 Hydrologic Conditions and Major Surface Water Facilities

This section of Chapter 5 provides an overview of hydrologic conditions in the Trinity River and Central Valley watersheds. As described below, not all of the tributaries and sub-watersheds would be affected by changes in the CVP and SWP operations considered under the alternatives in this EIS.

Changes in surface water hydrology may occur in the rivers within the Trinity River and Central Valley regions due to changes in CVP and SWP operations because some rivers in these regions are used to convey CVP and/or SWP water supplies. Tributaries to the Sacramento and San Joaquin rivers that are not affected by CVP and SWP operations are also discussed briefly in this section to provide an overview of the major streams in the Central Valley watersheds. Available information related to flow conditions between Water Years 2001 and 2012 (October 2000 through September 2012) are provided for reservoirs and rivers that are affected by CVP and/or SWP operations.

In the San Francisco Bay Area, Central Coast, and Southern California regions, the surface water streams generally are not used to convey CVP and SWP water supplies. The streams downstream of reservoirs that store CVP and SWP water supplies generally receive either reservoir overflows in storm conditions or minimum instream flows related to water rights and/or aquatic resources beneficial uses. After the minimum instream flow requirements are fulfilled, the remaining volumes of water are provided to municipal, agricultural, and/or environmental water users. Changes in CVP and SWP water operations will not affect the need to meet minimum instream flows or high flows during storm conditions.

#### *5.3.2.1 Trinity River Region*

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

##### 5.3.2.1.1 Trinity River Watershed

The Trinity River watershed extends over approximately 1,897,600 acres and ranges in elevation from over 9,000 feet above sea level in the headwaters area to less than 300 feet at the confluence of the Trinity River with the Klamath River (California North Coast Regional Water Quality Control Board [NCRWQCB] et al. 2009; U.S. Fish and Wildlife Service [USFWS] et al. 1999). Average precipitation in the Trinity River watershed range from 30 to 70 inches per year, with a long-term average of approximately 62 inches per year. Over 90 percent of the precipitation has historically occurred between October and April. Precipitation ranges from mostly snow at higher elevations to mostly rain near the confluence with the Klamath River.

The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 1999). The mainstem of the Trinity River flows 170 miles to the west from the headwaters to the confluence with the Klamath River. The CVP Trinity and Lewiston dams are located at approximately River Miles 105 and 112, respectively; and upstream of the confluences of the Trinity River and the North Fork, South Fork, and New River. Flows on the North Fork, South Fork, and New River are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Dam to the Klamath River through

Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties.

Trinity Lake, a CVP facility on the Trinity River formed by the Trinity Dam, was constructed by 1962. The 2.4-MAF reservoir is located approximately 50 miles northwest of Redding (USFWS et al. 1999). Lewiston Reservoir, a CVP facility on the Trinity River formed by Lewiston Dam, was constructed by 1963 and is located 7 miles downstream of the Trinity Dam. Lewiston Reservoir is used as a regulating reservoir for downstream releases to the Trinity River and to Whiskeytown Lake, located in the adjacent Clear Creek watershed. Water is diverted from the lower outlets in Trinity Lake to Lewiston Reservoir to provide cold water to Trinity River. There are no other major dams in the Trinity River watershed.

Prior to completion of Trinity and Lewiston dams, flows in the Trinity River were highly variable and could range from over 100,000 cubic feet per second (cfs) in the winter and spring to 25 cfs in the summer and fall (USFWS et al. 1999). Total annual flow volume at Lewiston (immediately downstream of the current location of Lewiston Dam) ranged from 0.27 to 2.7 MAF with a long-term average of 1.2 MAF.

A large portion of the Trinity River flows upstream of Trinity Lake and Lewiston Dam is exported to the Sacramento River watershed through CVP facilities. The reduction in flows in the Trinity River initially caused substantial reductions in the Trinity River fish populations (Department of the Interior [DOI] 2000). In response to the reductions in fish populations, Congress enacted legislation and directed that restoration actions be evaluated for the Trinity River. In December 2000, the U.S. Department of the Interior (DOI) adopted the Trinity River Mainstem Fishery Restoration Record of Decision (Trinity River ROD) which restored Trinity River flow and habitat to produce a healthy, functioning alluvial river system. The Trinity River ROD included physical channel rehabilitation; sediment management; watershed restoration; and variable annual instream flow releases from Lewiston Dam based on forecasted hydrology for the Trinity River Basin as of April 1st each year that range from 368,600 acre-feet/year in critically dry years to 815,000 acre-feet/year in extremely wet years. The Trinity River ROD was challenged in United States District Court for the Eastern District of California (District Court); and the changes in operations related to flow were not allowed to proceed while supplemental environmental documentation was prepared and reviewed (NCRWQCB et al. 2009). In 2004, the United States Court of Appeals for the Ninth Circuit entered an opinion that reversed the District Court order; and all actions in the Trinity River ROD were mandated. The flow actions were not completely implemented until several infrastructure projects in the Trinity River channel were completed to protect areas from flood damage.

Additional water releases periodically occur into the Trinity River as part of flood control operations and to provide other flow releases (NCRWQCB et al. 2009; Reclamation 2011a). Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations. The Reclamation Safety of Dams release criteria generally provide for maximum storage in Trinity Lake of 2.1 between November and March. Initial flood releases are discharged from Trinity Lake into Lewiston Reservoir, and then, through the powerplant and into Whiskeytown Lake in the Clear Creek watershed. To reduce the potential for flooding on the Trinity River, releases into Trinity River generally are less than 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high water concerns in the floodplain and local bridge flow capacities. Reclamation has periodically released water from Lewiston Dam into the Trinity River to improve late summer flow conditions to avoid fish die-offs in the lower Klamath River or for tribal requirements along the Trinity River (DOI 2014; Trinity River Restoration Program [TRPP] 2014).

Temperature objectives for the Trinity River are set forth in State Water Resources Control Board (SWRCB) Water Rights Order 90-5, as summarized in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River.

Historical water storage volumes and water storage elevations for Trinity Lake for Water Years 2001 through 2012 are presented on Figures 5.7 and 5.8 (DWR 2013d, 2013e). Trinity Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down.

Historical water storage volumes and water storage elevations in Lewiston Reservoir for Water Years 2001 through 2012 are presented on Figures 5.9 and 5.10 (DWR 2013g, 2013h). The Lewiston Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses; and not to provide long-term water storage.

Trinity River flows downstream of Lewiston Reservoir at Douglas City are presented on Figure 5.11 (DWR 2013i). The flow record is limited at the Douglas City gauge to 2003 through 2012. The mean monthly flows reflect the wet year pattern in 2006 and the drier year patterns in 2008 and 2009.

##### 5.3.2.1.2 Lower Klamath River from Trinity River Confluence to the Pacific Ocean

The Klamath River watershed extends over 15,600 square miles from southern Oregon to northern California, and ranges in elevation from over 9,500 feet above sea level near the headwaters to sea level at the Pacific Ocean (USFWS et al. 1999). The Klamath River watershed is generally divided into two or three subbasins. For the purpose of this study, the upper Klamath River basin extends over 60 miles from the headwaters to Iron Gate Dam (DOI and DFG 2012).

The lower Klamath River basin extends 190 miles from Iron Gate Dam to the Pacific Ocean. Four major tributaries flow into the lower Klamath River, including Shasta, Scott, Salmon, and Trinity rivers. The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and Department of Fish and Game [now known as Department of Fish and Wildlife] DFG 2012).

The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The western portion of the Klamath River watershed receives substantial rainfall during the winter months. Average precipitation in the western portion of the watershed ranges from 60 to 125 inches per year (DWR 2013a). Due to the heavy precipitation and the upstream water supply projects in the Klamath River, approximately 85 percent of the flows in the lower Klamath River occur due to runoff in the lower watershed during the winter months (DOI and DFG 2012).

The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean (DOI and DFG 2012). This area is generally under tidal effects and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low. Klamath River flows at Klamath within the Klamath River estuary are affected by tidal influence within the estuary, as presented on Figure 5.12 (DWR 2014d).

#### *5.3.2.2 Central Valley Region*

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

##### 5.3.2.2.1 Sacramento Valley

Rivers in the Sacramento Valley that could be affected by changes in CVP and SWP operations include the following:

- Clear Creek from Whiskeytown Reservoirs to the confluence with the Sacramento River
- Sacramento River from Shasta Lake to the confluence with the San Joaquin River in the Delta
- Feather River from upstream of Oroville Reservoir to the confluence with the Sacramento River
- Yuba River from New Bullards Bar Reservoir to the confluence with the Feather River
- Bear River from Camp Far West Reservoir to the confluence with the Feather River

- American River from Folsom Lake to the confluence with the Sacramento River

Flows from smaller tributaries to the Sacramento River and the Cosumnes and Mokelumne rivers in the Sacramento Valley contribute substantial flows into the Sacramento River and affect CVP and SWP operations; however, flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, hydrologic conditions on these waterbodies are not described in this EIS.

The Sacramento River watershed encompasses an area over 15,360,000 acres in the northern portion of the Central Valley; extends from the foothills of the Coast Ranges and Klamath Mountains on the west; extends from the foothills of the Sierra Nevada and Cascade Range on the east; and extends through the Delta on the south (Reclamation 2013a).

Ground surface elevations in the northern portion of the Sacramento River watershed range from approximately 14,000 feet above mean sea level in the headwaters of the Sacramento River to approximately 1,070 feet at Shasta Lake (Reclamation 2013a). In the mountains surrounding the valley, annual average precipitation generally ranges between 60 and 70 inches up to 90 inches, with snow prevalent at higher elevations. The floor of the Sacramento Valley is relatively flat, with elevations ranging from approximately 60 to 300 feet above mean sea level. This area is characterized by hot dry summers and mild winters. Average precipitation ranges from 15 to 20 inches per year, falling mostly as rain.

The Sacramento River flows approximately 351 miles from the north near Mount Shasta to the confluence with the San Joaquin River at Collinsville in the western Delta (Reclamation 2013a). The Sacramento River receives contributing flows from numerous major and minor streams and rivers that drain the east and west sides of the basin. The Sacramento River also receives imported flows from the Trinity River watershed, as discussed above. The volume of flow increases as the river progresses southward, and is increased considerably by the contribution of flows from the Feather River and the American River.

*Upper Sacramento River Watershed Hydrology*

The portion of the watershed upstream of Keswick Dam includes the McCloud River, Pit River, Squaw Creek, headwaters of the Sacramento River, and Goose Lake basins. The Goose Lake basin is located within the Pit River watershed; however, water rarely spills from Goose Lake into the Pit River. The last recorded spill occurred in 1880 (Reclamation 2013a). Long-term average annual inflows into Shasta Lake are approximately 4.875 MAF between the mid-1940s and 2010.

The McCloud River watershed extends over approximately 402,000 acres (Reclamation 2013a). The McCloud River flows approximately 59 miles from the headwaters in Moosehead Creek located southeast of Mount Shasta, through McCloud Reservoir, and into Shasta Lake. McCloud Reservoir is operated primarily to generate hydroelectric power.

The Pit River watershed extends over approximately 3,008,000 acres along the north and south forks of the Pit River basins, and includes 21 named tributaries and numerous smaller tributaries (Reclamation 2013a). Pacific Gas and Electric Company operate several hydropower diversions and reservoirs within the Pit River watershed.

The Squaw Creek watershed extends over approximately 66,000 acres located to the east of Shasta Lake (Reclamation 2013a).

The Sacramento River extends approximately 40 miles from the headwaters to Shasta Lake downstream of the town of Delta (Reclamation 2013a). The basin extends into portions of Mount Shasta and the Trinity and Klamath mountains.

Hydrological conditions in these upper watersheds would not be affected by implementation of the alternatives considered in this EIS.

*Whiskeytown Lake*

Whiskeytown Lake is located within the Clear Creek watershed. The Clear Creek watershed is 238 square miles that extends from the Trinity Mountains to the confluence with the Sacramento River downstream of the City of Redding (DWR 1986 and Western Shasta Resource Conservation District [WSRCD] 2004). Hydrology in the watershed is divided into the upper 238-square mile watershed upstream of Whiskeytown Dam at River Mile 18.1, and the lower 49 square miles watershed downstream of the dam. Clear Creek flows approximately 17 miles from the Trinity Mountains into Whiskeytown Lake. Clear Creek continues for 18.1 miles downstream of Whiskeytown Lake into the Sacramento River downstream of the CVP Keswick Dam and south of the City of Redding.

Whiskeytown Dam, a CVP facility constructed by 1963, is the only dam on Clear Creek and is located approximately 16.5 miles downstream of the headwaters (Reclamation 1997). Whiskeytown Lake, which is formed by the dam, has a storage capacity of 0.241 MAF; and regulates runoff from Clear Creek and diversions from the Trinity River watershed, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Flows from Lewiston Reservoir in the Trinity River watershed are diverted to Whiskeytown Lake through the Clear Creek Tunnel. Currently, the Clear Creek Tunnel between Lewiston Reservoir and Whiskeytown Lake has a capacity of 3,200 cfs (Reclamation 2011b).

Water from Whiskeytown Lake is released to the Sacramento River through the Spring Creek Tunnel which conveys water to the Spring Creek Conduit, and then to Keswick Reservoir. Water from Whiskeytown Lake also is released into Clear Creek directly from Whiskeytown Lake; or during high flow conditions (e.g., flood flows), from a Glory Hole within Whiskeytown Lake through a conduit into Clear Creek. Most of the flows are released through the Spring Creek Tunnel and Powerplant to Keswick Reservoir. These flows into Keswick Reservoir provide cold water flows that reduce temperatures in the upper Sacramento River, especially during the fall months. Water also is discharged from Whiskeytown Lake to Clear Creek to provide for instream flows and water for users located in the CVP Clear Creek South Unit within, or adjacent to, the Clear Creek watershed.

The capacity of the outlet from Whiskeytown Dam that conveys water to Clear Creek is 1,240 cfs when the water elevation in Whiskeytown Lake is at 1,220.5 feet. To provide flows into Clear Creek in excess of 1,240 cfs, the Whiskeytown Reservoir water elevations need to be raised higher than 1,220 feet to allow water to flow through the Glory Hole spillway, as described below (CALFED 2004; Reclamation 2009a).

Historical water storage volume and water storage elevations related to Whiskeytown Lake for Water Years 2001 through 2012 are presented on Figures 5.13 and 5.14 (DWR 2013j, 2013k, 2013l). Whiskeytown Lake storage is relatively constant due to agreements between Reclamation and the National Park Service to maintain certain winter and summer lake elevations for recreation. Whiskeytown Lake outflow variations were greater prior to 2006 when Trinity River restoration flows were implemented which reduced the amount of water available for conveyance to CVP water users. In addition, hydrologic conditions in the years following 2006 were drier than the water years between 2001 and 2006.

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

In accordance with the 2009 National Marine Fisheries Service (NMFS) Biological Opinion (BO) Reasonable and Prudent Alternative (RPA), Reclamation is required to manage Whiskeytown Lake releases to meet daily water temperatures in Clear Creek at Igo, as discussed in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Clear Creek*

Substantial modifications of the Clear Creek stream channel occurred due to placer mining activities from the mid-1800s through the early 1900s. In addition, several irrigation diversions were constructed along the lower Clear Creek reach during the late 1800s and early 1900s. One of the largest diversions was the 15-foot-high, 200-foot-wide McCormick-Saeltzer Dam constructed in 1903 at River Mile 6.5 (approximately 12 miles downstream of Whiskeytown Dam). The downstream of Whiskeytown Dam was constructed upstream of a steep gorge along Clear Creek and removed in 2001. More recent channel modifications occurred in the lower Clear Creek due to gravel extraction activities from the 1950s to 1970s.

Construction of Whiskeytown Dam modified the hydraulics, gravel loading, and sediment transport in the lower Clear Creek. The overall average annual flow in the lower Clear Creek was reduced by 87 percent following construction of the dam (DWR 1984, 1986). The dam also reduced gravel loading into the lower Clear Creek and the frequency of high flow events that move the gravel and remove fine sediments from riffles. This change in hydrology and loss of gravel loading adversely affected the salmonid habitat downstream of Whiskeytown Dam, including compaction of riffles with sand. Recently, minimum flow releases from Whiskeytown Lake into Clear Creek occur in accordance with Federal and state requirements (DWR 1984), as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Historical flow data has been collected since 1941 at the Igo Gage at River Mile 10.9 (approximately 7.2 miles downstream of Whiskeytown Dam) (DWR 1986 and WSRCD 2004).

Since the early 1980s, numerous studies were conducted to evaluate methods to rehabilitate and/or restore habitat along lower Clear Creek. In the 1990s, additional studies were conducted following the adoption of the 1992 Central Valley Project Improvement Act (CVPIA). In 1998, a watershed management plan prepared by the WSRCD evaluated methods to achieve healthy fish populations, diverse biological habitats, recreational opportunities, clean and safe conditions for visitors, and protection of property rights developed by the Lower Clear Creek Coordinated Resource Management and Planning Group of local landowners, stakeholders, and agencies (WSRCD 1998). The recommendations included the following:

- Removal of the McCormick-Saeltzer Dam.
- Inject gravel downstream of Whiskeytown Dam and reconstruct gravel channels below McCormick-Saeltzer Dam to reduce stranding.
- Modify water release patterns from Whiskeytown Dam.
- Reduce exotic vegetation along Clear Creek.
- Reduce sands in Clear Creek through erosion control programs in the lower watershed.

This and other studies led to the formation of the Lower Clear Creek Floodway Rehabilitation Project that was implemented under CVPIA (CALFED 2004, WSRCD 2002). Initial actions under this program included gravel augmentation initiated in 1996, increase in Whiskeytown Dam releases initiated in 2001, removal of the McCormick-Saeltzer Dam in 2001, reconstruction and revegetation of the floodway, and reduction of watershed erosion.

Following the removal of the McCormick-Saeltzer Dam, extensive geomorphological studies have been conducted to recommend approaches for restoration of the channel and adjacent floodplain downstream of the McCormick-Saeltzer Dam site. Based upon hydrological data collected at the Igo gage, one of the studies discussed that peak flow events in lower Clear Creek following completion of Whiskeytown Dam occur about once every 3 years; although, the pre-dam frequency was approximately once every 2 years. Clear Creek flows at Igo between 2000 and 2012 are presented on Figure 5.15. During this period, high flow events occurred in April and May of 2003 and December 2005 (DWR 2013s). The high flow events: 1) naturally moved gravel placed downstream of Whiskeytown Dam and along Clear Creek; 2) developed and maintained Clear Creek channel and adjacent floodplain habitat for spring-run and fall-run Chinook Salmon and steelhead; 3) created and maintained deep pools in the channel to support spawning of spring-run Chinook Salmon and steelhead, and create appropriate salmonid habitat within and along Clear Creek; and 4) established and maintained nesting and foraging habitat for neotropical migrant birds, native resident birds, and amphibians.

Following removal of McCormick-Saeltzer Dam, the Clear Creek channel and adjacent floodplain geomorphology changed. The Clear Creek channel capacity is generally about 3,000 cfs. The 2004 studies indicated that flows in excess of 3,000 cfs are required to overflow from the Clear Creek channel onto the adjacent floodplains. The study discussed that during pre- and post-Whiskeytown periods, the 5-year flood event at Igo decreased from 9,000 to 3,400 cfs and the 2.5-year flood event decreased from 6,200 to 1,800 cfs. Therefore, the study discussed that flows in excess of 5,000 cfs did not occur more frequently than 3 times in 10 years (CALFED 2004).

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to release spring attraction flows for adult spring-run Chinook Salmon and channel maintenance flows in Clear Creek and to continue gravel augmentation programs initiated under CVPIA. The spring attraction flows are to be released from Whiskeytown Lake into Clear Creek in at least two pulse flows of at least 600 cfs in May and June.

The channel maintenance flows are to be released at a minimum flow of 3,250 cfs, which is excess of the 1,240 cfs capacity of the Whiskeytown Dam outlet to Clear Creek. Therefore, to provide channel maintenance flows, the Whiskeytown Lake water elevation must be increased to provide flow of water over the Glory Hole inlet. The Glory Hole is designed to operate with the higher water elevations during flood events. However, during non-flood periods, raising the water elevations and operating the Glory Hole inlet can cause safety concerns for recreationists along the Whiskeytown Lake shoreline.

*Shasta Lake and Keswick Reservoir*

The CVP Shasta and Keswick dams are located at approximately River Miles 308 and 299, respectively, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, is located near Redding. Construction on the 4.552-MAF reservoir was initiated in 1945. Water flows from Shasta Lake along the Sacramento River into the 0.0238 MAF Keswick Reservoir, a CVP facility, which operates as an afterbay, or regulating reservoir, for Shasta Lake hydropower operations. Construction on Keswick Reservoir was initiated in 1950. A temperature control device at Shasta Dam was constructed between 1996 and 1998 to provide cold water without power bypass to the Sacramento River downstream of Keswick Reservoir.

Historical water storage volumes and water storage elevations for Shasta Lake for Water Years 2001 through 2012 are presented on Figures 5.16 and 5.17 (DWR 2013m, 2013n, 2013o). Shasta Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. For example, storage declined during the drier years in 2008 and 2009.

Keswick Reservoir receives water from Shasta Lake and Whiskeytown Lake, as described above; and from Spring Creek. Flows on Spring Creek are partially regulated by the CVP Spring Creek Debris Dam (Reclamation 2014d, 2014e). The debris dam minimizes the potential for debris entering the Spring Creek Powerplant, which is located at the discharge end of the Spring Creek Conduit immediately upstream of Keswick Reservoir. The debris dam also controls contaminated runoff from old mine tailings on upper Spring Creek, which reduces water quality effects on aquatic resources.

The Keswick Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage, as shown on Figures 5.18 and 5.19 (DWR 2013p, 2013q, 2013r).

##### *Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation meet specific temperature requirements at Balls Ferry, Jelly's Ferry, and Bend Bridge based upon minimum end-of-September storage in Shasta Lake for a specified frequency over 10 years, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Reclamation also is required to evaluate a monthly Keswick release schedule to address releases in fall and early winter within the range of 7,000 and 3,250 cfs; to be adjusted in consideration of the water year type, Shasta Lake storage, and the need to provide flow releases under the 2009 NMFS BO RPA and to meet other Federal and state water quality requirements in the Delta.

#### *Sacramento River from Keswick Dam to the Delta*

Water released from Shasta Dam travels approximately 245 miles over three to four days to the northern Delta boundary near Freeport (Reclamation 2013a). The upper reach of the Sacramento River flows for approximately 60 miles from Keswick Dam to Red Bluff; and the middle reach of the Sacramento River flows approximately 160 miles from Red Bluff to the confluence with the Feather River. The lower reach of the Sacramento River flows for approximately 20 river miles between the confluence with the Feather River and Freeport, immediately downstream of the confluence with the American River.

Moderately high releases (greater than 10,000 cfs) are typically sustained during the major irrigation season of June through September. Flows are released in the fall months from CVP and SWP reservoirs to meet water temperature criteria for winter-run Chinook Salmon spawning and incubation, to provide suitable habitat for spring-run and early returning fall-run Chinook Salmon, provide water supplies to rice farms for rice stubble decomposition, and to provide water for wildlife refuges.

##### *Sacramento River from Keswick Dam to Red Bluff*

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05. An April 5, 1960 Memorandum of Agreement between Reclamation and

California Department of Fish and Wildlife (CDFW) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Generally, releases from Keswick Reservoir are implemented to comply with the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

The Sacramento River between Keswick Dam and the City of Red Bluff flows through the northern foothills of the Sacramento Valley. Flows are influenced by outflow from Keswick Reservoir and inflows from Clear Creek (described above); and Cow Creek, Bear Creek, Cottonwood Creek, Battle Creek, and Paynes Creek which provide 15 to 20 percent of the flows in this reach as measured at Bend Bridge. There are several moderate major diversions along the Sacramento River upstream of Red Bluff, including the CVP Wintu Pumping Plant to provide water for the Bella Vista Water District, and the Anderson-Cottonwood Irrigation District Diversion. Both of these diversions near Redding provide water to agricultural, municipal, and industrial water users (Reclamation 1997). No major storage or diversion structures have been constructed in the tributary watersheds in this reach of the Sacramento River, although several small diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Flow patterns on one major tributary in this reach, Battle Creek, are undergoing changes as the Battle Creek Salmon and Steelhead Restoration Project is implemented to restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation through the decommissioning of five powerplants.

*Sacramento River from Red Bluff to the Delta*

Between Red Bluff and Colusa, the Sacramento River is a meandering stream, migrating through alluvial deposits between widely spaced levees. From Colusa to the northern boundary of the Delta near Freeport, flows increase due to the addition of the Feather and American rivers flows.

Recent mean daily flows in the Sacramento River at Bend Bridge (near Red Bluff), Vina Bridge (near Tehama), Hamilton City, Wilkins Slough (upstream of the Feather River confluence), Verona (downstream of the Feather River confluence), and Freeport (downstream of the American River Confluence and near the northern boundary of the Delta), are presented on Figures 5.20 through 5.25 (DWR 2013u, 2013v, 2013w, 2013x, 2103y, 2013z). Flows in the Sacramento River generally peak during winter and spring storm events. Upstream of Hamilton City, sharp increases in flow occur during rainfall events, such as events in February 2004, December 2005/January 2006, and January 2010. Downstream of Hamilton City, the high flow events occur over a longer period of time as water flows into the river from the tributaries.

Historically, Reclamation has maintained a minimum flow of 5,000 cfs at Chico Landing to support navigation in accordance with references to Sacramento River Division operations in the River and Harbors Act of 1935 and the Rivers and Harbors Act of 1937. Currently, there is no commercial traffic between Sacramento and Chico Landing, and USACE has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs at the Wilkins Slough gauging station when diversions are occurring downstream, under all but the most critical water supply conditions.

Major diversions in this reach of the Sacramento River include the CVP Red Bluff Pumping Plant, Glenn-Colusa Irrigation District (GCID) intake, and individual diversions for the CVP Sacramento River Settlement Contractors. The Red Bluff Pumping Plant was completed in August 2012 to improve fish passage conditions on the Sacramento River by removing the Red Bluff Diversion Dam, and to continue to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. The GCID Main Pump Station is located near Hamilton City to divert water into the GCID Canal that conveys water to over 130,000 acres, including the USFWS Sacramento National Wildlife Refuge; and terminates at the Colusa Basin Drain near Williams. In 2001, the GCID Fish Screen was completed in addition to several canal improvements to allow year-round water deliveries.

Major streams entering the Sacramento River between Red Bluff and the Feather River include Antelope, Elder, Mill, Thomes, Deer, Stony, Big Chico, and Butte creeks. No major storage or diversion structures have been constructed on Antelope, Elder, Mill, and Thomes creeks, although several small seasonal diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Moderate non-CVP and non-SWP diversion dams are located on Deer, Big Chico, and Butte creeks.

Stony Creek flows are controlled by East Park Dam, Stony Gorge Dam, and Black Butte Dam (Reclamation 1997). East Park and Stony Gorge reservoirs store surplus water for irrigation deliveries and are operated by Reclamation as part of the Orland Project which is independent of the CVP. Black Butte Dam is operated by the USACE for flood control and irrigation supply. Black Butte Dam operations are coordinated with the CVP. The GCID canal, which crosses Stony Creek downstream of Black Butte Dam, includes a seasonal gravel dam constructed across the creek on the downstream side of the canal.

The Sacramento River between Red Bluff and Chico Landing, the Sacramento River Flood Control Project has provided bank protection and incidental channel modification since 1958 (DWR 2013t). Between Chico Landing and Colusa, the flood management facilities consist of levees and overflow areas. Black Butte Reservoir regulates Stony Creek flood flows, which enter the Sacramento River downstream of Hamilton City. Right bank levees from Ord Ferry through Colusa prevent Sacramento River flood water from entering the Colusa Basin, except when flows exceed 300,000 cfs near Ord Ferry (DWR 2013t). Three flood relief weirs along the right bank, downstream of Chico Landing, allow flood flows to spill into the Butte Basin Overflow Area. The left bank levee begins midway between Ord Ferry and Butte City and extends south through Verona, and includes the Moulton and Colusa weirs that allow flood flows to spill into the Butte Basin Overflow Area. The natural Sutter Basin overflow (Sutter Bypass) to the east of the Sacramento River and downstream of the Sutter Buttes was included in the Sacramento River Flood Control Project. The Sutter Bypass conveys floodwaters from the Butte Basin Overflow Area, Butte Creek, Wadsworth Canal, and Reclamation Districts 1660 and 1500 drainage plants, state drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather rivers. Downstream of Colusa, Reclamation Districts 70, 108, and 787 pump flood waters from adjacent closed basin lands into the river.

The Colusa Basin Drain provides drainage for a large portion of the irrigated lands on the western side of the Sacramento Valley in Glenn, Colusa, and Yolo counties; and supplies irrigation water to lands in this area. Water from the drain is discharged to the Sacramento River through the Knights Landing Outfall, a gravity flow structure and prevents the Sacramento River from flowing into the Colusa Basin.

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to evaluate approaches to provide minimum flows at Wilkins Slough of less than 5,000 cfs.

*Yolo Bypass*

Flows from the Sacramento River, Feather River, Sutter Bypass, and Natomas Cross Canal join upstream of Verona on the Sacramento River. When the Sacramento River flows exceed 62,000 cfs, flows spill over the Fremont Weir into the Yolo Bypass. The Yolo Basin was a natural overflow area located to the west of the Sacramento River. The Sacramento River Flood Control Project modified the basin by confining the extent of overflow through a leveed bypass and allowing flood flows to enter the Yolo Bypass from the Sacramento River over the Fremont and Sacramento weirs. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects to the Sacramento River at Rio Vista (DWR 2013t). Tributaries within the Yolo Bypass include the Cache Creek Detention Basin, Willow Slough, and Putah Creek.

Flows also enter the Yolo Bypass from the Colusa Basin, including from the Colusa Basin Drain through the Knights Landing Ridge Cut. In 2011 and 2012, construction at the outfall gates required water from the Colusa Basin Drain to be diverted into the Yolo Bypass. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014).

Historical mean daily flows into the Yolo Bypass at Fremont Weir are presented on Figure 5.26 (DWR 2013aa). Between 2002 and 2012, flows have entered the Yolo Bypass at Fremont Weir during 13 periods, including:

- January 2002 – spill continued for 7 days with flows up to 30,000 cfs
- January 2003 – spill continued for 6 days with flows up to 22,000 cfs
- May 2003 – spill continued for 1 day with flows up to 100 cfs
- January 2004 – spill continued for 3 days with flows up to 3,000 cfs
- February 2004 – spill continued for 20 days with flows up to 79,000 cfs
- May 2005 – spill continued for 4 days with flows up to 35,000 cfs
- January/February 2006 (2 events) – spill continued for a total of 37 days with flows up to 205,000 cfs
- March/April/May 2006 – spill continued for 65 days with flows up to 96,000 cfs
- January 2010 – spill continued for 4 days with flows up to 5,000 cfs
- December 2010 – spill continued for 4 days with flows up to 9,000 cfs
- March/April 2011 – spill continued for 24 days with flows up to 85,000 cfs
- December 2012 – spill continued for 5 days with flows up to 26,000 cfs

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to evaluate approaches to increase acreage of seasonal floodplain rearing habitat with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years. The initial performance measure was defined in the RPA as 17,000 to 20,000 acres of floodplain rearing habitat, such as in the Yolo Bypass, excluding tidally influenced areas. Reclamation also is required to develop enhancement plans for Lower Putah Creek, Liberty Island/Lower Cache Slough, and Lower Yolo Bypass. The plans also are required to develop improvements to Fremont Weir and Lisbon Weir to eliminate migration barriers and stranding potential.

### *Feather River Watershed*

The Feather River, with a drainage area of 3,607 square miles on the east side of the Sacramento Valley, is the largest tributary to the Sacramento River below Shasta Dam (Reclamation 1997, DWR 2007a). The Feather River enters the Sacramento River from the east at Verona. The total flow is provided by the Feather River and tributaries, which include the Yuba and Bear rivers.

#### *Upper Feather River, Lake Oroville, and the Thermalito Complex*

The upper Feather River includes numerous reservoirs and powerplant diversions, including the 1,308-TAF Lake Almanor owned by Pacific Gas & Electric Company; and the SWP Upper Feather River Lakes, including Antelope Lake, Lake Davis, and Frenchman Lake. The major SWP facility on the Feather River is the 3,500-TAF Lake Oroville, which is formed by the Oroville Dam located at the confluence of the North, Middle, and South forks of the Feather River. Lake Oroville stores winter and spring runoff, which is released into the Feather River to meet SWP water demands; provide pumpback capability to allow for on-peak electrical generation; provide 750 TAF of flood control storage, recreation, and freshwater releases to control salinity intrusion in the Delta; and for fish and wildlife protection, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Historical water storage volumes and water storage elevations for Lake Oroville for Water Years 2001 through 2012 are presented on Figures 5.27 and 5.28 (DWR 2013 ab, 2013ac).

A maximum of 17,400 cfs can be released from Lake Oroville through the Edward Hyatt Powerplant, and the Thermalito Power Canal into the Thermalito Diversion Pool. Water continues through the Thermalito Diversion Pool into the Feather River Fish Hatchery and the 11,768-acre-foot Thermalito Forebay formed by the Thermalito Diversion Dam. Water is released from the Thermalito Forebay through the Thermalito Powerplant into the Thermalito Afterbay and the low flow channel of the Feather River.

Historical water storage volumes and water storage elevations for Thermalito Afterbay for Water Years 2001 through 2012 are presented on Figures 5.29 and 5.30 (DWR 2013ab, 2013ac, 2013ad). Water from the afterbay flows into the Feather River. Historical mean daily flows in the Feather River are presented on Figure 5.31 (DWR 2013af). Local agricultural districts divert water directly from the afterbay.

Maximum allowable ramp-down release requirements in the low flow channel of the Feather River are required to prevent rapid reductions in water levels that could potentially cause redd dewatering and stranding of juvenile salmonids and other aquatic organisms. Water releases from Lake Oroville are also affected by temperature criteria, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

Major diversions on the Feather River downstream of the Thermalito Complex include diversions into the Western Canal, Richvale Canal, the Pacific Gas and Electric Company Lateral, and the Sutter-Butte Canal. Some of the water diverted into these canals is exported to the Butte Creek watershed. Riparian water users along the Feather River also divert water for agricultural and municipal uses within the Feather River and Butte Creek watersheds (Reclamation 1997; DWR 2007).

*Lower Yuba River*

The Yuba River watershed extends over 1,339 square miles in the Sierra Nevada. The Yuba River is a major tributary to the Feather River, and historically has contributed over 40 percent of the lower Feather River flows (Reclamation 1997). The major reservoir in the watershed is the 970-TAF New Bullards Bar Reservoir that is owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation (Yuba County Water Agency [YCWA] 2012). The Yuba River watershed also includes over 400 TAF additional storage in reservoirs located upstream of New Bullards Bar Reservoir.

Water is diverted from New Bullards Bar Reservoir through the Colgate Tunnel and Powerhouse and discharged into the Yuba River. The 70-TAF Englebright Lake is formed by the Harry L. Englebright Dam downstream of New Bullards Dam. Englebright Lake was constructed by the California Debris Commission to trap and store sediment from historical hydraulic mining sites in the upper watershed and provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Lake was assumed by the USACE (USACE 2012, 2013, 2014). Major water diversions from the Yuba River occur 12.5 miles downstream of Englebright Dam at Daguerre Point Dam. Water transfers have occurred between Yuba County Water Agency and other water agencies, including CVP and SWP water users, since 2008 under the Lower Yuba River Accord, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations (Lower Yuba River Accord, River Management Team [LYRARMT] 2013).

*American River from Folsom Lake to Sacramento River*

The American River watershed extends over 1,895 square miles and contributes approximately 15 percent of the flow in the lower Sacramento River.

*Folsom Lake and Lake Natoma*

Folsom Lake and Lake Natoma on the American River are located within portions of the American River watershed that could be affected by changes in CVP and/or SWP operations. Folsom Lake is a CVP facility formed by Folsom Dam 7 miles upstream of the CVP Nimbus Dam (Reclamation et al. 2006). Folsom, Lake is the largest reservoir in the American River watershed, and has a capacity of 967 TAF. Numerous smaller reservoirs in the upper basin provide hydroelectric generation and water supply and are not owned or operated by Reclamation or DWR. The total upstream reservoir storage above Folsom Lake is approximately 820 TAF. Ninety percent of this upstream storage is provided by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF).

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate flows of the American River and to direct water into the CVP Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant when releases are less than 5,000 cfs or the spillway gates for higher flows. The American River flows 23 miles between Nimbus Dam and the confluence with the Sacramento River. Historical water storage volumes and water storage elevations for Folsom Lake and Lake Natoma for Water Years 2001 through 2012 are presented on Figures 5.32 through 5.35) (DWR 2013ag, 2013ah, 2013ai, 2013aj). Median daily flows in American River downstream of Nimbus Dam are presented in Figure 5.36 (DWR 2013ak).

Water is diverted to municipal and industrial water users, including water rights holders, upstream of Folsom Dam, from the Folsom South Canal, and from the American River downstream of Folsom Dam. During extreme critical dry years, water elevations in Folsom Lake can be too low for adequate operation of diversion facilities; and Reclamation has provided temporary barges with intake and conveyance facilities to divert water from the lake to the adjacent water users.

*Lower American River Flows*

Flow patterns in the lower American River (downstream of Lake Natoma) are influenced by operations of the CVP both within the American River watershed and within the entire Sacramento River watershed. Flows can be affected by local operations such as flood management requirements at Folsom Lake and Lake Natoma, federal and state flow requirements, temperature requirements and water uses in the American River watershed. Flows can also be affected by delta operations including outflow and salinity requirements as well as exports within and south of the delta. Recent mean daily flows in the American River are presented on Figure 5.36 (DWR 2013ak).

*Lower American River Flood Management*

Flood management requirements and regulating criteria for October 1 through May 31 each year were specified in 1987 by the USACE to manage flooding in the Sacramento area, as practicable; provide maximum amount of water conservation storage in Folsom without impairing the flood control; and provide maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir. Following significant flood events in February 1986 and January 1997, the lower American River flooding issues were analyzed; and revised flood operations criteria were developed by the Sacramento Area Flood Control Agency (SAFCA), as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. The SAFCA release criteria are generally equivalent to the USACE plan, except the SAFCA diagram may prescribe flood releases earlier than the USACE plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 TAF of flood control space in Folsom Reservoir in combination with empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom Reservoir.

Reclamation and USACE constructed an auxiliary spillway under the Joint Federal Project, at Folsom Dam in accordance with the recommendations of the Water Control Manual Update (Reoperation Study). The USACE is also implementing increased system capabilities provided by the authorized features of the Common Features Project to strengthen the American River levees to convey up to 160,000 cfs and completion of the authorized Folsom Dam Mini-Raise Project.

#### *Lower American River Minimum Flow and Temperature Requirements*

The minimum allowable flows in the lower American River are defined by SWRCB Water Right Decision 893 (D-893), which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet CVP water supply and Delta operations objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases generally exceed the D-893 minimum flows in all but the driest of conditions.

Dedication of water in accordance with Section 3406(b)(2) of CVPIA on the American River provides instream flows below Nimbus Dam greater than those that would have occurred under pre-CVPIA conditions, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Instream flow objectives from October through May generally aim to provide suitable habitat for salmon and steelhead spawning, incubation, and rearing, while considering impacts to other CVP and SWP uses. Instream flow objectives for June to September endeavor to provide suitable flows and water temperatures for juvenile steelhead rearing, while balancing the effects on temperature operations into October and November to help support fall-run Chinook Salmon spawning.

In July 2006, Reclamation, the Sacramento Area Water Forum and other stakeholders agreed to a flow and temperature regime (known as the Lower American River Flow Management Standard [FMS]) to improve conditions for fish in the lower American River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Minimum flow requirements during October, November, and December are primarily intended to address fall-run Chinook Salmon spawning, and flow requirements during January and February address fall-run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of fall-run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult fall-run Chinook Salmon immigration.

Water temperature control operations in the lower American River are affected by many factors and operational tradeoffs. These include available cold water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply Temperature Control Device (TCD) management, and Nimbus Hatchery considerations, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Meeting both the summer steelhead and fall salmon temperature objectives without negatively impacting other CVP project purposes requires reserving water in Folsom Lake for use in the fall to provide suitable fall-run Chinook Salmon spawning temperatures. In most years, the volume of cold water is not sufficient to support strict compliance with the summer water temperature target of 65°F at the downstream end of the compliance reach at the Watt Avenue Bridge; while at the same time reserving adequate water for fall releases to protect fall-run Chinook Salmon, or in some cases, continuing to meet steelhead over-summer rearing objectives later in the summer. The Folsom Water Supply Intake TCD has provided additional flexibility to conserve cold water for later use.

*American River Flows to Meet Delta Salinity Requirements*

Folsom Reservoir also is operated by Reclamation to release water to meet Delta salinity and flow objectives established to improve fisheries conditions. Weather conditions combined with tidal action and local accretions from runoff and return flows can quickly affect Delta salinity conditions, and require increases in spring Delta inflow to maintain salinity standards, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. In accordance with Federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Folsom Lake is located closer to the Delta than Lake Oroville and Shasta Lake; therefore, the water generally is first released from Folsom Lake. Water released from Lake Oroville and Shasta Lake generally reaches the Delta in approximately three and four days, respectively. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be reduced.

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to implement the FMS; minimize flow fluctuation effects in the lower American River between January and May; and meet specific temperature requirements in the lower American River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations, through operational modifications of temperature control shutters on Folsom Dam, and installation of structural improvements (TCDs or the functional equivalent) on several intakes in Folsom Lake and Lake Natoma.

#### 5.3.2.2.2 San Joaquin Valley

The San Joaquin Valley is divided into two drainage major drainage basins. The northern drainage basin extends from the San Joaquin River along the southern boundary of the Delta and along the adjacent lands to the San Joaquin River from the northern drainage of the San Joaquin River in Madera County to the southern drainage in Fresno County (DWR 2013a). The northern drainage basin includes the San Joaquin River; five major tributaries that flow from westward from the Sierra Nevada, including Fresno, Chowchilla, Tuolumne, Merced, Stanislaus, and Calaveras rivers; and three major creeks that flow eastward from the Coast Range, including Del Puerto, Orestimba, and Panoche Creek. All flows in the San Joaquin River flow westward to the Delta.

The southern drainage basin (also known as the Tulare Lake Basin) extends into the southern San Joaquin Valley between the Sierra Nevada on the east, Tehachapi Mountains on the south, and the Coast Rage on the west (DWR 2013a). The southern basin includes four major tributaries, including Kings, Kaweah, Tule, and Kern rivers, which drain towards three ancient lakes on the valley floor, including the Tulare, Buena Vista, and Goose lakes. Flows into these lakes have declined as water supply projects and agricultural development has occurred. The northern and southern drainage basins are generally hydrologically separated by a low, broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings rivers. However, in flood years, water flows from the Kings River through the James Bypass and Fresno Slough into the San Joaquin River near Mendota; therefore, the basins become hydrologically connected.

Flows from Fresno, Chowchilla, Tuolumne, Merced, Calaveras, Kings, Kaweah, Tule, and Kern rivers contribute substantial flows into the San Joaquin Valley and affect operations of CVP and SWP water users and operations. However, the operations of reservoirs on these rivers are not modified within the alternatives evaluated in this EIS. Therefore, these rivers are not discussed in this chapter. This chapter will focus on the flows in the San Joaquin and Stanislaus rivers that are affected by changes in CVP and SWP operations considered in the alternatives evaluated in this EIS.

*San Joaquin River*

The San Joaquin River flows 100 miles from Friant Dam to the Delta. Flows in the upper San Joaquin River are regulated by the CVP Friant Dam which forms Millerton Lake. Flows downstream of Friant Dam are influenced by flows from tributary rivers and streams, as described below; including CVP operations of New Melones Reservoir on the Stanislaus River. Flows on the San Joaquin River have recently changed since the expiration of the Vernalis Adaptive Management Plan in 2012.

*Millerton Lake*

Operations of Millerton Lake and the CVP Friant Division will not be modified by changes in CVP and SWP operations under the alternatives considered in this EIS. Therefore, Millerton Lake and Friant Division are not analyzed in this EIS.

The following information is presented to provide a general understanding of Millerton Lake and Friant Division operations as part of the CVP.

Friant Dam is located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. The drainage basin is 1,676 square miles. Millerton Lake, formed by Friant Dam, has a capacity of 520 TAF. Several reservoirs in the upper portion of the San Joaquin River watershed, including Mammoth Pool and Shaver Lake, affect the inflow to Millerton Lake (Reclamation and DWR 2011).

Millerton Lake provides flood control capacity on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals. Flood control storage space in Millerton Lake is based on a complex formula, which considers storage in upstream reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately once every 3 years and are managed based on downstream channel design capacity to the extent possible.

*San Joaquin River from Friant Dam to Mendota Pool*

Historically, in the 40-mile reach between Friant Dam and the Gravelly Ford, flow is influenced by releases from Friant Dam, with minor contributions from agricultural and urban return flows. Gravelly Ford, located downstream of Friant Dam, is a sandy and gravelly section of the San Joaquin River that is subject to high losses of river flow. The 17-mile reach of the San Joaquin River between Gravelly Ford and the Mendota Pool historically has been generally dry since construction of Friant Dam except when flood control flows are released from Millerton Lake. Reclamation releases water from Millerton Lake to comply with Holding Contracts between Reclamation and riparian water right holders downstream of Friant Dam that will provide for at least 5 cfs past each of the Holding Contract diversion locations that extend to Gravelly Ford (San Joaquin River Restoration Program [SJRRP] 2011a). The typical release from Millerton Lake to provide water to water rights holders is approximately 125 cfs (SWRCB 2012).

Two major flood control facilities, the Chowchilla and Eastside bypasses, intercept flows of the San Joaquin, Fresno, and Chowchilla rivers and smaller San Joaquin River tributaries to provide flood protection for downstream agricultural lands. During flood control operations, up to 6,500 cfs of excess flows in the San Joaquin River at Mendota Pool are diverted into the Chowchilla Bypass which conveys water to the Chowchilla River. The East Side Bypass conveys high flows from the Chowchilla River to the San Joaquin River upstream of Fremont Ford. These bypasses are located in highly permeable soils and are used to provide an area for groundwater recharge using flood flows.

The 50-TAF Mendota Pool serves as a forebay for diversions to the Main and Outside canals; and is the termination of the Delta-Mendota Canal, which conveys CVP water from the Delta, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Water also enters

Mendota Pool via Fresno Slough (also known as James Bypass) which conveys flood flows to the San Joaquin River from the Kings River (located in the Tulare Lake Basin). Recent mean daily flows in the San Joaquin River at Mendota are presented on Figure 5.37 (DWR 2013al).

*San Joaquin River Restoration Program: Friant Dam to Confluence of Merced River*

In 2006, parties to *NRDC, et al., v. Rodgers, et al.*, executed a stipulation of settlement that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook Salmon fishery while reducing or avoiding adverse water supply impacts. The SJRRP implements the settlement consistent with the San Joaquin River Restoration Settlement Act in Public Law 111-11. The USFWS issued a Programmatic BO for the implementation of the SJRRP on August 21, 2012 and NMFS issued a Programmatic BO on September 18, 2012 for SJRRP flow releases of up to 1,660 cfs from Millerton Lake into the San Joaquin River. The settlement-required flow targets for releases from Millerton Lake include six water year types for releases depending upon available water supply as measures of inflow to Millerton Lake, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. The Millerton Lake releases include the flexibility to reshape and retime releases forwards or backwards by 4 weeks during the spring and fall pulse periods. Flood flows may potentially occur and meet or exceed the Settlement flow targets. If flood flows meet the settlement flow targets, then Reclamation would not release additional water from Millerton Lake. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the Merced River and releases are limited accordingly. Reclamation has initiated planning and environmental compliance activities to improve river channel conveyance and allow for the full release of SJRRP flows. Diversions and infiltration losses reduce the amount of Settlement flows reaching the San Joaquin River and Merced River confluence. For the purposes of this analysis, flows that reach the Merced confluence are assumed to continue to the Delta.

*San Joaquin River from Merced River to the Delta*

Two major tributaries, the Tuolumne and Stanislaus rivers, join the San Joaquin River between the confluence with the Merced River and Vernalis (located at the southeastern boundary of the Delta). The flows in this reach are influenced by flow and water quality requirements at Vernalis as well as releases from the upstream reach and the two major tributaries. Recent mean daily flows in the San Joaquin River at Vernalis are presented on Figure 5.38 (DWR 2013am).

*Stanislaus River*

The Stanislaus River originates in the western slopes of the Sierra Nevada and drains a watershed of approximately 900 square miles. The median annual unimpaired runoff in the basin is approximately 1.08 MAF per year (SWRCB 2012). Snowmelt from March through early July contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June.

The North, Middle, and South forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. The 2.4 MAF New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus River and the San Joaquin River. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010a). Tulloch Reservoir is owned and operated by the Tri-Dams Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir and Powerplant flows downstream to Goodwin Reservoir where water is either diverted to canals to serve, Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District; or released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012).

Below Goodwin Dam, the lower Stanislaus River flows approximately 40 miles to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals also enter the lower Stanislaus River.

*New Melones Reservoir*

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the Federal Endangered Species Act (ESA) and CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with the SWRCB Decision 1422 (D-1422) and Decision 1616 (D-1616); through protest settlement agreements with Tuolumne and Calaveras Counties; and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Reclamation also is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply.

Required releases include flows to meet flow and water quality requirements included in the SWRCB Revised Decision 1641 (D-1641). This includes dissolved oxygen requirements in the lower Stanislaus River in accordance with the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan; minimum flow requirements in the lower San Joaquin River at Vernalis per SWRCB D-1641; and total dissolved solids requirement in the lower San Joaquin River at Vernalis per SWRCB D-1641.

Reservoir storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Recent water storage volumes and elevations for Water Years 2001 through 2012 in New Melones and Goodwin reservoirs are presented on Figures 5.39 through 5.42 (DWR 2013an, 2013ao, 2013ap, 2013aq). Recent mean daily flows in the Stanislaus River downstream of Goodwin Dam are presented on Figure 5.43 (DWR 2013as).

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to adaptively manage available flows to meet minimum instream flow, ramping flow, pulse flow, floodplain inundation, and geomorphic and function flow patterns, through the following actions. The available flows to meet the 2009 NMFS BO RPA are defined following compliance with water rights needs.

- Minimum base flows to optimize available steelhead habitat for adult migration, spawning, and juvenile rearing by water year type, as measured downstream of Goodwin Dam, as specified in Appendix 2-E of the 2009 NMFS BO RPA.
- Fall pulse flows to improve instream conditions sufficiently to attract steelhead to the Stanislaus River.
- Winter instability flows to simulate natural variability in the winter hydrograph and to enhance access to varied rearing habitats.
- Channel forming and maintenance flows in the 3,000 to 5,000 cfs range in above normal and wet years to maintain spawning and rearing habitat quality after March 1 to protect incubating eggs and to provide outmigration flow cues and late spring flows.
- Outmigration flow cues to enhance likelihood of anadromy.
- Late spring flows for conveyance and maintenance of downstream migratory habitat quality in the lowest reaches and into the Delta.

The 2009 NMFS BO also required Reclamation to meet temperature requirements at Orange Blossom Bridge and Knights Ferry to protect steelhead, as discussed in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Reclamation is also required to evaluate an approach to operate New Melones Reservoir flow releases to achieve floodplain inundation flows and improved freshwater migratory habitat for steelhead. Reclamation also participates in gravel augmentation to improve spawning habitat.

#### 5.3.2.2.3 Delta and Suisun Marsh

The Delta and Suisun Marsh area constitutes a natural floodplain that covers 1,315 square miles and drains approximately 40 percent of the state (DWR 2013a). The Delta and Suisun Marsh have a complex web of channels and islands and is located at the confluence of the Sacramento and San Joaquin rivers.

Historically, the natural Delta system was formed by water inflows from upstream tributaries in the Delta watershed and outflow to Suisun Bay and San Francisco Bay. In the late 1800s, local land reclamation efforts in the Delta resulted in the construction of channels and levees that began altering the Delta's surface water flows. Over time, the natural pattern of water flows continued to change as the result of upper watershed diversions and the construction of facilities to divert and export water through the Delta to areas where supplemental water supplies are needed, including densely populated areas such as San Francisco and Southern California and agricultural regions such as the San Joaquin Valley and Tulare Lake. The SWP and CVP use the Delta as the hub of their conveyance systems to deliver water to large pumps located in the southern Delta.

Inflows to the Delta occur primarily from the Sacramento River system and Yolo Bypass, the San Joaquin River, and other eastside tributaries such as the Mokelumne, Calaveras, and Cosumnes rivers. In general, in any given year, approximately 77 percent of water enters the Delta from the Sacramento River, approximately 15 percent enters from the San Joaquin River, and approximately 8 percent enters from the eastside tributaries (DWR 1994). The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2013a).

Water quality in the Delta is highly variable and strongly influenced by inflows from the rivers and by seawater intrusion into the western and central portions of the Delta during periods of low outflow that may be affected by high volumes of export pumping. The concentrations of salts and other materials in the Delta are affected by river inflows, tidal flows, agricultural diversions, drainage flows, wastewater discharges, water exports, cooling water intakes and discharges, and groundwater accretions. Seawater intrusion into the Delta is dependent on tidal conditions, inflows to the Delta, and Delta channel geometry. Delta channels are typically less than 30 feet deep, unless dredged, and vary in width from less than 100 feet to more than 1 mile. Although some channels are edged with riparian and aquatic vegetation, steep mud or rip-rap covered levees border most channels. To enhance flow and aid in levee maintenance, vegetation is often removed from the channel margins. The tidal currents carry large volumes of seawater back and forth through the San Francisco Bay-Delta Estuary with the tidal cycle. The mixing zone of salt and fresh water can shift 2 to 6 miles daily depending on the tides, and may reach far into the Delta during periods of low inflow.

Salinity objectives adopted by the SWRCB were established to protect beneficial uses, including agricultural and municipal water supplies, and fisheries. The CVP and SWP facilities are operated to comply with the requirements that would protect the Delta water quality, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. These operational requirements affect the hydrology in the Delta.

Hydrological conditions in the Delta and Suisun Marsh are substantially affected by structures that route water through the Delta towards the major Delta water diversions in the south Delta, including the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the Delta-Mendota/California Aqueduct Intertie, the CVP Contra Costa Canal Pumping Plant at Rock Slough, and the Contra Costa Water District (CCWD) intakes on Old and Middle rivers; while protecting Delta water quality for these intakes, the SWP Barker Slough Pumping Plant in the north Delta and over 1,800 municipal and agricultural in-Delta diversions (DWR 2010b). These structures include the Delta Cross Channel and temporary barriers in the south Delta. Diversion patterns for the major facilities also are regulated to maintain Delta water quality and to protect fish that are listed as threatened or endangered species under ESA in accordance with the SWRCB D-1641, 2008 USFWS BO, and the 2009 NMFS BO. The diversion patterns are implemented to maintain ratios of exports of the CVP and SWP facilities to the Delta inflow; ratios of San Joaquin River inflow to Delta exports; and reverse flow conditions in Old and Middle rivers (known as the OMR criteria). Operations of the Jones and Banks pumping plants are affected by downstream CVP and SWP water demands and reservoir operations in San Luis Reservoir that is jointly used by the CVP and SWP.

Facilities implemented in Suisun Marsh also affect hydrologic and water quality conditions throughout the Delta. To meet the Delta water quality requirements and water rights requirements of users located upstream of the Delta, the CVP and SWP are operated in a coordinated manner in accordance with Coordinated Operation Agreement (COA), as described in the following section.

*Delta Cross Channel*

The Delta Cross Channel (DCC) is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small craft, and is used extensively by recreational boaters and fishermen whenever it is open. The SWRCB D-1641 requires closure of the DCC gates for fisheries protection as follows.

- From November through January, the DCC may be closed for up to 45 days for fishery protection purposes.
- From February 1 through May 20, the gates are closed for fishery protection purposes.
- The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 time period.

*Implementation of 2009 National Marine Fisheries Service Biological Opinion*

The 2009 NMFS BO RPA requires Reclamation to close the DCC for additional days from October 1 through November 30, if fish are present; December 1 through December 14, unless closures cause adverse impacts on water quality conditions; and December 15 through January 31.

*Temporary Agricultural Barriers*

The DWR South Delta Temporary Barrier Project (TBP) was initiated in 1991to seasonally construct and demolish four rock barriers across south Delta channels, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. In various combinations, these barriers improve water levels and San Joaquin River salmon migration in the south Delta. The existing TBP consists of installation and removal of temporary rock barriers at the following locations.

- Middle River near Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- The head of Old River (HOR) at the confluence of Old River and San Joaquin River.

The barriers on Middle River, Old River near Tracy, and Grant Line Canal are flow control facilities designed to improve water levels for agricultural diversions and are in place during the irrigation season. The Head of Old River Barrier (HORB) is only installed from early September to November 30th when requested by CDFW if needed to improve dissolved oxygen in the San Joaquin River. The HORB also has been installed in the spring months to improve outmigrating conditions for juvenile salmonids.

The agricultural barriers at Middle River and Old River near Tracy can be installed as early as March 1 if the HORB is installed; and can be fully operated as early as April 1, if the HORB is installed, or May 15, if the HORB is not installed. From May 15 to May 31 (if the barrier at the head of Old River is removed), the barrier tide gates are tied open in Middle River and Old River near Tracy. After May 31, the barriers in Middle River, Old River near Tracy, and Grant Line Canal are permitted to be operational until they are completely removed by November 30.

*Major Delta Water Diversions*

Major water diversions in the Delta include the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the CVP Contra Costa Canal Pumping Plant at Rock Slough, the SWP Barker Slough Pumping Plant for the North Bay Aqueduct, Contra Costa Water District intakes on Old and Middle rivers, and over 1,800 municipal and agricultural diversions for in-Delta use (DWR 2010b).

Delta channels have been modified to allow transport of Delta inflow to the diversions throughout the Delta, including the CVP and SWP south Delta intakes, and to reduce the effects of pumping on the direction of flows and salinity intrusion within the Delta. The conveyance of water from the Sacramento River southward through the Delta to the CVP and SWP south Delta intakes is aided by the Delta Cross Channel (DCC), a constructed, gated channel that conveys water from the Sacramento River to the Mokelumne River.

*CVP Jones Pumping Plant*

The CVP Jones Pumping Plant, located about 5 miles north of Tracy, has a permitted diversion capacity of 4,600 cfs and sits at the end of a 2.5-mile long earth-lined intake channel that extends to Old River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Water diverted at the Jones Pumping Plant is discharged to the CVP Delta-Mendota Canal (DMC) which extends 117 miles to the Mendota Pool. Water from Jones Pumping Plant may be pumped from the DMC O'Neill Forebay, and then pumped into San Luis Reservoir by the Gianelli Pumping-Generating Plant. The DMC has an initial capacity of 4,600 cfs at Jones Pumping Plant that decreases to about 3,200 cfs at its terminus.

*SWP Clifton Court and Banks Pumping Plant*

The SWP facilities in the southern Delta include the 31-TAF Clifton Court Forebay (CCF), located about 10 miles northwest of the city of Tracy, and the Banks Pumping Plant, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Water is diverted from Old River into CCF that provides storage for off-peak pumping, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment upstream of the Banks Pumping Plant and the California Aqueduct. Water flows from CCF to Banks Pumping Plant which conveys the water to California Aqueduct. The California Aqueduct transports water to O'Neill Forebay, from which water can be released to the San Luis Canal, a portion of the California Aqueduct jointly owned by the SWP and CVP; or pumped into San Luis Reservoir at the Gianelli Pumping Plant. Water from San Luis Reservoir is released into the San Luis Canal which ends near Kettleman City. From that location, the California Aqueduct continues to southern California.

The nominal capacity of the Banks Pumping Plant is 10,300 cfs. Permits issued by the USACE regulate the rate of diversion of water into CCF. This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to CCF and 6,993 cfs as a one-day average inflow to CCF. CCF diversions may be greater than these rates between December 15 and March 15, when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis when those flows are equal to or greater than 1,000 cfs.

In 2000, the maximum diversion rate was increased for the months of July, August, and September through 2016 to recover export reductions that occurred due to actions taken to benefit fisheries resources. The expanded maximum allowable daily diversion rate into CCF was increased from 13,870 acre-feet to 14,860 acre-feet and three-day average diversions from 13,250 acre-feet to 14,240 acre-feet (500 cfs per day equals 990 acre-feet per day). Implementation of this action is contingent on meeting the following conditions.

- The increased diversion rate will not result in greater annual SWP water supply allocations than would occur in the absence of the increased diversion rate. Water pumped due to the increased capacity will only be used to offset reduced diversions that occurred or will occur because of actions taken to benefit fisheries.
- Use of the increased diversion rate will be in accordance with all terms and conditions of existing BOs governing SWP operations.
- All three temporary agricultural barriers (Middle River, Old River near Tracy and Grant Line Canal) must be in place and operating when SWP diversions are increased.

Between July 1 and September 30, if the combined salvage of listed fish species reaches a level of concern, the relevant fish regulatory agencies will determine whether the 500 cfs increased diversion is or continues to be implemented. Variations to hydrologic conditions coupled with regulatory requirements may limit the ability of the SWP to fully utilize the proposed increased diversion rate. Also, facility capabilities may limit the ability of the SWP to fully utilize the increased diversion rate. The CCF radial gates are closed during critical periods of the ebb/flood tidal cycle to protect water levels relied upon by local agricultural water diverters in the south Delta area.

Banks Pumping Plant is operated to minimize the impact on power loads on the California electrical grid to the extent practical. Generally more pump units are operated during off-peak periods and fewer during peak periods with water stored temporarily in CCF. Because the installed capacity of the pumping plant is 10,300 cfs, the plant can be operated to reduce power grid impacts by running all available pumps at night and fewer during the higher energy-demand hours.

*SWP Barker Slough Pumping Plant*

The SWP Barker Slough Pumping Plant (BSPP) diverts water from Barker Slough into the SWP North Bay Aqueduct (NBA) for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. The current 162.5-cfs NBA intake with a positive barrier fish screen, located approximately 10 miles from the Sacramento River at the end of Barker Slough.

The NBA was designed to deliver up to 131,181 acre-feet per year SWP water supply contracts. However, the ability of BSPP to deliver this amount of water is limited due to several factors. The current BSPP pumping capacity is limited due to a thick bio-film growth on the interior of the NBA pipeline and a need to reduce the pressure in the pipeline within safe limits. Water quality in Barker Slough becomes degraded during winter and spring rainfall events due to elevated levels of coliform bacteria, organic matter, turbidity, and pollutants from the upstream watershed, which limits the period of time that the BSPP can be operated each year. In 2008, USFWS issued a BO for preservation of delta smelt that reduced the total BSPP annual diversion to 71 TAF. In 2009, CDFW issued an incidental take permit for the preservation of longfin smelt that restricted pumping rates during dry and critical dry years from January 15 to March 31. As tidal wetlands in Suisun Marsh and Cache Slough and floodplains in the Yolo Bypass are restored in accordance with the 2008 USFWS BO and 2009 NMFS BO, respectively, Delta smelt, longfin smelt and salmonid populations in the Barker Slough area are anticipated to increase which could further restrict diversions at BSPP.

*Contra Costa Water District Intakes*

The CCWD diverts approximately 127 TAF per year, including approximately 110 TAF under the CVP water service contract. The CCWD diverts water at the CVP Rock Slough Intake, and at the CCWD Mallard Slough, Old River, and Middle River (on Victoria Canal) intakes, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Water diverted at Mallard Slough, Old River, and Middle River intakes occur under water rights issued by the SWRCB to CCWD. Water diverted at Rock Slough, Old River, and Middle River intakes occur under water rights issued by the SWRCB to Reclamation for the CVP. All four intakes have positive barrier fish screens. Water from the Old River and Middle River intakes can be diverted to the 160-TAF Los Vaqueros Reservoir when Delta salinity is low. When Delta salinity is high, typically in the fall months, CCWD blends low salinity water from Los Vaqueros Reservoir with water from the Delta to meet CCWD water quality goals. Water from Los Vaqueros Reservoir is also used by CCWD when Delta diversions are restricted.

The Mallard Slough Intake, located on a channel that extends to Suisun Bay (across from Chipps Island), can divert water into the CCWD conveyance system, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Generally, less than 3 percent of CCWD diversions are from Mallard Slough intake due to high salinity in Suisun Bay from late spring until winter.

The CVP Rock Slough Intake, located about four miles southeast of Oakley, can divert into the CVP Contra Costa Canal for conveyance into the CCWD water system. CCWD may divert approximately 30 percent to 50 percent of its total supply through the Rock Slough Intake depending upon salinity.

The Old River Intake, located on Old River near State Route 4, can divert water to the CVP Contra Costa Canal or to the 160-TAF Los Vaqueros Reservoir. Diversion to Los Vaqueros Reservoir storage is limited to 200 cfs by the terms of the Los Vaqueros Project BOs and SWRCB Decision 1629 (D-1629), the water right decision for the Los Vaqueros Project.

The Middle River Intake (formerly referred to as Alternative Intake Project), located on Victoria Canal, diverts water to the Contra Costa Canal or to

Los Vaqueros Reservoir. Salinity at the Middle River Intake is generally lower in the late summer and fall than at the other intakes. Therefore, CCWD can decrease winter and spring diversions while still meeting water quality goals in the summer and fall through use of the Middle River Intake.

*Delta-Mendota Canal/California Aqueduct Intertie*

The DMC/California Aqueduct Intertie between the DMC and the California Aqueduct allows water to flow in both directions between the CVP and SWP conveyance facilities, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. The DMC/California Aqueduct Intertie achieves multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies. The DMC/California Aqueduct Intertie can be used under one of the following three different scenarios.

- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to ease DMC conveyance constraints related to Jones Pumping Plant capacity limitations.
- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the Intertie) or the upper California Aqueduct (north of the Intertie) for system maintenance or due to an emergency shutdown.
- Up to 900 cfs may be conveyed from the California Aqueduct to the DMC using gravity flow to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower California Aqueduct (downstream of the Intertie) or the upper DMC (upstream of the Intertie) for system maintenance or for an emergency shutdown.

*San Luis Reservoir*

The 2.027-MAF San Luis Reservoir, formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF used by the CVP and 1.062 MAF used by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports.

When all SWP demands are met, including diversion to storage facilities south of the Delta and Table A demands, and the Delta is in excess conditions, DWR would use available excess pumping capacity at Banks Pumping Plant to make excess water supplies, called Article 21 water under the long-term SWP water supply contracts, available to the SWP Contractors. Article 21 of the SWP water contracts describes the conditions under which water can be delivered in addition to the amounts specified in Table A of the contracts.

Unlike Table A water, which is an allocated annual SWP supply made available for scheduled delivery throughout the year, Article 21 water is an interruptible water supply made available only when certain conditions exist. However, while not a dependable supply, Article 21 water is an important part of the total SWP supplies provided to the SWP contractors. As with all SWP water, Article 21 water is pumped consistent with the existing terms and conditions of SWP water rights permits, and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP operations.

Article 21 water is only available as long as the required conditions exist as determined by DWR. As Article 21 deliveries are in addition to scheduled Table A deliveries, this supply is delivered to SWP contractors that can, on relatively short notice, put it to beneficial use. SWP contractors have used Article 21 water to meet needs such as additional short-term irrigation demands, replenishment of local groundwater basins, short-term substitution of local supplies and storage in local surface reservoirs for later use by the requesting SWP contractor, all of which provide SWP contractors with opportunities for better water management through more efficient coordination with their local water supplies. Allocated Article 21 water to a SWP contractor cannot be transferred.

Article 21 water is typically offered to SWP contractors on a short-term (daily or weekly) basis when all of the following conditions exist: the SWP share of San Luis Reservoir is physically full, or projected to be physically full; other SWP reservoirs south of the Delta are at their storage targets or the SWP conveyance capacity to fill these reservoirs is maximized; the Delta is in excess condition; current Table A and SWP operational demands are being fully met; and Banks Pumping Plant has export capacity beyond that which is needed to meet all Table A and other SWP operational demands. The increment of available unused Banks Pumping Plant capacity is offered as the Article 21 delivery capacity. SWP contractors then indicate their desired rate of delivery of Article 21 water. DWR allocates the available Article 21 water in proportion to the requesting SWP contractors annual Table A amounts if requests exceed the amount offered. Deliveries can be discontinued at any time when SWP operations change. In the modeling for Article 21, deliveries are only made in months when the SWP share of San Luis Reservoir is full. In actual operations, Article 21 may be offered a short period in advance of actual filling.

By April or May, demands from both agricultural and M&I SWP Contractors usually exceed the pumping rate at Banks Pumping Plant, and releases from San Luis Reservoir to the SWP facilities are needed to supplement the Delta pumping at Banks Pumping Plant to meet SWP contractor demands for Table A water.

Historical water storage volumes and water storage elevations for San Luis Reservoir for Water Years 2001 through 2012 are presented on Figures 5.44 and 5.45 (DWR 2013as, 2013at).

The San Luis Complex consists of the following.

- O’Neill Pumping-Generating Plant (CVP facility)
- William R. Gianelli Pumping-Generating Plant (joint CVP and SWP facility)
- San Luis Canal (joint CVP and SWP facility)

- Dos Amigos Pumping Plant (joint CVP and SWP facility)
- Coalinga Canal (CVP facility)
- Pleasant Valley Pumping Plant (CVP facility)
- Los Banos and Little Panoche Detention Dams and Reservoirs (joint CVP and SWP facilities)

The CVP diverts water from San Luis Reservoir by the Pacheco Pumping Plant through the Pacheco Tunnel and Pacheco Conduit that conveys water to CVP water service contractors in Santa Clara and San Benito counties, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Regulatory Limitations on Operations of Delta Water Diversions*

Operations of the CVP and SWP are implemented in accordance with SWRCB water rights and water quality decisions, including SWRCB D-1641, and the 2008 USFWS BO and 2009 NMFS BO.

*Decision 1641*

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995, which became the basis of SWRCB D-1641 (adopted on December 29, 1999 and revised on March 15, 2000). The SWRCB D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. SWRCB also grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641. The SWRCB adopted a revised Bay-Delta Plan on December 13, 2006; however, there were no changes to the beneficial uses or water quality objectives. The changes were primarily to improve readability and consistency to reflect current physical conditions and other regulations.

The requirements in SWRCB D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type. One of the requirements is to provide a minimum flow on the Sacramento River at Rio Vista in September through December of 3,000 to 4,500 cfs, depending on the month and water year type, to protect water quality for Delta water users.

The SWRCB D-1641 includes two Delta outflow criteria. A Net Delta Outflow Index is specified for all months in all water year types. A “spring X2” Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an “X2” location. X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the

Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs; the X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

During February through June, SWRCB D-1641 also limits CVP and SWP exports as compared to Delta inflows (also known as the "E/I Ratio") to reduce potential impacts on migrating salmon and spawning Delta smelt, Sacramento Splittail, and Striped Bass.

Historical mean daily Delta outflow flows for Water Years 2001 through 2012 are presented on Figure 5.46 (DWR 2013au).

Historical mean daily flows for Water Years 2001 through 2012 are presented on Figures 5.46 through 5.52 for diversions at Jones, Banks, Barker Slough, and Contra Costa Canal pumping plants; and Contra Costa Water District intakes at Old River and Middle River (DWR 2013av, 2103aw, 2013ax, 2013ay, 2013az, 2013ba).

*Joint Point of Diversion*

SWRCB D-1641 authorized the SWP and CVP to jointly use both Jones and Banks pumping plants in the southern Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1—for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery and Musco Family Olive Company), and to recover export reductions implemented to benefit fish;
- Stage 2—for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3—for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the Project with the deficit in San Luis storage may elect to pursue the use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies;

- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and
- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each stage of JPOD has regulatory terms and conditions that must be satisfied in order to implement JPOD. All stages require a response plan to ensure water elevations in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan); and a response plan to ensure the water quality in the southern and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and central Delta. Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water (Fisheries Response Plan). Stage 3 has an additional requirement to protect water levels in the southern Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project, and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta smelt.

*Implementation of 2008 USFWS and 2009 NMFS Biological Opinions*

The 2008 USFWS BO and the 2009 NMFS BO restrict CVP and SWP diversions to reduce reverse flows in OMR. The 2008 USFWS BO also includes criteria for fall Delta outflow. The 2009 NMFS BO includes criteria for a San Joaquin River Inflow/Export (I:E) ratio.

*2008 USFWS BO OMR Criteria*

The 2008 USFWS BO restricts south Delta pumping to preserve certain OMR flows as prescribed in the following three actions.

- **Action 1:** to protect adult Delta smelt migration and entrainment. Limits exports so that the average daily OMR flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).
  - December 1 to December 20 – Based upon turbidity data from turbidity stations (Prisoner’s Point, Holland Cut, and Victoria Canal) and salvage data from CVP and SWP fish handling facilities at the south Delta intakes, and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, Fall Midwater Trawl Survey (FMWT), and river flows.
  - After December 20 – The action will begin if the three-day average turbidity at Prisoner’s Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTU).

- Triggers would be based on:
  - Three-day average of 12 NTU or greater at all three turbidity stations; or
  - Three days of delta smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value of greater than or equal to 0.5 (daily delta smelt salvage is greater than one-half prior year FMWT index value). The window for triggering Action 1 concludes when either off-ramp condition described below is met. These off-ramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered, unless the Service concludes on the basis of the totality of available information that Action 2 should be implemented instead.
- Action 1 offramps occur when water temperature reaches 12 degrees Centigrade (°C) based on a three station daily mean at the temperature stations: Mossdale, Antioch, and Rio Vista; or the onset of spawning based upon the presence of spent females in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

- **Action 2:** to protect adult Delta smelt migration and entrainment. An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions. The range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions, specific OMR flows within this range are recommended by the USFWS Smelt Working Group (SWG) from the onset of Action 2 through its termination. The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The USFWS will make the final determination.
  - Action 2 begins immediately following Action 1. If Action 1 is not implemented based upon triggers, the SWG may recommend a start date for Action 2.
  - Action 2 is suspended when whenever a three-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of Action 2 are restarted.
  - Offramps for Action 2 are related to water temperature reaches 12°C based on a three-station daily average at the temperature stations: Rio Vista, Antioch, and Mossdale; or the onset of spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

- **Action 3:** to protect larval and juvenile Delta Smelt. Minimize the number of larval delta smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval delta smelt. Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. Depending on extant conditions, specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination.
  - Action 3 begins when temperature reaches 12°C based on a three-station average at the temperature stations: Mossdale, Antioch, and Rio Vista; or onset of spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.
  - Offramps for Action 3 would occur by June 30; or if water temperature reaches a daily average of 25°C for three consecutive days 10 at Clifton Court Forebay.

*2009 NMFS BO OMR Criteria*

The 2009 NMFS BO includes OMR criteria to protect juvenile salmonids during winter and spring emigration downstream into the San Joaquin River, and to increase survival of salmonids and green sturgeon entering the San Joaquin River from Georgiana Slough and the lower Mokelumne River by reducing the potential for entrainment at the south Delta intakes. The action is implemented from January 1 through June 15, and reduces exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow is managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range is determine based on the decision tree presented in Table 5.8.

**Table 5.8 Old and Middle River Criteria under the 2009 NMFS BO**

| Date | Action Triggers | Action Responses |
|---|---|---|
| January 1 – June 15 | January 1 – June 15 | -5,000 cfs |
| January 1 – June 15 First Stage Trigger (increasing level of concern) | Daily SWP/CVP older juvenile loss density (fish per TAF): 1) is greater than incidental take limit divided by 2000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily measured fish density divided by 12 TAF, or 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 TAF. | -3,500 to -5,000 cfs |
| January 1 – June 15 Second Stage Trigger (analogous to high concern level) | Daily SWP/CVP older juvenile loss density (fish per TAF) is: 1) greater than incidental take limit divided by 1000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily fish density divided by 8 TAF, or 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 TAF. | -2,500 to -5,000 cfs |
| End of Triggers | Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72ºF (22ºC) for 7 consecutive days (1 week), whichever is earlier. | No OMR restriction |

*2009 NMFS BO San Joaquin River Inflow:Export Ratio*

The 2009 NMFS BO requires south Delta exports to be reduced during April and May to protect emigrating steelhead from the lower San Joaquin River into the south Delta channels and intakes. The I:E ratio from April 1 through May 31 specifies that Reclamation operates the New Melones Reservoir to maintain the 2009 NMFS BO flow schedule for the Stanislaus River at Goodwin in accordance with Action III.1.3 and Appendix 2-E of the 2009 NMFS BO. In addition, the CVP and SWP pumps are operated to meet the ratios based upon a 14-day running average, as summarized in Table 5.9.

**Table 5.9 Inflow:Export Ratios under the 2009 NMFS BO**

| San Joaquin Valley Classification | San Joaquin River flow at Vernalis (cfs):CVP/SWP combined export ratio (cfs) |
|---|---|
| Critically dry | 1:1 |
| Dry | 2:1 |
| Below normal | 3:1 |
| Above normal | 4:1 |
| Wet | 4:1 |
| Vernalis flow equal to or greater than 21,750 cfs | Unrestricted exports until flood recedes below 21,750 cfs. |

During multiple dry years, the ratio will be limited to 1:1 if the New Melones Index related to storage is less than 1,000 TAF and the sum of the "indicator" numbers established for water year classifications in SWRCB D-1641 (based on the San Joaquin Valley 60-20-20 Water Year Classification in SWRCB D-1641) is greater than 6 for the past two years and the current year. The indicator numbers are 1 for a critically dry year, 2 for a dry year, 3 for a below normal year, 4 for an above normal year, and 5 for a wet year.

Implementation of the I:E ratio under all conditions would allow a minimum pumping rate of 1,500 cfs to meet public health and safety needs of communities that solely rely upon water diverted from the CVP and SWP pumping plants.

*2008 USFWS BO Fall X2 Criteria*

The 2008 USFWS BO also includes an additional Delta salinity requirement in September and October in wet and above normal water years. This new requirement is frequently referred to as "Fall X2." The action requires that 2 Practical Salinity Units (psu) is maintained at 74 kilometers (km) during wet years, and 81 km during above normal water years when the preceding year was wet or above normal based upon the Sacramento Basin 40-30-30 index in the SWRCB D-1641. In November of these years, there is no specific X2 requirement; however, there is a requirement that all inflow into SWP and CVP upstream reservoirs be conveyed downstream to augment Delta outflow to maintain X2 at the locations in September and October. If storage increases during November under this action, the increased storage volume is to be released in December in addition to the requirements under SWRCB D-1641 net Delta Outflow Index.

*Coordinated Operation Agreement*

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the COA. The CVP and SWP are also operated under the SWRCB decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

*Obligations for In-Basin Uses*

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the SWRCB D-1485.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equals the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to make additional releases. In excess water conditions, water accounting is not required and some of the excess water is available to CVP water contractors, SWP water contractors, and users located upstream of the Delta. However, during balanced water conditions, CVP and SWP share the responsibility in meeting in-basin uses.

When water must be withdrawn from reservoir storage to meet in-basin uses, 75 percent of the responsibility is borne by the CVP and 25 percent is borne by the SWP. When unstored water is available for export (i.e., Delta exports exceed storage withdrawals while balanced water conditions exist), the sum of CVP stored water, SWP stored water, and the unstored water for export is allocated 55/45 to the CVP and SWP, respectively. The percentages and ratios included in the COA were derived from negotiations between Reclamation and DWR for SWRCB D-1485 standards and CVP and SWP annual supplies existing at the time and projected into the future. Reclamation and DWR have continued to apply these ratios as new SWRCB standards and other statutory and regulatory changes have been adopted.

*Accounting and Coordination of Operations*

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other's facilities for pumping and wheeling. During balanced water conditions, daily water accounting is maintained for the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days' travel time from the Delta.

The accounting language of the COA provides the mechanism for determining the responsibility of each project for Delta outflow influenced standards; however, real-time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow required to maintain standards. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. Lake Oroville water releases require about three days to reach the Delta, while water released from Shasta Lake requires five days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. Any imbalance in meeting each project's initial shared obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. Increasing or decreasing project exports can also immediately achieve changes to Delta outflow. As with changes in reservoir releases, imbalances in meeting the CVP and SWP initial shared obligations are captured by the COA accounting.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions.

*Joint Facilities in Suisun Marsh*

The Suisun Marsh Preservation Agreement (SMPA) requires DWR and Reclamation to meet salinity standards, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements in accordance with SWRCB D-1641 to implement and operate physical facilities in the Marsh; and management of Delta outflow.

*Suisun Marsh Salinity Control Gates*

The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about two miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west. When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately 5,000 to 6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000 to 6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500 to 2,800 cfs. The USACE permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as October 1, although in some years (e.g., 1996) the gate was not operated at all. When the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season, CVP and SWP provide unrestricted movement through Montezuma Slough.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at moving the salinity downstream in Montezuma Slough. Salinity is reduced by roughly 100 percent at Belden's Landing, and by lesser amounts farther west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow (measured nominally at Chipps Island) is reduced by gate operation. Net outflow through Carquinez Strait is not affected. The SMSCG are operated during the salinity control season, which spans from October to May.

*Roaring River Distribution System*

The Roaring River Distribution System (RRDS) was constructed during 1979 and 1980 to provide lower salinity water to 5,000 acres of private and 3,000 acres of CDFW-managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly islands.

The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides.

Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

*Morrow Island Distribution System*

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 in the southwestern Suisun Marsh to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough.

The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles long and the C-Line ditch is approximately 0.8 miles long.

#### *5.3.2.3 CVP and SWP Conveyance Facilities Downstream of San Luis Reservoir*

Water is released from the San Luis Reservoir into the lower portion the California Aqueduct that extends to Lake Perris in Riverside County and delivers water to the San Joaquin Valley, Central Coast, and southern California. The first reach of the California Aqueduct, the San Luis Canal, is jointly owned by the SWP and CVP and extends from San Luis Reservoir to Kettleman City. This reach includes Dos Amigos, Buena Vista, Teerink, and Chrisman pumping plants.

Near Kettleman City, water is diverted into the SWP Coastal Branch Aqueduct to serves agricultural areas west of the California Aqueduct and communities in San Luis Obispo and Santa Barbara counties.

The California Aqueduct continues into southern California through the Edmonston Pumping Plant, located at the foot of the Tehachapi Mountains, that raises the water 1,926 feet into approximately 8 miles of tunnels and siphons that convey water into Antelope Valley. At that location, the California Aqueduct divides into two branches; the East Branch and the West Branch.

The East Branch conveys water through the Tehachapi East Afterbay, Alamo Powerplant, Pearblossom Pumping Plant, and Mojave Siphon Powerplant into Silverwood Lake in the San Bernardino Mountains, which stores 73,000 acre-feet of water. From Silverwood Lake, water flows through the San Bernardino Tunnel into Devil Canyon Powerplant to Lake Perris. Lake Perris, located near the City of Riverside, provides up to 131,500 acre-feet of storage, and serves as a regulatory and emergency water supply facility for the East Branch. The Phase I of the East Branch Extension was completed in 2003 and conveys water to San Gorgonio Pass Water Agency and the eastern portion of the San Bernardino Valley Municipal Water District.

The West Branch conveys water through Oso Pumping Plant, Quail Lake, Lower Quail Canal, and William E. Warne Powerplant into Pyramid Lake in Los Angeles County. Water from Pyramid Lake is conveyed through the Angeles Tunnel, Castaic Powerplant, Elderberry Forebay, and Castaic Lake. Castaic Lake, located north of the City of Santa Clarita, provides 324,000 acre-feet of storage, and is a regulatory and emergency water supply facility for the West Branch. The Castaic Powerplant is owned and operated by the Los Angeles Department of Water and Power.

#### *5.3.2.4 Non-CVP and SWP Reservoirs that Store CVP and SWP Water*

The CVP and SWP water is delivered to water agencies. Some of those water agencies store the water in regional and local reservoirs. These reservoirs frequently store non-CVP and SWP water supplies, including local runoff or water diverted under separate water rights or contracts. The capacities of these reservoirs are listed in Tables 5.5, 5.6, and 5.7.

In the San Francisco Bay Area Region, CVP water is stored in the Contra Costa Water District Los Vaqueros Reservoir and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. The Los Vaqueros Reservoir, as previously described, also stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District reservoirs primarily store water diverted under water rights on the Mokelumne River.

In the Central Coast Region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California Region, SWP water is stored in the Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner; United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, Lower Otay, Hodges, and Murray reservoirs; Helix Water District's Lake Jennings; Sweetwater Authority's Sweetwater Reservoir; and San Diego County Water Authority's Olivenhain Reservoir. There are future plans to expand local and regional water surface water storage.

### 5.3.3 Water Supplies Used by Central Valley Project and State Water Project Water Users

The CVP and SWP water supplies are the only water supplies available to some water users, many of the CVP Sacramento River Settlement Contractors, communities near Redding (Centerville, Clear Creek, and Shasta community services districts; Shasta County Water Agency), communities in the San Joaquin Valley (cities of Avenal, Coalinga, and Huron), and some communities served by the Antelope Valley-East Kern Water Agency. Other CVP and SWP water users rely upon other surface water supplies and groundwater. However, when the CVP and SWP water supplies are limited due to climate conditions and hydrology, the other surface water supplies are also limited.

Several CVP and SWP water users also rely upon other imported water supplies, including water from Solano Project (used by the Solano County Water Agency), San Francisco Public Utilities Commission (used by portions of the service areas of Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency), and the Colorado River (used by portions of the service area of the Metropolitan Water District of Southern California and Coachella Valley Water District). These surface water supplies are also subject to reductions due to hydrologic conditions. In the case of water users that rely upon Colorado River water supplies, Delta water is used to dilute the salts and trace elements (e.g., selenium) in the Colorado River water in addition to providing direct water supplies (Reclamation 2012).

In response to recent reductions in CVP and SWP water supply reliability, water agencies have been improving regional and local water supply reliability through enhanced water conservation efforts, wastewater effluent and stormwater recycling, construction of surface water and groundwater storage facilities, and construction of desalination treatment plants for brackish water sources and ocean water sources. In addition, many agencies have constructed conveyance facilities to allow sharing of water supplies between communities, including the recent Bay Area Regional Water Supply Reliability project that provided conveyance opportunities between several CVP and SWP water users in the San Francisco Bay Area Region.

Water conservation is an integral part of water management in the study area. Water use efficiency programs and initiatives reduce the need for more expensive water supplies by facilitating the efficient use of existing water supplies. For example, a cost-effective component of many water plans is to reduce water use through educational tools that include commercial and residential guidance for water efficient landscapes, water use calculators for agricultural and municipal users, and conservation websites. All of these efforts are implemented to meet the statewide goals to reduce municipal per capita water use by 20 percent by 2020 and to optimize agricultural water use efficiency.

Water transfers also are an integral part of water management. Historically, water transfers primarily were in-basin transfers (e.g., Sacramento Valley water seller to Sacramento Valley water user) (Reclamation 2013b; DWR, Reclamation, USFWS and NMFS 2013). However, between 2001 and 2012, water transfers from the Sacramento Valley to the areas located south of the Delta of up to 298,806 acre-feet occurred (not including water transfers under the Environmental Water Account Program in the early 2000s) (DWR, Reclamation, USFWS and NMFS 2013). These transfers occurred in drier years. In the 2012 and 2013, the following types of water transfers occurred (DWR and SWRCB 2014).

- Water transfers involving CVP and SWP water:
  - 2012: 47,420 acre-feet of water transfers (43 percent were between agricultural water users, 36 percent were between municipal water users, and 21 percent were between agricultural and municipal water users).
  - 2013: 63,790 acre-feet of water transfers (28 percent were between agricultural water users, and 72 percent were between agricultural and municipal water users).
- Water transfers involving non-CVP and SWP water:
  - 2012: 188,074 acre-feet of water transfers (72 percent were between agricultural water users, 14 percent were from agricultural water users to

wildlife refuges, and 14 percent were between agricultural and municipal water users).

- 2013: 268,370 acre-feet of water transfers (72 percent were between agricultural water users, 1 percent were from agricultural water users to wildlife refuges, and 27 percent were between agricultural and municipal water users).

Until recently, most of the water transfers extended for one or two years. In 2008, one of the first long-term water transfer agreements was approved by the SWRCB for the Lower Yuba River Accord. The plan was designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water users, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. In 2013, Reclamation approved an overall program for a 25-year period (2014 to 2038) to transfer up to 150,000 acre-feet per year of water from the San Joaquin River Exchange Contractors Water Authority to DOI for refuge water supplies or CVP and SWP water users (Reclamation 2013b). Reclamation is currently evaluating a long-term water transfer program (2015 to 2024) between water sellers in the Sacramento Valley and water users located in the San Francisco Bay Area and south of the Delta (Reclamation 2014b).

### 5.3.4 Surface Water Resources and Water Supplies During Droughts

Drought is a gradual phenomenon and can best be thought of as a condition of water shortage for a particular user in a particular location. Although persistent drought may be characterized as an emergency, it differs from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a period of time. There is no universal definition of when a drought begins or ends. Impacts of drought are typically felt first by those most reliant on annual rainfall -- ranchers engaged in dryland grazing, rural residents relying on wells in low-yield rock formations, or small water systems lacking a reliable water source. Criteria used to identify statewide drought conditions do not address these localized impacts. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

Measurements of California water conditions cover only a small slice of the past. Widespread collection of rainfall and streamflow information began around the turn of the 20th century. During our period of recorded hydrology, the most significant statewide droughts occurred during 1928-34, 1976-77, 1987-92, and 2007-09. A significant regional drought occurred in parts of Southern California in 1999-2002. Historical data combined with estimates created from indirect indicators such as tree rings suggest that the 1928-34 event may have been the driest period in the Sacramento River watershed since about the mid-1550s.

#### *5.3.4.1 Prior General Drought Responses*

Previous droughts that have occurred throughout California's history are constantly shaping and innovating the ways in which DWR and Reclamation handle both public health standards and urban and agricultural water demand, as well as protecting the Delta ecosystem and its inhabitants. The most notable droughts in recent history are the droughts that occurred in 1976-77 and 1987-92. The climactic situation helped shape legislation and stressed the importance of maintaining water supplies for all water users.

The impacts of a dry hydrology in 1976 were mitigated by reservoir storage and groundwater availability. The immediate succession of an even drier 1977, however, set the stage for widespread impacts. In 1977 CVP agricultural water contractors received 25 percent of their allocations, municipal contractors received 25 to 50 percent, and the exchange contractors received 75 percent. SWP agricultural contractors received 40 percent of their allocations and urban contractors received 90 percent.

Managing Delta salinity is a major challenge, given the competing needs to preserve critical carry-over storage and to release water from storage to meet Bay-Delta water quality standards. In February 1977, the SWRCB adopted an interim water quality control plan to modify Delta standards to allow the SWP to conserve storage in Lake Oroville. As extremely dry conditions continued that spring, the SWRCB subsequently adopted an emergency regulation superseding its interim water quality control plan, temporarily eliminating most water quality standards and forbidding the SWP to export stored water. As a further measure to conserve reservoir storage, DWR constructed temporary facilities (i.e., rock barriers, new diversions for Sherman Island agricultural water users, and facilities to provide better water quality for duck clubs in Suisun Marsh) in the Delta to help manage salinity with physical, rather than hydraulic, approaches.

In 1977, SWP and CVP contractors used water exchanges to respond to drought. One of the largest exchanges involved 435,000 acre-feet of SWP contract water made available by Metropolitan Water District of Southern California and three other SWP Southern California water contractors for use by San Joaquin Valley irrigators and urban agencies in the San Francisco Bay area.

During the 1987-92 drought, the state's 1990 population was close to 80 percent of present amounts and irrigated acreage was roughly the same as that of the present, but the institutional setting for water management differed significantly. Delta regulatory constraints affecting CVP and SWP operations were based on SWRCB D-1485, which had taken effect in 1978 immediately following the 1976-77 drought. In addition to SWRCB D-1485 requirements on CVP and SWP operations in the Delta, other operational constraints included water temperature standards imposed by the SWRCB through Water Rights Orders 90-5 and 91-01 for portions of the Sacramento and Trinity rivers. As part of managing salinity during the drought, DWR installed temporary barriers at two South Delta locations (along Middle River and in Old River near the Delta-Mendota Canal intake) to improve water levels and water quality/water circulation for agricultural diverters.

#### *5.3.4.2 Recent General Drought Response*

As a result of more recent drought conditions, California Governor Edmund G. Brown issued a Drought Emergency Proclamation on January 17, 2014 that is effective through May 31, 2016. This proclamation directs the SWRCB to, among other things, consider petitions, such as Temporary Urgency Change Petitions (TUCP), to modify requirements for reservoir releases or diversion limitations that were established to implement a water quality control plan.

On January 29, 2014, Reclamation and DWR sought a temporary modification to their water rights permits and licenses through a TUCP, allowing the CVP and SWP to reduce Delta outflow and thus conserve upstream storage for later use. The resultant January 31, 2014, Governor's Executive Order (January Order) also allowed the projects to pump at a minimum level (up to a total of 1,500 cfs) to supply essential public health and safety needs when Delta outflow was lower than would typically allow such pumping. Reclamation and DWR convened a Real Time Drought Operations Management Team (RTDOMT) comprised of representatives from Reclamation, DWR, USFWS, NMFS, CDFW, and SWRCB to discuss more flexible operations of the projects while protecting beneficial uses. Throughout 2014, the federal and state fish and wildlife agencies worked in close coordination with Reclamation and DWR to receive, analyze, and respond to the CVP and SWP operators' requests for additional operational flexibility while still remaining within the boundaries of the applicable environmental laws and regulations.

The January Order was amended several times to allow project operators to pump at higher levels to capture storm run-off. The January Order was also extended and/or amended to modify SWRCB D-1641 Delta Outflow requirements. The *CVP and SWP Drought Operations Plan and Operational Forecast for April 1, 2014 through November 15, 2014* (DOP) (Reclamation and DWR 2014a), outlined critical CVP/SWP operational considerations including providing for essential human health and safety needs; maintaining salinity control; planning for installation of three emergency drought barriers; maintaining adequate water supply reserves for 2015; providing for cold water species' needs, CVP and SWP water supplies, and refuge water supplies; and providing for operational flexibility, exchanges, and transfers. The DOP included upstream tributary operations as well as further modifications to D-1641 provisions associated with Delta outflow levels, maximum export limits, Delta E:I averaging period, combined export limitations, Vernalis base and pulse flows, and agricultural salinity compliance locations. Modifications to the DOP were requested in September 2014, regarding changes to San Joaquin River flows at Vernalis and extension of the water transfer window.

The *CVP and SWP Drought Contingency Plan for October 15, 2014 through January 15, 2015* (Drought Contingency Plan) (Reclamation and DWR 2015a), was prepared by Reclamation and DWR in response to the SWRCB October 7, 2014 Modified TUC Order. This Plan provided an overview of current conditions and available supplies as they related to projected flow and storage conditions for assumed hydrology, and addressed projected water operations based on various hydrologic scenarios and potential adjustments to regulatory requirement through January 15, 2015.

The subsequent *Drought Contingency Plan for January 15, 2015 through September 30, 2015*, was prepared to incorporate changes in snowpack, reservoir storage, and updated hydrologic forecasts. The January 15, 2015, *Drought Contingency Plan* appended a December 12, 2014 working draft of the *Interagency 2015 Drought Strategy for the CVP and SWP* (Reclamation and DWR 2014b). The 2015 Drought Strategy described the anticipated coordination, process, planning, and potential drought response actions for 2015.

Similar to 2014, Reclamation and DWR jointly filed several TUCPs starting on January 23, 2015, to temporarily modify requirements in their water right permits and licenses for the SWP and CVP. The TUCPs requested temporary modification of requirements included in SWRCB Revised D-1641 to meet water quality objectives in the *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. Specifically, the TUCPs during 2015 requested modifications to Delta outflow, San Joaquin River flow, DCC gate operation, and export limit objectives/or requirements, as well as upstream tributary operations, Rio Vista flows, western Delta salinity, and San Joaquin River salinity objectives.

The combination of virtually no snowpack and diminished reservoir storage in the spring of 2015 convinced federal and state wildlife and water agency managers that an emergency salinity barrier on West False River in the Sacramento-San Joaquin Delta was needed to repel salinity that could threaten a source of water used by 25 million Californians. Installation of a single emergency salinity barrier across West False River began in early May; with removal scheduled by mid-November. The barrier helped to limit the tidal push of saltwater from San Francisco Bay into the central Delta and helped minimize the amount of fresh water that must be released during the summer from upstream reservoirs to repel saltwater. Sufficient reserves in upstream reservoirs are needed to repel saltwater and prevent the contamination of water supplies for residents of the Delta; Contra Costa, Alameda and Santa Clara counties, and the 25 million people who rely on the Delta-based federal and state water projects for at least some of their supplies. Removal of the emergency barrier by November 15 is needed to avoid the flood season and harm to migratory fish. While it is in place, boaters used alternative routes between the San Joaquin River and the Delta's interior.

##### *5.3.4.3 Recent Drought Effects on Surface Water Resources and Supplies*

California is currently in its fourth consecutive year of below-average rainfall and very low snowpack. Water Year 2015 is also the eighth of 9 years with below-average runoff, which has resulted in chronic and significant shortages to municipal and industrial, agricultural, and refuge water supplies and historically low levels of groundwater. As of October 2015, 46 percent of the state was experiencing an Extreme Drought and 25 percent was experiencing an Exceptional Drought, as recorded by the National Drought Mitigation Center, U.S. Drought Monitor (Drought Monitor 2015). Of particular concern has been the state's critically low snow pack which typically provides much of California's seasonal water storage. On April 1, 2015, for the first time in 75 years of early-April measurements, DWR found no snow at the Phillips snow course, a primary snowpack measurement site in the Sierra Nevada mountain range. Lack of precipitation the last several years has also contributed to low reservoir storage levels in the Sacramento watershed. Shasta Reservoir on the Sacramento River and Lake Oroville on the Feather River, and Folsom Lake on the American River were at 35 and 30 percent of capacity, respectively, on October 5, 2015 (58 and 49 percent of historical average, respectively). Trinity Lake on the Trinity River was at 22 percent of capacity and 32 percent of historical average. The San Joaquin River watershed in particular has experienced severely dry conditions for the past three years, with and New Melones Reservoir at 11 percent capacity (20 percent historical average as of October 5, 2015.

Recently, one of the most critical reservoir water elevations has occurred at Folsom Lake. On October 5, 2015, the storage was at 17 percent of capacity, or 21 percent of historical average at this time of the year. When the water elevations in Folsom Lake decline substantially, the intakes along Folsom Dam may not be able to operate at full capacity. Therefore, in 2015, Reclamation installed a barge and pump system in Folsom Lake to allow diversions when low water surface elevations would cause capacity issues for existing intakes.

Overall, in 2014 and 2015, CVP and SWP water allocations were substantially reduced. The final 2014 water allocations and the February 2015 water allocations were as follows (Reclamation 2015; DWR 2014e, 2015):

- CVP agricultural water contractors: zero percent in 2014 and 2015.
- CVP municipal and industrial contractors: 50 percent in 2014 and 25 percent in 2015.
- CVP Eastside Division contractors: 55 percent in 2014 and zero percent in 2015.
- CVP Friant Water Division Class I and II contractors: zero percent in 2014 and 2015.
- CVP Sacramento River Water Rights Settlement Contractors and Sacramento Valley wildlife refuges (Level 2 water supplies): 75 percent in 2014 and 2015 (based on preliminary allocations in February 2016).
- CVP San Joaquin River Exchange Contractors and San Joaquin Valley wildlife refuges (Level 2 water supplies): 65 percent in 2014 and 75 percent in 2015 (based on preliminary allocations in February 2016). In 2014 and 2015, San Joaquin River Exchange Contractors received a portion of the contract amounts from Millerton Lake.
- SWP agricultural and urban contractors: up to 20 percent of the Table A water contract amounts in 2014 and 2015.

- SWP Feather River water rights contractors: 100 percent in 2014 and 50 percent in 2015.

The Congressional Research Service summarized the following information prepared by the SWRCB to describe the economic impacts of the 2014 drought period (CRS 2015):

- 428,000 acres agricultural lands idled in the Central Valley, Central Coast, and Southern California regions.
- $447 million of increased cost to increase groundwater pumping.
- $2.2 billion total economic loss, including $1.5 billion direct loss to agriculture (or 3 percent of the total average agricultural production value).
- 17,100 agricultural-related jobs lost (including 3.8 percent of total farm employment).
- Unaccounted loses for commercial and recreational fishing, reservoir and river recreation, and non-agricultural water dependent industrial job losses.

Responses to droughts have changed since the 1976-77 drought. The federal and state governments have acknowledged the droughts early in the process and implemented emergency actions to preserve water supplies for future years in case the droughts extend over long-periods. As discussed above in this section, these actions have included reductions in water supply allocations as well as modification of regulatory requirements to protect future water supplies for all beneficial uses. The responses to drought are generally limited to short-term actions, including stringent water conservation by municipal users, increased groundwater pumping by municipal and agricultural users, and modification of regulatory requirements. However, these short-term responses generally cannot be maintained on a long-term basis without economic effects. Following the drought in 1987-92, longer term programs were initiated by both municipal and industrial water users. For example, water recycling increased 144 percent between 1977 and 1987, and 251 percent between 2009 and 1987 (SWRCB 2009). Other long-term water supply reduction programs were initiated after the previous droughts, including increased use of drip irrigation. For example, Westlands Water District increased the use of drip irrigation from 3 percent of the crops in 1990 to 65 percent of the crops in 2011 (WWD 2013). However, these types of long-term responses take time to implement and once the savings are realized, there is less flexibility to respond to future droughts because the savings have occurred on a long-term basis.

It is also recognized that some effects of droughts do not occur within the year that the drought occurs. For example, increased use of groundwater in one year may result in subsidence in following years. Effects in commercial and sport fishing ocean salmon fishing also would not be realized in the years that the drought occurs because loss of spawning populations affects available salmon stocks for several years and future spawning populations. For example, coded wire tag recoveries of Sacramento River fall-run Chinook Salmon for commercial fishing noticeably declined following the 1987-1992 and 2007-09 droughts up to 95 percent (PFMC 2015).

# 5.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in surface water resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

## 5.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact assessment considers changes in surface water resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

### *5.4.1.1 Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison would result in changes to reservoir storage volumes (and elevations) and flow patterns in the downstream rivers. Numerical models are available to quantitatively analyze the changes in CVP and SWP reservoirs and pumping plants in the Central Valley, affected surface water bodies, and deliveries of CVP and SWP water. Changes in reservoirs that store CVP and SWP water outside of the Central Valley are not included in the CVP and SWP numerical models, and are evaluated qualitatively.

The surface water supply analysis was conducted using the CalSim II model, as described in Appendix 5A, CalSim II and DSM2 Modeling, to simulate the operational assumptions of each alternative that were described in Chapter 3, Description of Alternatives.

#### 5.4.1.1.1 Use of CalSim II Model

CalSim II is a reservoir-river basin planning model developed by DWR and Reclamation to simulate the operation of the CVP and SWP over a range of different hydrologic conditions. Inputs to CalSim II include water demands (including water rights), stream accretions and depletions, reservoir inflows, irrigation efficiencies, and parameters to calculate return flows, non-recoverable losses and groundwater operations. Sacramento Valley and tributary rim basin hydrology uses an adjusted historical sequence of monthly stream flows over an 82-year period (1922 to 2003) to represent a sequence of flows at a future level of development. Adjustments to historic water supplies are imposed based on future land use conditions and historical meteorological and hydrologic conditions. The resulting hydrology represents the water supply available from Central Valley streams to the CVP and SWP at a future level of development. Water rights deliveries to non-CVP and non-SWP water rights holders are not modified in the CalSim II simulations of the alternatives. CalSim II produces outputs for river flows and diversions, reservoir storage, Delta flows and exports, Delta inflow and outflow, deliveries to project and non-project users, and controls on project operations.

The CalSim II model monthly simulation of an actual daily (or even hourly) operation of the CVP and SWP results in several limitations in use of the model results. The model results must be used in a comparative manner to reduce the effects of use of monthly assumptions and other assumptions that are indicative of real-time operations, but do not specific match real-time observations. The CalSim II model output is based upon a monthly time step. The CalSim II model output includes minor fluctuations of up to 5 percent due to model assumptions and approaches. Therefore, if the quantitative changes between a specific alternative and the No Action Alternative and/or Second Basis of Comparison are 5 percent or less, the conditions under the specific alternative would be considered to be "similar" to conditions under the No Action Alternative and/or Second Basis of Comparison.

Under extreme hydrologic and operational conditions where there is not enough water supply to meet all requirements, CalSim II utilizes a series of operating rules to reach a solution to allow for the continuation of the simulation. It is recognized that these operating rules are a simplified version of the very complex decision processes that CVP and SWP operators would use in actual extreme conditions. Therefore, model results and potential changes under these extreme conditions should be evaluated on a comparative basis between alternatives and are an approximation of extreme operational conditions. As an example, CalSim II model results show simulated occurrences of extremely low storage conditions at CVP and SWP reservoirs during critical drought periods when storage is at dead pool levels at or below the elevation of the lowest level outlet. Simulated occurrences of reservoir storage conditions at dead pool levels may occur coincidentally with simulated impacts that are determined to be potentially significant. When reservoir storage is at dead pool levels, there may be instances in which flow conditions fall short of minimum flow criteria, salinity conditions may exceed salinity standards, diversion conditions fall short of allocated diversion amounts, and operating agreements are not met.

##### 5.4.1.1.2 Analysis of Changes in Reservoir Storage and Downstream River Flows

CalSim II outputs for the alternatives are compared to the CalSim II outputs for the No Action Alternative and the Second Basis of Comparison to evaluate changes in reservoir storages at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir; flows downstream of CVP and SWP reservoirs in Trinity, Sacramento, Feather, American, Stanislaus rivers and Clear Creek; flows from the Sacramento River at Fremont Weir into the Yolo Bypass; Delta outflow; and reverse flows in Old and Middle rivers (OMR criteria).

The analyses discussed in Chapters 5 through 21 do not include specific analysis for Millerton Lake and the San Joaquin River between Friant Dam and the confluence with the Stanislaus River under Alternatives 1 through 5 as compared to the No Action Alternative and Second Basis of Comparison. The results of these analyses (presented in Appendix 5A, CalSim II and DSM2 Modeling) indicated that there were no differences in Millerton Lake storage or San Joaquin River flows upstream of the confluence with the Stanislaus River between Alternatives 1 through 5 as compared to the No Action Alternative and Second Basis of Comparison because implementation of the alternatives would not affect the operations of Millerton Lake. Therefore, conditions at Millerton Lake and the San Joaquin River between Friant Dam and the confluence of the Stanislaus River are not analyzed in this EIS.

The analyses discussed in Chapters 5 through 21 do not include specific analysis for creeks downstream of San Luis Reservoir complex. Unlike the rivers located downstream of CVP and SWP reservoirs (e.g., Sacramento River downstream of Shasta Dam), river channels located downstream of the San Luis Reservoir complex are not used to convey CVP and SWP water. Instream flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, flows in streams downstream of San Luis Reservoir are not analyzed in this EIS.

Reservoirs that store CVP and SWP water are also located in the San Francisco Bay Area, Central Coast, and Southern California regions. Many of these reservoirs also store water from other water supplies including CVP and SWP water. These reservoirs are not included in the CalSim II model simulation. Storage volumes in non-CVP and SWP reservoirs located south of the Delta that store CVP or SWP water also are affected by the availability local runoff stored in these reservoirs; and from imported Colorado River water in some Southern California reservoirs. This EIS does not analyze availability of future local runoff or imported Colorado River water supplies in 2030. For this EIS, it is assumed that under a worst-case scenario, changes in CVP and SWP water deliveries would result in similar changes to storage in these reservoirs. For example, reductions in CVP or SWP deliveries would result in reductions in storage in reservoirs located south of the Delta. Generally, river channels located downstream of these reservoirs are not used to convey CVP and SWP water. Instream flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, flows in these streams are not analyzed in this EIS.

##### *5.4.1.2 Changes in Flows over Fremont Weir into Yolo Bypass*

All of the alternatives, including the No Action Alternative and the Second Basis of Comparison, include operations of an operable gate at Fremont Weir, as described in Chapter 3, Description of Alternatives. Results of the CalSim II model were used to assess changes in average monthly flows that would flow into the Yolo Bypass over an operable gate at Fremont Weir. Operational assumptions for the operable gate were developed for the purposes of this EIS analysis, and are the same in all alternatives and the Second Basis of Comparison. Specific operational assumptions are being developed by Reclamation and others in a separate analysis that includes separate environmental documentation. Although the operational assumptions for an operable gate at Fremont Weir would be the same under all alternatives and the Second Basis of Comparison; the flow patterns into the Yolo Bypass would change based upon the magnitude of flows in the Sacramento River at Fremont Weir, as evaluated quantitatively using CalSim II model output. Assumptions used in the CalSim II model are described in Appendix 5A, CalSim II and DSM2 Modeling.

Flows also enter the Yolo Bypass at the Sacramento Weir (downstream of Fremont Weir) at a lower flow rate. However, the Sacramento Weir operations are assumed to remain as described in Section 5.3, Affected Environment, in all alternatives and the Second Basis of Comparison.

#### *5.4.1.3 Changes in Delta Conditions*

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison would change the Delta inflows from the tributary watersheds, Delta outflow, and reverse flows in Old and Middle River (as indicated by OMR flows). Results of the CalSim II model were used to assess changes in Delta outflow and positive and negative OMR flows. Assumptions used in the CalSim II model are described in Appendix 5A, CalSim II and DSM2 Modeling.

#### *5.4.1.4 Changes in Delta Exports and CVP and SWP Deliveries*

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison would change CVP and SWP exports and deliveries, as analyzed using the CalSim II model. Assumptions used in the CalSim II model are described in Appendix 5A, CalSim II and DSM2 Modeling.

It should be noted that deliveries to CVP and SWP water users located to the south of the Delta are not necessarily the same volume as the Delta export patterns because a portion of the exported water is stored in San Luis Reservoir and released on a different pattern than Delta exports.

It also should be noted that the monthly CalSim II model results do not represent daily water operations decisions, especially for extreme conditions. For example, in very dry years, the model simulates minimum reservoir volumes (also known as “dead pool conditions”) that appear to prevent Reclamation and DWR from meeting their contractual obligations, including water deliveries to CVP Sacramento River Settlement Contractors, CVP San Joaquin River Exchange Contractors, SWP Feather River Service Area Contractors, and Level II refuge water supplies. Such model results are anomalies that reflect the inability of the monthly model to make real-time policy decisions under extreme circumstances. Projected reservoir storage conditions near dead pool conditions should only be considered as an indicator of stressed water supply conditions, and not necessarily reflective of actual CVP and SWP operations in the future.

#### *5.4.1.5 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pumping groundwater instead of using surface water (groundwater substitution), idle crops, or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations (defined as "balanced Delta conditions" in the COA, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations). In nonwet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Water transfers using CVP and SWP conveyance facilities frequently do not occur when releases from upstream reservoirs plus unregulated flows are greater than the Sacramento Valley water demands and the CVP and SWP export allocations (defined as "excess Delta conditions in the COA) because the available water is being conveyed to meet the CVP and SWP contract demands. This condition generally occurs in winter and spring months of wet years.

Without implementation of the 2008 USFWS BO and 2009 NMFS BO, water transfers could occur in most months when exports are less than conveyance capacity. The 2008 USFWS BO and 2009 NMFS BO include export restrictions in the winter and spring months that limit use of the conveyance capacity.

Transfers requiring conveyance through the Delta occur when pumping and conveyance capacity at the CVP or SWP export facilities is available. Reclamation and DWR must coordinate review of the transfer proposals and related CVP and SWP operations to assure that the CVP and SWP are not impacted including the ability to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way. To avoid impacts to Delta water quality the individual transfer is assessed a carriage water loss to account for flows required to avoid impacts to Delta water quality or flow objectives. All transfers are required to be implemented in accordance with all existing regulations and requirements, including not causing adverse impacts on other water users in accordance with SWRCB requirements.

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014i). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 5.4.2 Conditions in Year 2030 without implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section.

Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison. Other future conditions would be different under the No Action Alternative as compared to the Second Basis of Comparison due to the implementation of the 2008 USFWS BO and 2009 NMFS BO under the No Action Alternative.

This section of Chapter 5 provides qualitative projections of the No Action Alternative as compared to existing conditions described under the Affected Environment; and qualitative projections of the Second Basis of Comparison as compared to “recent historical conditions.” Recent historical conditions are not the same as existing conditions which include implementation of the 2008 USFWS BO and 2009 NMFS BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

#### *5.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries.

##### 5.4.2.1.1 Changes in Conditions due to Climate Change and Sea-Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end-of-September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

Sea level rise also would result in reduced CVP and SWP reservoir storage. As sea level rise occurs, the location of the salt water-freshwater zone moves further inland. However, the CVP and SWP must continue to meet the salinity criteria to protect Delta water users and Delta aquatic resources, including the SWRCB D-1641 and other salinity criteria to protect Delta water users. To meet these criteria, the amount of water released from CVP and SWP reservoirs must be increased as compared to recent historical conditions.

Climate change also would cause changes in stream flows. During the storm events, the flows would be higher than in recent historical conditions because a larger portion of the precipitation would occur as rainfall instead of snowfall. Flows would increase in the spring as more water is released from CVP and SWP reservoirs to meet Delta salinity criteria. In the summer and fall months, flows could be lower due to reduced amounts of water remaining in reservoir storage.

Climate change also would reduce groundwater supplies due to reduced groundwater recharge potential and increased groundwater overdraft potential as surface water supplies decline. However, in some locations, sustainable groundwater supplies could remain similar to recent historical conditions or rise due to implementation of groundwater management plans to reduce groundwater overdraft, including the completion of ongoing groundwater recharge and recovery programs.

#### 5.4.2.1.2 General Plan Development in California

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Preparation of general plans includes an environmental evaluation under the California Environmental Quality Act to identify adverse impacts to the physical environment and to provide mitigation measures to reduce those impacts to a level of less than significance. Most of the counties where CVP and SWP water supplies are delivered have adopted general plans following the environmental review of the plans and appropriate alternatives. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and the Second Basis of Comparison assume that land uses will develop through 2030 in accordance with existing general plans.

Development in accordance with the general plans in the Sacramento Valley would result in increased water demands. By 2030, water demands associated with water rights and CVP and SWP contracts in the Sacramento Valley is projected to increase by 443,000 acre-feet per year, especially in the communities in El Dorado, Placer, and Sacramento Counties. Increased water demands in the Sacramento Valley would result in reductions in CVP and SWP water supply availability for other water users under the No Action Alternative and the Second Basis of Comparison.

##### 5.4.2.1.3 Reasonable and Foreseeable Water Resources Management Projects

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of the 2008 USFWS BO and 2009 NMFS BO by 2030, as described in Chapter 3, Description of Alternatives.

The No Action Alternative and the Second Basis of Comparison would include the following actions included in the 2008 USFWS BO and 2009 NMFS BO that are ongoing.

- Restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass
- Gravel augmentation in the Sacramento Valley watershed
- Replacement of the Spring Creek Temperature Control Curtain
- Restoration of Battle Creek
- Implementation of Red Bluff Pumping Plant
- Implementation of the CVPIA Anadromous Fish Screen Program
- Implementation of the American River Flow Management Standard

Under the No Action Alternative and Second Basis of Comparison, it is assumed that water demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, CVP and SWP water supplies, other imported water supplies, groundwater, recycled water, infrastructure improvements, desalination water treatment, and water transfers and exchanges. It is anticipated that individual communities or users could be in a situation that would not allow for affordable water supply options, and that water demands could not be fully met. However, on a regional scale, it is anticipated that water demands would be met.

The assumptions related to 2030 municipal water demands are based upon a review of the 2010 Urban Water Management Plans (UWMPs) prepared by CVP and SWP water users. The No Action Alternative and the Second Basis of Comparison assumptions related to future water supplies presented in the UWMPs were evaluated to determine if the projects were reasonable and certain to occur by 2030. Projects that had undergone environmental review, were under design, or under construction were included in the future water supply assumptions for 2030 in the No Action Alternative and the Second Basis of Comparison. Projects described in the UWMPs that currently were under evaluation were included in the Cumulative Effects analysis for future water supplies. Future water supplies considered for municipalities by 2030 are presented in Appendix 5D and summarized in Table 5.10.

**Table 5.10 Future Long-Term Average Municipal Water Supply Assumptions for CVP and SWP Water Users**

| | 2030 Water Demands and Water Supplies | | | | |
|---|---|---|---|---|---|
| | **Central Valley Region – Sacramento Valley** | **Central Valley Region – San Joaquin Valley** | **San Francisco Bay Area Region** | **Central Coast and Southern California Regions** | **Total** |
| 2030 Water Demand (after conservation) | 747,771 | 378,999 | 784,313 | 5,653,807 | 7,564,890 |
| CVP Deliveries | 214,187 | 131,150 | 311,370 | – | 656,707 |
| SWP Deliveries | 88,192 | 82,946 | 143,045 | 1,798,353 | 2,112,536 |
| Water Rights | 724,583 | 170,600 | 127,400 | 240,333 | 1,262,916 |
| Groundwater | 136,759 | 188,346 | 101,704 | 2,216,118 | 2,642,927 |
| Recycled Wastewater | 24,324 | 25,000 | 44,270 | 404,449 | 498,043 |
| Recycled Stormwater | – | – | – | 21,400 | 21,400 |
| Desalination Water Treatment | – | – | 5,100 | 454,145 | 459,245 |
| Transfers and Exchanges | 156,325 | 30,000 | 16,700 | – | 203,025 |
| Non-CVP and SWP Imported Water Supplies | 205,276 | – | 76,400 | 1,319,321 | 1,600,997 |
| **Total Supplies** | **1,549,646** | **628,042** | **825,989** | **6,454,119** | **9,457,796** |

Note: Does not include the East Bay Municipal Utility District dry year water supply.

The No Action Alternative and the Second Basis of Comparison assume that several CVP and SWP water users also rely upon other imported water supplies, including water from Solano Project (used by the Solano County Water Agency), San Francisco Public Utilities Commission (used by portions of the service areas of Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency), and the Colorado River (used by portions of the service area of the Metropolitan Water District of Southern California).

The No Action Alternative and the Second Basis of Comparison assume that groundwater would continue to be used even if groundwater overdraft conditions continue or become worse. It is recognized that in September 2014 the Sustainable Groundwater Management Act (SGMA) was enacted. The SGMA provides for the establishment of a Groundwater Sustainability Agencies (GSAs) to prepare Groundwater Sustainability Plans (GSPs) that will include best management practices for sustainable groundwater management. The SGMA defines sustainable groundwater management as “the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.” Undesirable results are defined as any of the following effects.

- Chronic lowering of groundwater levels (not including overdraft during a drought if a basin is otherwise managed)
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

The SGMA requires the formation of GSPs in groundwater basins or subbasins that DWR designates as medium or high priority based upon groundwater conditions identified using the CAGESM results by 2022. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs. In some areas with adjudicated groundwater basins, sustainable groundwater management could be achieved and/or maintained by 2030. However, to achieve sustainable conditions in many areas, measures could require several years to design and construct water supply facilities to replace groundwater, such as seawater desalination. Therefore, it does not appear to be reasonable and foreseeable that sustainable groundwater management would be achieved by 2030; and it is assumed that groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030.

The No Action Alternative and the Second Basis of Comparison assumptions also include implementation of numerous conservation efforts and major water supply projects, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. There are over 50 projects considered in the study area to be included in the No Action Alternative, including the following major water supply projects.

- Cambria Emergency Water Supply Project desalination project (CCSD 2014)
- Carlsbad Metropolitan Water District (MWD) water recycling project (Carlsbad MWD 2012)
- Central Basin Municipal Water District Southeast Water Reliability Project (CBMWD 2011)
- City of Los Angeles Department of Water and Power groundwater recharge projects (City of Los Angeles 2011, 2013)
- City of Oxnard GREAT Program Desalter (City of Oxnard 2013)
- Eastern Municipal Water District (EMWD) water recycling programs (EMWD 2014a, 2014b)
- Fresno Irrigation District (FID) groundwater recharge projects (FID 2015)
- Inland Empire Utilities Agency (IEUA) groundwater recharge projects (IEUA 2015).
- Kern County and Antelope Valley-East Kern Water Agency (AVEK 2011)
- Los Angeles County Sanitation District expansion of water recycling programs (LACSD 2005)
- San Benito County Water District (SBCWD) expansion of water treatment plant to treat CVP water (SBCWD 2014)
- San Diego County Water Authority (SDCWA) Carlsbad Seawater Desalination Facility (SDCWA 2014)
- Santa Barbara desalination water treatment plant (KEYT News [KEYT] 2015).
- SCVWD wastewater recycling projects (SCVWD 2012a)
- Victor Valley Wastewater Reclamation Authority (VVWRA) water recycling programs (VVWRA 2015)
- Water Replenishment District (WRD) Groundwater Reliability Improvement Program and water recycling programs (WRD 2012, 2015)
- West Basin Municipal Water District recycling water programs (WBMWD 2011)
- Western Development and Storage Antelope Valley Water Bank (Reclamation 2010b)
- Western Municipal Water District (WMD) Arlington Desalter Expansion to use saline groundwater (WMD 2015)
- Woodland-Davis Clean Water Agency (WDCWA) water treatment plant (WDCWA 2013)

Water transfer programs, including those that require Warren Act contracts with Reclamation to convey non-CVP water in CVP facilities, are anticipated to continue under the No Action Alternative and the Second Basis of Comparison. Transfer programs generally involve annual crop changes using temporary crop idling or shifting, release of stored water in reservoirs on different patterns for the purchasers' water demands, and/or groundwater substitution (DWR and Reclamation 2014). The transfers must be approved by the CVP and/or SWP if the transfer involves CVP or SWP water or utilizes CVP or SWP facilities. Except for water transfers among CVP water users, water transfers also require approval from the SWRCB. Environmental documentation is required for all water transfers involving CVP and/or SWP water supplies or facilities. Under State law, water transfers cannot result in injury to other legal users of water; unreasonable impacts on fish and wildlife and instream uses; and unreasonable economic or environmental impact on the county in which the transfer water originates. It is assumed that transfers would continue under the No Action Alternative and the Second Basis of Comparison in a similar manner as have occurred for the past 10 years. It is anticipated that the number of long-term transfer agreements could increase to facilitate annual decisions for water transfers.

#### *5.4.2.2 Changes in Conditions under the No Action Alternative*

CVP and SWP operational criteria under the No Action Alternative would be the same as described under the Affected Environment. However, due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that climate change and sea level rise conditions would result in lower reservoir storage and elevations and flows in the rivers by the end of September.

#### *5.4.2.3 Changes in Conditions under the Second Basis of Comparison*

CVP and SWP operational criteria under the Second Basis of Comparison would not include implementation of the 2008 USFWS BO and 2009 NMFS BO. As described in Section 5.4.4.1, CVP and SWP water deliveries would higher than under existing conditions which include implementation of the BOs. However, due to the climate change and sea level rise and increased water demands in the Sacramento Valley, CVP and SWP water supply availability and deliveries would be less in 2030 than under recent historical conditions that existed prior to implementation of the BOs. It is anticipated that climate change and sea level rise conditions would result in lower reservoir storage and elevations and flows in the rivers by the end of September.

### 5.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, two issues were discovered. First, it was discovered that the demands for the El Dorado Irrigation District (EID) and El Dorado County Water Agency (EDCWA) contracts were not included in Alternatives 3 and 5, as intended. Second, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs.

With respect to the water demands, the 17 TAF per year Warren Act Contract for EIS and 15 TAF per year under a CVP water service contract for EDCWA were not included in Alternatives 3 and 5, as intended. These demands are not included in the analysis presented in Chapters 5 through 21 of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS for Alternatives 3 and 5. The sensitivity analysis focuses on potential changes that would occur within Folsom Lake and along the American River. The results of this analysis indicate that surface water and water temperature conditions in Folsom Lake and in the American River would be similar (within 5 percent or less) in the model run with these demands as compared to model runs without these demands; except in August of critical dry years. In August of critical dry years, the American River flows under Alternative 3 would be 6 percent less with these demands than without these demands. It is anticipated that similar results would occur under the No Action Alternative. The results of these model runs indicated that there was not sensitivity with the addition of these demands in the analyses; therefore, no further model simulations were necessary to capture potential effects and the inclusion of these contracts would not change the previous conclusions in Chapters 5 through 21.

With respect to the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs, a sensitivity analysis was conducted as presented in Appendix 5C. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of the following alternative analysis.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

Model results for Alternatives 1, 4, and Second Basis of Comparison are the same, therefore Alternative 4 results are not presented separately. Model results for Alternative 2 and No Action Alternative are the same, therefore Alternative 2 results are not presented separately. Alternative 3 was not compared to the No Action Alternative because the model error did not occur in either of these model runs.

#### *5.4.3.1 No Action Alternative*

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

##### 5.4.3.1.1 Trinity River Region

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under the No Action Alternative as compared to the Second Basis of Comparison in Trinity Lake are summarized in Tables 5.11 and 5.12. A summary of the results is provided following Table 5.12.

**Table 5.11 Changes in Trinity Lake Storage under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,490 | 1,516 | 1,630 | 1,756 | 1,921 | 2,053 | 2,220 | 2,245 | 2,190 | 2,067 | 1,939 | 1,784 |
| Above Normal | 1,159 | 1,178 | 1,286 | 1,455 | 1,658 | 1,847 | 2,025 | 1,999 | 1,907 | 1,773 | 1,619 | 1,495 |
| Below Normal | 1,393 | 1,400 | 1,417 | 1,488 | 1,575 | 1,662 | 1,817 | 1,743 | 1,637 | 1,470 | 1,304 | 1,185 |
| Dry | 1,152 | 1,148 | 1,174 | 1,182 | 1,274 | 1,403 | 1,539 | 1,490 | 1,413 | 1,253 | 1,104 | 1,008 |
| Critical Dry | 747 | 731 | 746 | 750 | 790 | 872 | 923 | 888 | 862 | 745 | 612 | 536 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,501 | 1,535 | 1,644 | 1,767 | 1,931 | 2,055 | 2,224 | 2,250 | 2,194 | 2,068 | 1,939 | 1,805 |
| Above Normal | 1,208 | 1,245 | 1,363 | 1,524 | 1,718 | 1,901 | 2,079 | 2,053 | 1,955 | 1,815 | 1,647 | 1,513 |
| Below Normal | 1,451 | 1,472 | 1,492 | 1,554 | 1,641 | 1,729 | 1,872 | 1,799 | 1,696 | 1,515 | 1,337 | 1,204 |
| Dry | 1,178 | 1,184 | 1,210 | 1,230 | 1,322 | 1,453 | 1,586 | 1,536 | 1,466 | 1,302 | 1,152 | 1,055 |
| Critical Dry | 819 | 803 | 813 | 825 | 868 | 949 | 999 | 962 | 929 | 811 | 667 | 598 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -11 | -19 | -14 | -11 | -9 | -2 | -4 | -5 | -4 | 0 | 1 | -21 |
| Above Normal | -49 | -68 | -77 | -69 | -60 | -54 | -55 | -54 | -49 | -42 | -27 | -18 |
| Below Normal | -59 | -72 | -74 | -66 | -67 | -67 | -54 | -57 | -60 | -44 | -33 | -18 |
| Dry | -26 | -36 | -36 | -48 | -48 | -49 | -47 | -46 | -53 | -48 | -48 | -48 |
| Critical Dry | -73 | -72 | -68 | -75 | -78 | -78 | -76 | -74 | -66 | -66 | -56 | -61 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.7 | -1.3 | -0.9 | -0.6 | -0.5 | -0.1 | -0.2 | -0.2 | -0.2 | 0.0 | 0.0 | -1.2 |
| Above Normal | -4.0 | -5.4 | -5.7 | -4.5 | -3.5 | -2.9 | -2.6 | -2.7 | -2.5 | -2.3 | -1.7 | -1.2 |
| Below Normal | -4.0 | -4.9 | -5.0 | -4.2 | -4.1 | -3.9 | -2.9 | -3.1 | -3.5 | -2.9 | -2.5 | -1.5 |
| Dry | -2.2 | -3.1 | -3.0 | -3.9 | -3.6 | -3.4 | -3.0 | -3.0 | -3.6 | -3.7 | -4.1 | -4.5 |
| Critical Dry | -8.9 | -9.0 | -8.3 | -9.1 | -8.9 | -8.2 | -7.6 | -7.7 | -7.2 | -8.1 | -8.4 | -10.3 |

**Table 5.12 Changes in Trinity Lake Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,324 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,327 |
| Above Normal | 2,261 | 2,264 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,341 | 2,335 | 2,325 | 2,313 | 2,302 |
| Below Normal | 2,289 | 2,289 | 2,291 | 2,299 | 2,307 | 2,315 | 2,327 | 2,321 | 2,313 | 2,299 | 2,283 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,264 | 2,254 |
| Critical Dry | 2,210 | 2,207 | 2,210 | 2,213 | 2,220 | 2,235 | 2,242 | 2,238 | 2,235 | 2,220 | 2,196 | 2,182 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,270 | 2,273 | 2,286 | 2,303 | 2,320 | 2,335 | 2,347 | 2,346 | 2,339 | 2,329 | 2,315 | 2,304 |
| Below Normal | 2,295 | 2,296 | 2,298 | 2,305 | 2,313 | 2,320 | 2,331 | 2,326 | 2,318 | 2,303 | 2,287 | 2,274 |
| Dry | 2,266 | 2,269 | 2,272 | 2,274 | 2,284 | 2,296 | 2,309 | 2,304 | 2,298 | 2,284 | 2,269 | 2,259 |
| Critical Dry | 2,218 | 2,216 | 2,217 | 2,222 | 2,229 | 2,243 | 2,250 | 2,246 | 2,243 | 2,227 | 2,204 | 2,191 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -1 | -2 | -1 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | -2 |
| Above Normal | -8 | -10 | -10 | -9 | -7 | -5 | -4 | -4 | -4 | -4 | -2 | -2 |
| Below Normal | -6 | -7 | -7 | -6 | -6 | -6 | -4 | -5 | -5 | -4 | -3 | -3 |
| Dry | -3 | -4 | -4 | -5 | -5 | -4 | -4 | -4 | -5 | -5 | -5 | -5 |
| Critical Dry | -8 | -8 | -8 | -9 | -8 | -8 | -8 | -8 | -7 | -8 | -8 | -9 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.1 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 |
| Above Normal | -0.4 | -0.4 | -0.5 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 |
| Below Normal | -0.3 | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 |
| Dry | -0.1 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 |
| Critical Dry | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.3 | -0.3 | -0.3 | -0.4 | -0.4 | -0.4 |

The following changes in Trinity Lake storage and surface water elevation would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, below normal, and dry years, storage would be similar (within 5 percent) in all months.
- In above-normal years, storage would be similar in January through October and less in November and December (up to 5.7 percent).
- In critical dry years, storage would be less in all months (up to 10.3 percent).

- In all months, in all water year types, surface water elevations would be similar.

The following changes would occur on the Trinity River under the No Action Alternative as compared to the Second Basis of Comparison, as shown on Figures 5.53 through 5.55.

- Over long-term conditions (over the 82-year analysis period), flows would be similar in March through November and reduced in December through February (up to 9.5 percent).
- In wet years, flows would be similar in April through November and reduced in December through March (up to 11.2 percent).
- In dry years, flows would be similar all months.

#### 5.4.3.1.2 Central Valley Region

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

*Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Tables 5.13 and 5.14. Changes in flows in the Sacramento River downstream of Keswick Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized in Table 5.14.

**Table 5.13 Changes in Shasta Lake Storage under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,700 | 2,719 | 3,077 | 3,384 | 3,589 | 3,836 | 4,298 | 4,460 | 4,242 | 3,735 | 3,410 | 2,985 |
| Above Normal | 2,369 | 2,385 | 2,600 | 3,167 | 3,453 | 4,021 | 4,404 | 4,429 | 4,039 | 3,407 | 3,069 | 2,834 |
| Below Normal | 2,587 | 2,548 | 2,686 | 3,062 | 3,442 | 3,814 | 4,026 | 3,957 | 3,588 | 3,002 | 2,643 | 2,608 |
| Dry | 2,345 | 2,283 | 2,428 | 2,621 | 3,034 | 3,505 | 3,737 | 3,668 | 3,284 | 2,767 | 2,496 | 2,462 |
| Critical Dry | 1,702 | 1,633 | 1,717 | 1,871 | 2,031 | 2,274 | 2,202 | 2,088 | 1,719 | 1,253 | 986 | 937 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,817 | 2,926 | 3,154 | 3,406 | 3,597 | 3,841 | 4,301 | 4,453 | 4,228 | 3,733 | 3,362 | 3,252 |
| Above Normal | 2,499 | 2,578 | 2,808 | 3,313 | 3,515 | 4,038 | 4,416 | 4,417 | 3,979 | 3,347 | 2,975 | 2,921 |
| Below Normal | 2,826 | 2,846 | 2,977 | 3,299 | 3,646 | 3,966 | 4,164 | 4,042 | 3,599 | 3,010 | 2,601 | 2,574 |
| Dry | 2,409 | 2,431 | 2,578 | 2,755 | 3,168 | 3,644 | 3,861 | 3,774 | 3,333 | 2,800 | 2,539 | 2,496 |
| Critical Dry | 1,873 | 1,826 | 1,911 | 2,050 | 2,222 | 2,460 | 2,386 | 2,270 | 1,861 | 1,409 | 1,151 | 1,086 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -117 | -208 | -77 | -22 | -8 | -5 | -3 | 7 | 14 | 2 | 49 | -267 |
| Above Normal | -130 | -193 | -208 | -146 | -62 | -17 | -12 | 11 | 60 | 60 | 94 | -87 |
| Below Normal | -239 | -298 | -291 | -237 | -204 | -152 | -138 | -86 | -10 | -8 | 42 | 33 |
| Dry | -64 | -148 | -150 | -135 | -134 | -139 | -123 | -106 | -48 | -33 | -42 | -35 |
| Critical Dry | -171 | -193 | -194 | -179 | -190 | -186 | -184 | -183 | -142 | -155 | -165 | -149 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -4.2 | -7.1 | -2.4 | -0.6 | -0.2 | -0.1 | -0.1 | 0.2 | 0.3 | 0.1 | 1.4 | -8.2 |
| Above Normal | -5.2 | -7.5 | -7.4 | -4.4 | -1.8 | -0.4 | -0.3 | 0.3 | 1.5 | 1.8 | 3.2 | -3.0 |
| Below Normal | -8.5 | -10.5 | -9.8 | -7.2 | -5.6 | -3.8 | -3.3 | -2.1 | -0.3 | -0.3 | 1.6 | 1.3 |
| Dry | -2.6 | -6.1 | -5.8 | -4.9 | -4.2 | -3.8 | -3.2 | -2.8 | -1.5 | -1.2 | -1.7 | -1.4 |
| Critical Dry | -9.1 | -10.6 | -10.1 | -8.7 | -8.6 | -7.5 | -7.7 | -8.0 | -7.6 | -11.0 | -14.4 | -13.8 |

**Table 5.14 Changes in Shasta Lake Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 986 | 985 | 991 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 989 | 987 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,034 | 1,018 | 995 | 982 | 980 |
| Critical Dry | 927 | 923 | 929 | 939 | 951 | 968 | 965 | 958 | 935 | 899 | 876 | 872 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,037 | 1,022 | 1,017 |
| Above Normal | 974 | 978 | 992 | 1,019 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,005 | 1,003 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,053 | 1,049 | 1,031 | 1,006 | 987 | 986 |
| Dry | 972 | 974 | 982 | 992 | 1,012 | 1,032 | 1,041 | 1,038 | 1,020 | 997 | 984 | 982 |
| Critical Dry | 938 | 935 | 941 | 950 | 961 | 977 | 974 | 967 | 943 | 910 | 889 | 884 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -6 | -10 | -4 | -1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | -12 |
| Above Normal | -7 | -10 | -10 | -7 | -3 | -1 | 0 | 0 | 2 | 3 | 4 | -4 |
| Below Normal | -11 | -14 | -13 | -10 | -9 | -6 | -5 | -4 | -1 | -1 | 2 | 1 |
| Dry | -3 | -7 | -7 | -6 | -6 | -6 | -5 | -4 | -2 | -2 | -3 | -2 |
| Critical Dry | -11 | -12 | -12 | -11 | -10 | -9 | -9 | -9 | -8 | -11 | -13 | -12 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.6 | -1.0 | -0.4 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | -1.2 |
| Above Normal | -0.7 | -1.0 | -1.0 | -0.7 | -0.3 | -0.1 | 0.0 | 0.0 | 0.2 | 0.3 | 0.4 | -0.4 |
| Below Normal | -1.1 | -1.4 | -1.3 | -1.0 | -0.8 | -0.6 | -0.5 | -0.3 | -0.1 | -0.1 | 0.2 | 0.1 |
| Dry | -0.3 | -0.7 | -0.7 | -0.6 | -0.6 | -0.5 | -0.5 | -0.4 | -0.2 | -0.2 | -0.3 | -0.2 |
| Critical Dry | -1.2 | -1.3 | -1.3 | -1.1 | -1.0 | -0.9 | -1.0 | -1.0 | -0.8 | -1.2 | -1.4 | -1.4 |

The following changes in Shasta Lake storage and surface water elevations would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in October and December through August and reduced in September and November (up to 8.2 percent).
- In above-normal years, storage would be similar in January through September and reduced in October through December (up to 7.5 percent).
- In below-normal years, storage would be similar in March through September and reduced in October through February (up to 10.5 percent).

- In dry years, storage would be similar in January through October and reduced in November and December (up to 6.1 percent).
- In critical dry years, storage would be reduced under all months (up to 14.4 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Sacramento River flows would occur under the No Action Alternative as compared to the Second Basis of Comparison, as shown on Figures 5.56 through 5.61.

- Sacramento River downstream of Keswick Dam (Figures 5.56 through 5.58).
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; increased flows in September and November (up to 37.7 percent); and reduced flows in December, January, and June (up to 7.8 percent).
  - In wet years, similar flows would occur in January through July; increased flows in September through November (up to 77.7 percent); and reduced flows in December and August (up to 14.6 percent).
  - In dry years, similar flows would occur in July through October, December through March, and May; increased flows in November (33.4 percent); and reduced flows in April and June (up to 7.3 percent).
- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61).
  - Over long-term conditions, similar flows would occur in October, December through May, and August; increased flows in September, November, and July (up to 43.3 percent); and reduced flows in June (11.4 percent).
  - In wet years, similar flows would occur in January through June and October; increased flows in July through September and November (up to 90.3 percent); and reduced flows in December (10.7 percent).
  - In dry years, similar flows would occur in August through October and December through April; increased flows in November and July (up to 15.8 percent); and reduced flows in May and June (up to 11.9 percent).

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Tables 5.15 and 5.16. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized in Table 5.16.

**Table 5.15 Changes in Lake Oroville Storage under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,691 | 1,732 | 2,189 | 2,554 | 2,832 | 2,942 | 3,300 | 3,488 | 3,445 | 2,964 | 2,626 | 2,109 |
| Above Normal | 1,279 | 1,322 | 1,485 | 1,959 | 2,519 | 2,892 | 3,247 | 3,393 | 3,232 | 2,600 | 2,117 | 1,659 |
| Below Normal | 1,542 | 1,497 | 1,507 | 1,719 | 2,122 | 2,397 | 2,653 | 2,714 | 2,530 | 1,923 | 1,513 | 1,307 |
| Dry | 1,206 | 1,158 | 1,177 | 1,305 | 1,582 | 1,938 | 2,178 | 2,210 | 1,951 | 1,478 | 1,287 | 1,144 |
| Critical Dry | 1,092 | 1,029 | 1,019 | 1,108 | 1,223 | 1,381 | 1,408 | 1,392 | 1,243 | 1,018 | 917 | 865 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,936 | 1,984 | 2,354 | 2,636 | 2,871 | 2,942 | 3,300 | 3,477 | 3,402 | 2,976 | 2,728 | 2,569 |
| Above Normal | 1,465 | 1,523 | 1,702 | 2,173 | 2,648 | 2,937 | 3,271 | 3,357 | 3,081 | 2,493 | 2,087 | 1,827 |
| Below Normal | 1,823 | 1,783 | 1,831 | 2,037 | 2,361 | 2,627 | 2,875 | 2,836 | 2,461 | 1,930 | 1,637 | 1,424 |
| Dry | 1,371 | 1,324 | 1,344 | 1,473 | 1,764 | 2,120 | 2,363 | 2,357 | 2,031 | 1,688 | 1,427 | 1,261 |
| Critical Dry | 1,117 | 1,044 | 1,041 | 1,125 | 1,235 | 1,406 | 1,423 | 1,407 | 1,219 | 1,027 | 911 | 839 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -245 | -252 | -165 | -82 | -39 | 0 | 0 | 10 | 43 | -12 | -102 | -459 |
| Above Normal | -187 | -201 | -217 | -214 | -129 | -44 | -24 | 37 | 150 | 107 | 29 | -167 |
| Below Normal | -281 | -285 | -324 | -318 | -239 | -230 | -222 | -122 | 69 | -7 | -125 | -117 |
| Dry | -165 | -165 | -167 | -168 | -182 | -182 | -185 | -147 | -80 | -210 | -140 | -117 |
| Critical Dry | -25 | -15 | -22 | -17 | -12 | -25 | -16 | -15 | 25 | -8 | 6 | 26 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -12.6 | -12.7 | -7.0 | -3.1 | -1.4 | 0.0 | 0.0 | 0.3 | 1.3 | -0.4 | -3.7 | -17.9 |
| Above Normal | -12.7 | -13.2 | -12.7 | -9.9 | -4.9 | -1.5 | -0.7 | 1.1 | 4.9 | 4.3 | 1.4 | -9.2 |
| Below Normal | -15.4 | -16.0 | -17.7 | -15.6 | -10.1 | -8.8 | -7.7 | -4.3 | 2.8 | -0.4 | -7.6 | -8.2 |
| Dry | -12.0 | -12.5 | -12.4 | -11.4 | -10.3 | -8.6 | -7.8 | -6.2 | -3.9 | -12.4 | -9.8 | -9.3 |
| Critical Dry | -2.2 | -1.5 | -2.1 | -1.5 | -1.0 | -1.8 | -1.1 | -1.1 | 2.0 | -0.8 | 0.7 | 3.1 |

**Table 5.16 Changes in Lake Oroville Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 743 | 748 | 794 | 829 | 852 | 859 | 884 | 897 | 894 | 861 | 836 | 790 |
| Above Normal | 698 | 703 | 722 | 776 | 828 | 856 | 880 | 890 | 879 | 835 | 794 | 746 |
| Below Normal | 730 | 725 | 726 | 751 | 793 | 818 | 838 | 842 | 828 | 773 | 729 | 704 |
| Dry | 688 | 683 | 686 | 704 | 737 | 775 | 798 | 800 | 775 | 724 | 702 | 684 |
| Critical Dry | 674 | 667 | 664 | 678 | 693 | 712 | 715 | 712 | 693 | 663 | 648 | 640 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 768 | 773 | 810 | 837 | 854 | 859 | 884 | 896 | 891 | 861 | 844 | 831 |
| Above Normal | 717 | 723 | 745 | 796 | 838 | 859 | 882 | 888 | 869 | 826 | 790 | 763 |
| Below Normal | 757 | 752 | 757 | 779 | 812 | 834 | 854 | 852 | 823 | 775 | 743 | 719 |
| Dry | 706 | 701 | 705 | 721 | 755 | 791 | 814 | 813 | 784 | 748 | 718 | 698 |
| Critical Dry | 677 | 668 | 668 | 680 | 694 | 715 | 716 | 714 | 691 | 664 | 647 | 636 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -24 | -25 | -16 | -8 | -3 | 0 | 0 | 1 | 3 | 0 | -8 | -41 |
| Above Normal | -19 | -21 | -24 | -20 | -10 | -3 | -2 | 3 | 10 | 10 | 4 | -18 |
| Below Normal | -27 | -27 | -31 | -28 | -20 | -17 | -16 | -9 | 5 | -1 | -14 | -14 |
| Dry | -18 | -18 | -18 | -17 | -18 | -16 | -15 | -14 | -9 | -24 | -17 | -15 |
| Critical Dry | -3 | -1 | -3 | -3 | -1 | -3 | -2 | -2 | 2 | 0 | 1 | 4 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -3.2 | -3.2 | -1.9 | -0.9 | -0.3 | 0.0 | 0.0 | 0.1 | 0.3 | -0.1 | -0.9 | -5.0 |
| Above Normal | -2.7 | -2.9 | -3.2 | -2.5 | -1.2 | -0.4 | -0.2 | 0.3 | 1.2 | 1.2 | 0.5 | -2.3 |
| Below Normal | -3.6 | -3.6 | -4.0 | -3.6 | -2.4 | -2.0 | -1.9 | -1.1 | 0.6 | -0.2 | -1.9 | -2.0 |
| Dry | -2.5 | -2.6 | -2.6 | -2.4 | -2.4 | -2.0 | -1.9 | -1.7 | -1.2 | -3.2 | -2.3 | -2.1 |
| Critical Dry | -0.4 | -0.2 | -0.5 | -0.4 | -0.2 | -0.4 | -0.2 | -0.3 | 0.4 | 0.0 | 0.2 | 0.6 |

The following changes in Lake Oroville storage and surface water elevations would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in January through August and reduced in September through December (up to 17.9 percent).
- In above-normal years, storage would be similar in February through August and reduced in September through January (up to 13.2 percent).
- In below-normal years, storage would be similar in May through July and reduced in August through April (up to 17.7 percent).

- In dry years, storage would be similar in June and reduced in all other months (up to 12.5 percent).
- In critical dry years, storage would be similar under all months.
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Feather River flows would occur under the No Action Alternative as compared to the Second Basis of Comparison, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in November and April; increased flows in July through September (up to 76.1 percent); and reduced flows in October, December through March, May, and June (up to 27.2 percent).
- In wet years, similar flows would occur in October through November and March through May; increased flows in July through September (up to 184 percent) and reduced flows in December through February (up to 26.0 percent).
- In dry years, similar flows would occur in November through March; increased flows in April and July (up to 52.4 percent); and reduced flows in August through October and May and June (up to 27.6 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Tables 5.17 and 5.18. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized in Table 5.18.

**Table 5.17 Changes in Folsom Lake Storage under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 454 | 435 | 514 | 518 | 515 | 632 | 785 | 951 | 941 | 800 | 712 | 576 |
| Above Normal | 377 | 380 | 429 | 513 | 531 | 640 | 787 | 946 | 887 | 621 | 552 | 477 |
| Below Normal | 446 | 431 | 467 | 484 | 533 | 619 | 757 | 843 | 780 | 527 | 472 | 453 |
| Dry | 394 | 383 | 408 | 423 | 479 | 579 | 691 | 760 | 658 | 495 | 443 | 419 |
| Critical Dry | 324 | 305 | 315 | 320 | 366 | 432 | 475 | 486 | 415 | 327 | 267 | 231 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 483 | 470 | 522 | 524 | 515 | 632 | 785 | 951 | 937 | 793 | 688 | 646 |
| Above Normal | 390 | 412 | 467 | 537 | 538 | 640 | 787 | 946 | 857 | 591 | 522 | 485 |
| Below Normal | 506 | 489 | 502 | 514 | 541 | 626 | 761 | 847 | 739 | 475 | 408 | 387 |
| Dry | 405 | 399 | 423 | 437 | 486 | 585 | 698 | 769 | 664 | 486 | 432 | 408 |
| Critical Dry | 339 | 317 | 323 | 325 | 369 | 436 | 469 | 482 | 430 | 352 | 288 | 258 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -29 | -35 | -8 | -6 | 0 | 0 | 0 | 0 | 4 | 7 | 25 | -70 |
| Above Normal | -13 | -33 | -38 | -24 | -7 | 0 | 0 | 1 | 30 | 31 | 30 | -8 |
| Below Normal | -59 | -58 | -35 | -30 | -8 | -7 | -4 | -4 | 41 | 52 | 64 | 66 |
| Dry | -12 | -16 | -15 | -14 | -7 | -6 | -7 | -9 | -5 | 9 | 11 | 11 |
| Critical Dry | -14 | -11 | -9 | -5 | -3 | -3 | 6 | 4 | -16 | -25 | -21 | -28 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -6.1 | -7.4 | -1.5 | -1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.9 | 3.6 | -10.8 |
| Above Normal | -3.4 | -7.9 | -8.2 | -4.5 | -1.3 | 0.0 | 0.0 | 0.1 | 3.5 | 5.2 | 5.7 | -1.6 |
| Below Normal | -11.7 | -11.9 | -7.0 | -5.8 | -1.4 | -1.1 | -0.5 | -0.5 | 5.5 | 11.0 | 15.6 | 17.1 |
| Dry | -2.9 | -4.0 | -3.5 | -3.2 | -1.4 | -1.0 | -1.1 | -1.1 | -0.8 | 1.9 | 2.5 | 2.8 |
| Critical Dry | -4.2 | -3.6 | -2.7 | -1.6 | -0.7 | -0.7 | 1.2 | 0.8 | -3.6 | -7.2 | -7.2 | -10.8 |

**Table 5.18 Changes in Folsom Lake Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 464 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 430 | 422 | 413 |
| Below Normal | 408 | 406 | 411 | 414 | 420 | 431 | 445 | 454 | 447 | 418 | 411 | 409 |
| Dry | 400 | 399 | 403 | 405 | 413 | 426 | 438 | 445 | 434 | 414 | 408 | 405 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 411 | 412 | 401 | 386 | 374 | 366 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 412 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 464 | 449 | 438 | 433 |
| Above Normal | 397 | 400 | 410 | 421 | 421 | 433 | 448 | 465 | 456 | 427 | 419 | 414 |
| Below Normal | 415 | 414 | 416 | 417 | 421 | 432 | 446 | 455 | 443 | 410 | 401 | 398 |
| Dry | 401 | 401 | 405 | 407 | 414 | 427 | 439 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 389 | 386 | 390 | 391 | 397 | 406 | 410 | 411 | 404 | 391 | 378 | 372 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -4 | -5 | -1 | -1 | 0 | 0 | 0 | -1 | 0 | 1 | 3 | -8 |
| Above Normal | -2 | -5 | -5 | -3 | -1 | 0 | 0 | -1 | 3 | 4 | 4 | -1 |
| Below Normal | -7 | -7 | -4 | -4 | -1 | -1 | -1 | -1 | 4 | 8 | 10 | 10 |
| Dry | -1 | -2 | -2 | -2 | -1 | -1 | -1 | -1 | -1 | 1 | 1 | 1 |
| Critical Dry | -3 | -2 | -2 | -1 | 0 | 0 | 1 | 0 | -2 | -5 | -4 | -6 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.9 | -1.1 | -0.2 | -0.2 | 0.0 | 0.0 | 0.0 | -0.2 | -0.1 | 0.2 | 0.6 | -1.9 |
| Above Normal | -0.6 | -1.3 | -1.2 | -0.7 | -0.2 | 0.0 | 0.0 | -0.1 | 0.6 | 0.9 | 0.8 | -0.2 |
| Below Normal | -1.8 | -1.8 | -1.1 | -0.9 | -0.2 | -0.2 | -0.1 | -0.2 | 0.9 | 1.9 | 2.5 | 2.6 |
| Dry | -0.3 | -0.5 | -0.5 | -0.4 | -0.2 | -0.2 | -0.2 | -0.3 | -0.2 | 0.3 | 0.3 | 0.4 |
| Critical Dry | -0.7 | -0.6 | -0.4 | -0.2 | -0.1 | -0.1 | 0.2 | 0.1 | -0.6 | -1.2 | -1.1 | -1.7 |

The following changes in Folsom Lake storage would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in December through August and reduced in September through November (up to 10.8 percent).
- In above-normal years, storage would be similar in January through June, September, and October; reduced in November and December (up to 8.2 percent); and increased in July and August (up to 5.7 percent).
- In below-normal years, storage would be similar in February through May; reduced in October through January (up to 11.9 percent); and increased in July through September (up to 17.1 percent).

- In dry years, storage would be similar in all months.
- In critical dry years, storage would be similar in October through June and reduced in July through September (up to 10.8 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in American River flows would occur under the No Action Alternative as compared to the Second Basis of Comparison, as shown on Figures 5.65 through 5.67.

- Over long-term conditions, similar flows would occur in November through May and July; increased flows in September and October (up to 44.7 percent); and reduced flows in June and August (up to 6.1 percent).
- In wet years, similar flows would occur in October through November and January through July; increased flows in September (91.1 percent) and reduced flows in December and August (up to 10.7 percent).
- In dry years, similar flows would occur in all months except October, February and July; increased flows in October (16.5 percent); and reduced flows in February and July (up to 7.3 percent).

*Clear Creek*

Changes in flows in Clear Creek downstream of Whiskeytown Dam are summarized in Table 5.19. Monthly Clear Creek flows under the No Action Alternative as compared to the Second Basis of Comparison are identical except in May. In May, under the No Action Alternative, flows are up to 40.7 percent higher than under the Second Basis of Comparison in accordance with the 2009 NMFS BO.

**Table 5.19 Changes in Clear Creek Flows below Whiskeytown Dam under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 175 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 0 | 0 | 0 | 0 |
| Dry | -3 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 0 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | -1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.3 | 0.0 | 0.0 | 0.0 | 0.0 |

*New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under the No Action Alternative as compared to the Second Basis of Comparison, are summarized in Tables 5.20 and 5.21. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized in Table 5.21.

1 **Table 5.20 Changes in New Melones Reservoir Storage under the No Action**
2 **Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,379 | 1,390 | 1,454 | 1,562 | 1,666 | 1,724 | 1,758 | 1,878 | 1,968 | 1,890 | 1,773 | 1,703 |
| Above Normal | 1,029 | 1,060 | 1,125 | 1,214 | 1,317 | 1,406 | 1,413 | 1,484 | 1,467 | 1,372 | 1,277 | 1,232 |
| Below Normal | 1,294 | 1,305 | 1,326 | 1,351 | 1,413 | 1,438 | 1,390 | 1,383 | 1,359 | 1,268 | 1,175 | 1,133 |
| Dry | 1,094 | 1,094 | 1,106 | 1,121 | 1,156 | 1,188 | 1,154 | 1,132 | 1,087 | 997 | 914 | 871 |
| Critical Dry | 624 | 623 | 638 | 645 | 661 | 656 | 602 | 554 | 526 | 476 | 431 | 408 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,443 | 1,446 | 1,502 | 1,606 | 1,709 | 1,794 | 1,833 | 1,962 | 1,994 | 1,917 | 1,803 | 1,731 |
| Above Normal | 1,092 | 1,116 | 1,175 | 1,261 | 1,360 | 1,455 | 1,481 | 1,543 | 1,516 | 1,419 | 1,321 | 1,274 |
| Below Normal | 1,364 | 1,366 | 1,378 | 1,397 | 1,453 | 1,479 | 1,461 | 1,447 | 1,415 | 1,322 | 1,228 | 1,183 |
| Dry | 1,149 | 1,143 | 1,149 | 1,161 | 1,191 | 1,221 | 1,210 | 1,176 | 1,131 | 1,039 | 956 | 912 |
| Critical Dry | 667 | 663 | 674 | 680 | 696 | 690 | 646 | 585 | 557 | 498 | 449 | 426 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -64 | -56 | -49 | -44 | -43 | -70 | -75 | -84 | -25 | -27 | -30 | -28 |
| Above Normal | -62 | -56 | -50 | -46 | -43 | -48 | -68 | -59 | -49 | -46 | -44 | -42 |
| Below Normal | -69 | -61 | -52 | -46 | -40 | -41 | -71 | -63 | -55 | -54 | -52 | -51 |
| Dry | -55 | -49 | -43 | -40 | -35 | -33 | -56 | -45 | -44 | -43 | -42 | -42 |
| Critical Dry | -44 | -40 | -37 | -36 | -35 | -34 | -45 | -31 | -31 | -23 | -18 | -18 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -4.4 | -3.9 | -3.2 | -2.7 | -2.5 | -3.9 | -4.1 | -4.3 | -1.3 | -1.4 | -1.6 | -1.6 |
| Above Normal | -5.7 | -5.0 | -4.2 | -3.7 | -3.2 | -3.3 | -4.6 | -3.8 | -3.3 | -3.3 | -3.3 | -3.3 |
| Below Normal | -5.1 | -4.5 | -3.8 | -3.3 | -2.8 | -2.8 | -4.9 | -4.4 | -3.9 | -4.1 | -4.3 | -4.3 |
| Dry | -4.8 | -4.3 | -3.8 | -3.4 | -3.0 | -2.7 | -4.6 | -3.8 | -3.9 | -4.1 | -4.4 | -4.6 |
| Critical Dry | -6.6 | -6.1 | -5.4 | -5.2 | -5.0 | -5.0 | -6.9 | -5.3 | -5.5 | -4.5 | -4.0 | -4.2 |

**Table 5.21 Changes in New Melones Reservoir Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 980 | 982 | 990 | 1,004 | 1,016 | 1,023 | 1,026 | 1,039 | 1,047 | 1,040 | 1,029 | 1,022 |
| Above Normal | 932 | 937 | 945 | 960 | 974 | 986 | 988 | 997 | 996 | 985 | 973 | 967 |
| Below Normal | 968 | 969 | 972 | 975 | 985 | 988 | 985 | 985 | 983 | 972 | 960 | 955 |
| Dry | 943 | 943 | 944 | 947 | 951 | 957 | 955 | 953 | 948 | 934 | 922 | 915 |
| Critical Dry | 856 | 856 | 862 | 864 | 870 | 871 | 860 | 848 | 840 | 828 | 818 | 812 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 989 | 990 | 997 | 1,009 | 1,021 | 1,030 | 1,034 | 1,047 | 1,050 | 1,043 | 1,032 | 1,025 |
| Above Normal | 941 | 944 | 951 | 966 | 979 | 992 | 995 | 1,003 | 1,001 | 990 | 978 | 972 |
| Below Normal | 977 | 977 | 979 | 982 | 991 | 994 | 994 | 993 | 991 | 980 | 968 | 962 |
| Dry | 951 | 950 | 950 | 953 | 957 | 962 | 963 | 960 | 954 | 941 | 929 | 922 |
| Critical Dry | 866 | 866 | 870 | 872 | 878 | 879 | 871 | 856 | 850 | 835 | 823 | 817 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -9 | -8 | -7 | -6 | -5 | -8 | -8 | -8 | -3 | -3 | -3 | -3 |
| Above Normal | -9 | -7 | -6 | -6 | -6 | -6 | -8 | -7 | -5 | -5 | -5 | -5 |
| Below Normal | -9 | -8 | -7 | -7 | -6 | -6 | -9 | -8 | -7 | -8 | -8 | -8 |
| Dry | -8 | -7 | -6 | -6 | -5 | -5 | -8 | -7 | -7 | -7 | -7 | -7 |
| Critical Dry | -10 | -10 | -9 | -8 | -8 | -8 | -11 | -8 | -10 | -6 | -5 | -6 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.9 | -0.8 | -0.7 | -0.6 | -0.5 | -0.7 | -0.8 | -0.8 | -0.3 | -0.3 | -0.3 | -0.3 |
| Above Normal | -0.9 | -0.8 | -0.7 | -0.6 | -0.6 | -0.6 | -0.8 | -0.7 | -0.5 | -0.5 | -0.5 | -0.5 |
| Below Normal | -0.9 | -0.8 | -0.7 | -0.7 | -0.6 | -0.6 | -0.9 | -0.8 | -0.7 | -0.8 | -0.8 | -0.8 |
| Dry | -0.8 | -0.8 | -0.7 | -0.7 | -0.6 | -0.5 | -0.9 | -0.7 | -0.7 | -0.7 | -0.8 | -0.8 |
| Critical Dry | -1.2 | -1.1 | -1.0 | -1.0 | -0.9 | -0.9 | -1.2 | -1.0 | -1.2 | -0.8 | -0.6 | -0.7 |

The following changes in New Melones Reservoir storage would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet, below-normal, and dry years, storage would be similar in all months.
- In above-normal years, storage would be similar in all months except October when storage would be reduced by 5.7 percent.
- In critical dry years, storage would be similar in February, March, and July through September and reduced in October through January and April through June (up to 6.9 percent).

- In all months, in all water year types, surface water elevations would be similar.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in these rivers are summarized below.

- Over long-term conditions, similar flows would occur in May and July through September; increased flows in October, March, and April (up to 148.7 percent); and reduced flows in November through February and June (up to 33.8 percent).
- In wet years, similar flows would occur in February and April; increased flows in October, March, May, July, and August (up to 117.1 percent); and reduced flows in September, November through January, and June (up to 50.8 percent).
- In dry years, similar flows would occur in July through September; increased flows in October and April (up to 154.3 percent); and reduced flows in November through March, May, and June (up to 35.7 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions, similar flows would occur in July through September and November through May; increased flows in October (19 percent); and reduced flows in June (8 percent).
- In wet years, similar flows would occur in July through September and November through May; increased flows in October (16.8 percent); and reduced flows in June (9.4 percent).
- In dry years, similar flows would occur in November through March and May through September; and increased flows in October and April (up to 18.3 percent).

*San Luis Reservoir*

Storage levels and surface water elevations in San Luis Reservoir under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Tables 5.22 and 5.23. A summary of the results is provided following Table 5.23.

**Table 5.22 Changes in San Luis Reservoir Storage under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 555 | 681 | 931 | 1,236 | 1,526 | 1,788 | 1,598 | 1,251 | 946 | 741 | 628 | 679 |
| Above Normal | 490 | 649 | 957 | 1,223 | 1,441 | 1,661 | 1,444 | 1,048 | 666 | 466 | 433 | 513 |
| Below Normal | 525 | 624 | 907 | 1,141 | 1,314 | 1,473 | 1,312 | 967 | 555 | 500 | 426 | 467 |
| Dry | 476 | 590 | 867 | 1,150 | 1,339 | 1,494 | 1,413 | 1,167 | 840 | 763 | 476 | 469 |
| Critical Dry | 478 | 556 | 752 | 1,040 | 1,204 | 1,252 | 1,192 | 1,028 | 739 | 544 | 343 | 323 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 790 | 1,017 | 1,365 | 1,748 | 1,965 | 2,033 | 2,031 | 1,852 | 1,487 | 1,167 | 889 | 925 |
| Above Normal | 658 | 883 | 1,213 | 1,671 | 1,913 | 2,001 | 1,995 | 1,717 | 1,263 | 861 | 612 | 631 |
| Below Normal | 854 | 1,064 | 1,334 | 1,742 | 1,908 | 1,980 | 1,908 | 1,628 | 1,251 | 964 | 635 | 591 |
| Dry | 617 | 764 | 998 | 1,427 | 1,728 | 1,925 | 1,870 | 1,665 | 1,341 | 1,007 | 660 | 596 |
| Critical Dry | 622 | 709 | 910 | 1,257 | 1,556 | 1,664 | 1,623 | 1,451 | 1,168 | 808 | 545 | 472 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -234 | -336 | -433 | -513 | -439 | -245 | -433 | -601 | -541 | -426 | -261 | -245 |
| Above Normal | -168 | -234 | -257 | -448 | -471 | -341 | -551 | -669 | -598 | -395 | -179 | -117 |
| Below Normal | -329 | -439 | -427 | -601 | -594 | -507 | -596 | -660 | -696 | -465 | -209 | -124 |
| Dry | -141 | -174 | -130 | -277 | -390 | -431 | -457 | -498 | -501 | -244 | -185 | -127 |
| Critical Dry | -144 | -153 | -158 | -217 | -352 | -412 | -431 | -423 | -429 | -263 | -202 | -149 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -25.2 | -19.8 | -21.2 | -29.1 | -11.8 | 9.4 | -57.2 | -51.8 | -2.3 | 5.8 | 9.6 | -3.2 |
| Above Normal | -12.2 | -13.6 | -12.2 | -43.4 | -31.3 | -12.9 | -71.2 | -71.0 | -24.1 | 2.6 | 9.5 | -3.5 |
| Below Normal | -29.6 | -23.4 | -5.3 | -42.6 | -28.7 | -21.2 | -60.1 | -67.1 | -49.5 | 4.5 | 20.4 | 0.7 |
| Dry | -14.0 | -16.3 | -6.7 | -32.3 | -39.1 | -35.5 | -40.7 | -44.9 | -29.3 | 34.2 | -9.2 | -2.8 |
| Critical Dry | -7.7 | -15.2 | -15.7 | -19.4 | -38.4 | -32.7 | -30.7 | -25.3 | -51.1 | 60.2 | -13.0 | -3.0 |

**Table 5.23 Changes in San Luis Reservoir Elevation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 399 | 414 | 443 | 473 | 500 | 523 | 507 | 475 | 444 | 422 | 409 | 416 |
| Above Normal | 391 | 411 | 445 | 472 | 492 | 512 | 493 | 456 | 415 | 389 | 386 | 398 |
| Below Normal | 397 | 410 | 442 | 465 | 481 | 496 | 481 | 448 | 400 | 393 | 383 | 389 |
| Dry | 391 | 406 | 437 | 466 | 484 | 498 | 490 | 468 | 434 | 426 | 390 | 389 |
| Critical Dry | 390 | 400 | 423 | 454 | 470 | 475 | 469 | 453 | 422 | 399 | 369 | 366 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 426 | 451 | 485 | 520 | 538 | 543 | 543 | 529 | 497 | 468 | 440 | 443 |
| Above Normal | 412 | 437 | 470 | 513 | 534 | 541 | 540 | 518 | 477 | 437 | 409 | 411 |
| Below Normal | 435 | 457 | 483 | 519 | 533 | 539 | 533 | 510 | 476 | 448 | 412 | 406 |
| Dry | 407 | 425 | 450 | 492 | 518 | 535 | 530 | 513 | 484 | 453 | 415 | 406 |
| Critical Dry | 409 | 419 | 441 | 475 | 502 | 512 | 509 | 494 | 468 | 432 | 400 | 389 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -26 | -37 | -42 | -46 | -38 | -20 | -36 | -53 | -53 | -46 | -30 | -27 |
| Above Normal | -21 | -26 | -25 | -41 | -41 | -29 | -47 | -61 | -62 | -48 | -23 | -14 |
| Below Normal | -38 | -47 | -42 | -54 | -52 | -43 | -52 | -62 | -76 | -56 | -30 | -17 |
| Dry | -17 | -19 | -12 | -25 | -34 | -37 | -40 | -45 | -51 | -27 | -25 | -18 |
| Critical Dry | -19 | -20 | -18 | -21 | -32 | -38 | -40 | -41 | -45 | -32 | -32 | -24 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -6.2 | -8.2 | -8.7 | -8.9 | -7.0 | -3.7 | -6.7 | -10.1 | -10.7 | -9.8 | -6.9 | -6.1 |
| Above Normal | -5.1 | -6.0 | -5.4 | -8.1 | -7.7 | -5.3 | -8.7 | -11.8 | -13.0 | -11.0 | -5.7 | -3.3 |
| Below Normal | -8.6 | -10.2 | -8.6 | -10.4 | -9.8 | -8.0 | -9.7 | -12.1 | -16.0 | -12.4 | -7.2 | -4.1 |
| Dry | -4.1 | -4.4 | -2.8 | -5.1 | -6.6 | -6.9 | -7.5 | -8.8 | -10.4 | -5.9 | -6.0 | -4.3 |
| Critical Dry | -4.7 | -4.7 | -4.1 | -4.5 | -6.4 | -7.3 | -7.8 | -8.3 | -9.7 | -7.4 | -7.9 | -6.2 |

The following changes in San Luis Reservoir storage would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in June and September; increased in March, July, and August (up to 9.6 percent); and reduced in October through February, April, and May (up to 57.2 percent).
- In above-normal years, storage would be similar in July and September; increased in August (9.5 percent); and reduced in October through June (up to 71.2 percent).

- In below-normal years, storage would be similar in July and September; increased in August (20.4 percent); and reduced in October through June (up to 67.1 percent).
- In dry years, storage would be similar in September; increased in July (34.2 percent); and reduced in October through June and August (up to 44.0 percent).
- In critical dry years, storage would be similar in September; increased in July (60.2 percent); and reduced in August and October through June (up to 51.1 percent).

The following changes in San Luis Reservoir surface water elevations would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, surface water elevations would be less in all months (up to 10.7 percent).
- In above-normal years, surface water elevations would be less in all months (up to 13.0 percent).
- In below-normal years, surface water elevations would be less in all months (up to 16.0 percent).
- In dry years, surface water elevations would be similar in September through January and less in February through August (up to 10.4 percent).
- In critical dry years, surface water elevations would be similar in October through January and reduced in February through September (up to 9.7 percent).

*Changes in Flows into the Yolo Bypass at Fremont Weir*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Table 5.24. The results are summarized following Table 5.24.

**Table 5.24 Changes in Flows into the Yolo Bypass at Fremont Weir under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 183 | 910 | 8,420 | 24,291 | 29,547 | 18,493 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,765 | 5,997 | 13,013 | 7,928 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,031 | 883 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 322 | 902 | 2,024 | 1,393 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 528 | 534 | 396 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 147 | 996 | 9,888 | 25,442 | 30,547 | 18,997 | 5,602 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,659 | 6,349 | 15,114 | 8,566 | 1,765 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,256 | 4,057 | 1,166 | 292 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 932 | 2,032 | 1,411 | 411 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 542 | 533 | 408 | 106 | 100 | 100 | 0 | 0 | 100 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 37 | -86 | -1,468 | -1,151 | -1,000 | -504 | 25 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 106 | -352 | -2,102 | -638 | -77 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | -20 | -253 | -1,026 | -283 | 1 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | -20 | -30 | -7 | -17 | -4 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | -1 | -15 | 1 | -12 | 0 | 0 | 0 | 0 | 0 | 0 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 25.0 | -8.7 | -14.8 | -4.5 | -3.3 | -2.7 | 0.4 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 4.0 | -5.5 | -13.9 | -7.4 | -4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | -7.5 | -20.1 | -25.3 | -24.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | -5.9 | -3.2 | -0.4 | -1.2 | -1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | -0.5 | -2.7 | 0.2 | -2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The following changes in flows from the Sacramento River into Yolo Bypass at Fremont Weir would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- In wet years, flows into Yolo Bypass would be similar in January through September; increased in October (25 percent); and reduced in November and December (up to 14.8 percent).
- In above-normal years, flows into Yolo Bypass would be similar in April through December and reduced in January through March (up to 13.9 percent).

- In below-normal years, flows into Yolo Bypass would be similar in April through November and reduced in December through March (up to 25.3 percent).
- In dry years, flows into Yolo Bypass would be similar in January through November and reduced in December (5.9 percent).
- In critical dry years, flows into Yolo Bypass would be similar in all months.

*Changes in Delta Conditions*

Delta outflow under the No Action Alternative as compared to the Second Basis of Comparison are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow in July through November, January, April, and May (up to 13,683 cfs) and decrease in December, February, March, and June (up to 1,590 cfs).
- In dry years, average monthly Delta outflow would be similar or increase (up to 3,114 cfs).

The OMR conditions under the No Action Alternative as compared to the Second Basis of Comparison are summarized below and shown on Figures 5.76 through 5.78.

- Under the No Action Alternative, OMR flows are negative except in April and May of wet and above normal years and April of below normal years. Under the Second Basis of Comparison, OMR flows are negative in all months of all water year types.
- In wet years, average monthly OMR flows would be more positive in September through February, April, and May (up to 10,005 cfs) and more negative in March and June through August (up to 923 cfs).
- In dry years, average monthly OMR flows would be more positive in August through June (up to 3,489 cfs) and more negative in June (2,073 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under the No Action Alternative as compared to the Second Basis of Comparison are summarized in Table 5.25.

**Table 5.25 Changes in Exports at Jones and Banks Pumping Plants under the No Action Alternative as Compared to the Second Basis of Comparison**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 410 | 497 | 564 | 513 | 537 | 594 | 204 | 207 | 445 | 669 | 717 | 638 |
| Above Normal | 376 | 450 | 562 | 406 | 401 | 496 | 130 | 105 | 315 | 587 | 709 | 628 |
| Below Normal | 386 | 456 | 590 | 387 | 354 | 394 | 134 | 100 | 209 | 657 | 622 | 542 |
| Dry | 374 | 398 | 510 | 392 | 315 | 318 | 153 | 126 | 194 | 541 | 296 | 426 |
| Critical Dry | 314 | 293 | 384 | 349 | 250 | 179 | 93 | 90 | 64 | 223 | 176 | 242 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 549 | 619 | 716 | 724 | 609 | 543 | 476 | 430 | 456 | 632 | 655 | 660 |
| Above Normal | 428 | 521 | 641 | 716 | 584 | 570 | 453 | 363 | 415 | 572 | 647 | 651 |
| Below Normal | 548 | 595 | 623 | 674 | 497 | 500 | 337 | 304 | 414 | 629 | 517 | 539 |
| Dry | 435 | 475 | 546 | 579 | 518 | 493 | 259 | 228 | 274 | 403 | 325 | 438 |
| Critical Dry | 340 | 345 | 455 | 433 | 406 | 266 | 134 | 121 | 132 | 139 | 203 | 249 |
| **No Action Alternative as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -139 | -123 | -152 | -211 | -72 | 51 | -272 | -223 | -11 | 37 | 63 | -21 |
| Above Normal | -52 | -71 | -78 | -311 | -183 | -73 | -322 | -257 | -100 | 15 | 61 | -23 |
| Below Normal | -162 | -139 | -33 | -287 | -143 | -106 | -203 | -204 | -205 | 28 | 105 | 4 |
| Dry | -61 | -77 | -36 | -187 | -202 | -175 | -105 | -102 | -80 | 138 | -30 | -12 |
| Critical Dry | -26 | -52 | -71 | -84 | -156 | -87 | -41 | -31 | -67 | 84 | -26 | -8 |
| **No Action Alternative as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -25.2 | -19.8 | -21.2 | -29.1 | -11.8 | 9.4 | -57.2 | -51.8 | -2.3 | 5.8 | 9.6 | -3.2 |
| Above Normal | -12.2 | -13.6 | -12.2 | -43.4 | -31.3 | -12.9 | -71.2 | -71.0 | -24.1 | 2.6 | 9.5 | -3.5 |
| Below Normal | -29.6 | -23.4 | -5.3 | -42.6 | -28.7 | -21.2 | -60.1 | -67.1 | -49.5 | 4.5 | 20.4 | 0.7 |
| Dry | -14.0 | -16.3 | -6.7 | -32.3 | -39.1 | -35.5 | -40.7 | -44.9 | -29.3 | 34.2 | -9.2 | -2.8 |
| Critical Dry | -7.7 | -15.2 | -15.7 | -19.4 | -38.4 | -32.7 | -30.7 | -25.3 | -51.1 | 60.2 | -13.0 | -3.0 |

The following changes would occur in CVP and SWP exports under the No Action Alternative as compared to the Second Basis of Comparison.

- Long-term average annual exports would be 1,051 TAF (18 percent) less under the No Action Alternative as compared to the Second Basis of Comparison.
- In wet years, total exports would be similar in June and September; reduced in October through February, April, and May (up to 57.2 percent); and increased in March, July, and August (up to 9.6 percent).
- In above-normal and below-normal years, total exports would be similar in July and September; reduced in October through June (up to 71.2 and

67.1 percent, respectively); and increased in August (up to 9.5 and 20.4 percent, respectively).

- In dry and critical dry years, total exports would be similar in September; reduced in October through June and August (up to 44.9 and 51.1 percent, respectively); and increased in July (34.2 and 60.2 percent, respectively).

Deliveries to CVP and SWP water users decline under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Tables 5.26 and 5.27, respectively, due to reduced water supply availability and export limitations.

**Table 5.26 Changes in CVP Water Deliveries under the No Action Alternative as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | No Action Alternative as Compared to the Second Basis of Comparison | |
| | | No Action Alternative | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 185 | 219 | -34 | -16 |
| | Dry | 86 | 122 | -37 | -30 |
| | Critical Dry | 24 | 35 | -12 | -34 |
| CVP Municipal and Industrial (M&I) (Including American River Contractors and CCWD) | Long Term | 386 | 392 | -7 | -2 |
| | Dry | 385 | 390 | -5 | -1 |
| | Critical Dry | 383 | 383 | 1 | 0 |
| CVP M&I American River Contractors | Long Term | 113 | 120 | -7 | -6 |
| | Dry | 97 | 105 | -8 | -8 |
| | Critical Dry | 75 | 79 | -5 | -6 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,859 | 1,858 | 1 | 0 |
| | Dry | 1,906 | 1,905 | 1 | 0 |
| | Critical Dry | 1,737 | 1,732 | 5 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 146 | 155 | -8 | -5 |
| | Dry | 146 | 151 | -5 | -3 |
| | Critical Dry | 102 | 105 | -3 | -3 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | No Action Alternative as Compared to the Second Basis of Comparison | |
| | | No Action Alternative | Second Basis of Comparison | Difference | Percent Change |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 2,576 | 2,624 | -48 | -2 |
| | Dry | 2,523 | 2,568 | -45 | -2 |
| | Critical Dry | 2,246 | 2,255 | -9 | 0 |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 847 | 1,100 | -253 | -23 |
| | Dry | 445 | 650 | -206 | -32 |
| | Critical Dry | 131 | 195 | -64 | -33 |
| CVP M&I Users | Long Term | 112 | 125 | -13 | -10 |
| | Dry | 99 | 109 | -10 | -9 |
| | Critical Dry | 80 | 85 | -4 | -5 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 273 | 272 | 1 | 0 |
| | Dry | 281 | 280 | 1 | 0 |
| | Critical Dry | 234 | 232 | 3 | 1 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 2,084 | 2,349 | -266 | -11 |
| | Dry | 1,700 | 1,914 | -216 | -11 |
| | Critical Dry | 1,186 | 1,253 | -68 | -5 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 508 | 514 | -6 | -1 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 445 | 486 | -42 | -9 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | No Action Alternative | Second Basis of Comparison | No Action Alternative as Compared to the Second Basis of Comparison | |
| | | | | Difference | Percent Change |
| CVP Water Service Contracts | Long Term | 104 | 118 | -15 | -13 |
| | Dry | 84 | 98 | -13 | -13 |
| | Critical Dry | 4 | 25 | -21 | -84 |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 612 | 632 | -21 | -3 |
| | Dry | 608 | 622 | -13 | -2 |
| | Critical Dry | 449 | 511 | -63 | -12 |

The following changes in CVP water deliveries would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 16 percent over the long-term conditions (averaged over the 82-year period analyzed with CalSim II), 30 percent in dry years, and 34 percent in critical dry years.
- Deliveries to CVP North of Delta M&I contractors would be similar in total; however, deliveries to the American River CVP contractors would be reduced by 6 percent over the long-term conditions, 8 percent in dry years, and 6 percent in critical dry years.
- Deliveries to CVP South of Delta agricultural water service contractors would be reduced by 23 percent over the long-term conditions, 32 percent in dry years, and 33 percent in critical dry years.
- Deliveries to CVP South of Delta M&I contractors would be reduced by 10 percent over the long-term conditions, 9 percent in dry years, and 5 percent in critical dry years.
- Deliveries to the Eastside contractors would be similar under the long-term conditions and dry years, but reduce by 12 percent in critical dry years.

**Table 5.27 Changes in SWP Water Deliveries under the No Action Alternative as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | No Action Alternative as Compared to the Second Basis of Comparison | |
| | | No Action Alternative | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 68 | 83 | -15 | -18 |
| | Dry | 51 | 62 | -11 | -18 |
| | Critical Dry | 43 | 53 | -11 | -20 |
| SWP M&I Article 21 Deliveries | Long Term | 13 | 12 | 1 | 9 |
| | Dry | 14 | 13 | 1 | 7 |
| | Critical Dry | 13 | 12 | 1 | 9 |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 68 | 83 | -15 | -18 |
| | Dry | 51 | 62 | -11 | -18 |
| | Critical Dry | 43 | 53 | -11 | -20 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 13 | 12 | 1 | 9 |
| | Dry | 14 | 13 | 1 | 7 |
| | Critical Dry | 13 | 12 | 1 | 9 |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 610 | 750 | -139 | -19 |
| | Dry | 455 | 567 | -112 | -20 |
| | Critical Dry | 378 | 484 | -106 | -22 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | No Action Alternative as Compared to the Second Basis of Comparison | |
| | | No Action Alternative | Second Basis of Comparison | Difference | Percent Change |
| SWP Agricultural Article 21 Deliveries | Long Term | 27 | 178 | -152 | -85 |
| | Dry | 5 | 143 | -138 | -96 |
| | Critical Dry | 7 | 100 | -93 | -93 |
| SWP M&I Users (without Article 21) | Long Term | 1,800 | 2,183 | -383 | -18 |
| | Dry | 1,406 | 1,732 | -327 | -19 |
| | Critical Dry | 1,173 | 1,494 | -321 | -21 |
| SWP M&I Article 21 Deliveries | Long Term | 20 | 104 | -84 | -81 |
| | Dry | 5 | 86 | -82 | -95 |
| | Critical Dry | 5 | 58 | -53 | -91 |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,410 | 2,933 | -523 | -18 |
| | Dry | 1,861 | 2,299 | -439 | -19 |
| | Critical Dry | 1,551 | 1,978 | -427 | -22 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 47 | 282 | -236 | -83 |
| | Dry | 10 | 229 | -219 | -96 |
| | Critical Dry | 12 | 158 | -146 | -92 |

The following changes in SWP water deliveries would occur under the No Action Alternative as compared to the Second Basis of Comparison.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be reduced by 18 percent over the long-term conditions; 18 percent in dry years; and 20 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be reduced by 18 percent over the long-term conditions; 19 percent in dry years; and 22 percent in critical dry years.

- Deliveries of Article 21 water to SWP North of Delta water contractors would be increased by 9 percent over the long-term conditions; 7 percent in dry years; and 9 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 83 percent over the long-term conditions; 96 percent in dry years; and 92 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns; the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September in accordance with the 2008 USFWS BO and 2009 NMFS BO. The maximum amount of water to be transferred would be 600,000 acre-feet per year in critical dry years or in dry years following a dry or critical dry year. In all other water year types, the maximum amount of water would be 360,000 acre-feet per year. The maximum amount of water that can be exported in the CVP and SWP facilities is approximately 770,000 acre-feet per month. As indicated in Table 5.25, capacity would be available under the No Action Alternative between July and September for water transfers in all water year types.

Under the Second Basis of Comparison, water could be transferred throughout the year. As indicated in Table 5.25, capacity would be available under the Second Basis of Comparison in all months of all water year types without a maximum volume of transferred water.

Overall, the potential for water transfer conveyance would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 5.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including

CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability of CVP and SWP water supplies for storage in these reservoirs under the No Action Alternative as compared to the Second Basis of Comparison would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.26 and 5.27.

- Deliveries to CVP South of Delta M&I contractors and reservoirs in the San Francisco Bay Area would be reduced by 10 percent over the long-term conditions; 9 percent in dry years; and 7 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors and reservoirs in the San Francisco Bay Area, Central Coast, and Southern California regions would be reduced by 18 percent over the long-term conditions; 19 percent in dry years; and 22 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors and reservoirs in the San Francisco Bay Area, Central Coast, and Southern California regions would be reduced by 83 percent over the long-term conditions; 96 percent in dry years; and 92 percent in critical dry years.

*Changes in CVP and SWP Deliveries*

Deliveries to CVP and SWP water users are described in Section 5.4.3.1.2, Central Valley Region.

### *5.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because water resource conditions under Alternative 1 are identical to water resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 5.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.28 and 5.29. A summary of the results is provided following Table 5.29.

**Table 5.28 Changes in Trinity Lake Storage under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 1,501 | 1,535 | 1,644 | 1,767 | 1,931 | 2,055 | 2,224 | 2,250 | 2,194 | 2,068 | 1,939 | 1,805 |
| Above Normal | 1,208 | 1,245 | 1,363 | 1,524 | 1,718 | 1,901 | 2,079 | 2,053 | 1,955 | 1,815 | 1,647 | 1,513 |
| Below Normal | 1,451 | 1,472 | 1,492 | 1,554 | 1,641 | 1,729 | 1,872 | 1,799 | 1,696 | 1,515 | 1,337 | 1,204 |
| Dry | 1,178 | 1,184 | 1,210 | 1,230 | 1,322 | 1,453 | 1,586 | 1,536 | 1,466 | 1,302 | 1,152 | 1,055 |
| Critical Dry | 819 | 803 | 813 | 825 | 868 | 949 | 999 | 962 | 929 | 811 | 667 | 598 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,490 | 1,516 | 1,630 | 1,756 | 1,921 | 2,053 | 2,220 | 2,245 | 2,190 | 2,067 | 1,939 | 1,784 |
| Above Normal | 1,159 | 1,178 | 1,286 | 1,455 | 1,658 | 1,847 | 2,025 | 1,999 | 1,907 | 1,773 | 1,619 | 1,495 |
| Below Normal | 1,393 | 1,400 | 1,417 | 1,488 | 1,575 | 1,662 | 1,817 | 1,743 | 1,637 | 1,470 | 1,304 | 1,185 |
| Dry | 1,152 | 1,148 | 1,174 | 1,182 | 1,274 | 1,403 | 1,539 | 1,490 | 1,413 | 1,253 | 1,104 | 1,008 |
| Critical Dry | 747 | 731 | 746 | 750 | 790 | 872 | 923 | 888 | 862 | 745 | 612 | 536 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 11 | 19 | 14 | 11 | 9 | 2 | 4 | 5 | 4 | 0 | -1 | 21 |
| Above Normal | 49 | 68 | 77 | 69 | 60 | 54 | 55 | 54 | 49 | 42 | 27 | 18 |
| Below Normal | 59 | 72 | 74 | 66 | 67 | 67 | 54 | 57 | 60 | 44 | 33 | 18 |
| Dry | 26 | 36 | 36 | 48 | 48 | 49 | 47 | 46 | 53 | 48 | 48 | 48 |
| Critical Dry | 73 | 72 | 68 | 75 | 78 | 78 | 76 | 74 | 66 | 66 | 56 | 61 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.7 | 1.3 | 0.9 | 0.6 | 0.5 | 0.1 | 0.2 | 0.2 | 0.2 | 0.0 | 0.0 | 1.2 |
| Above Normal | 4.2 | 5.7 | 6.0 | 4.7 | 3.6 | 2.9 | 2.7 | 2.7 | 2.5 | 2.4 | 1.7 | 1.2 |
| Below Normal | 4.2 | 5.2 | 5.2 | 4.4 | 4.2 | 4.0 | 3.0 | 3.2 | 3.6 | 3.0 | 2.5 | 1.5 |
| Dry | 2.2 | 3.2 | 3.1 | 4.1 | 3.8 | 3.5 | 3.0 | 3.1 | 3.7 | 3.9 | 4.3 | 4.7 |
| Critical Dry | 9.7 | 9.9 | 9.1 | 10.1 | 9.8 | 8.9 | 8.2 | 8.4 | 7.7 | 8.8 | 9.1 | 11.5 |

**Table 5.29 Changes in Trinity Lake Elevation under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,270 | 2,273 | 2,286 | 2,303 | 2,320 | 2,335 | 2,347 | 2,346 | 2,339 | 2,329 | 2,315 | 2,304 |
| Below Normal | 2,295 | 2,296 | 2,298 | 2,305 | 2,313 | 2,320 | 2,331 | 2,326 | 2,318 | 2,303 | 2,287 | 2,274 |
| Dry | 2,266 | 2,269 | 2,272 | 2,274 | 2,284 | 2,296 | 2,309 | 2,304 | 2,298 | 2,284 | 2,269 | 2,259 |
| Critical Dry | 2,218 | 2,216 | 2,217 | 2,222 | 2,229 | 2,243 | 2,250 | 2,246 | 2,243 | 2,227 | 2,204 | 2,191 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,324 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,327 |
| Above Normal | 2,261 | 2,264 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,341 | 2,335 | 2,325 | 2,313 | 2,302 |
| Below Normal | 2,289 | 2,289 | 2,291 | 2,299 | 2,307 | 2,315 | 2,327 | 2,321 | 2,313 | 2,299 | 2,283 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,264 | 2,254 |
| Critical Dry | 2,210 | 2,207 | 2,210 | 2,213 | 2,220 | 2,235 | 2,242 | 2,238 | 2,235 | 2,220 | 2,196 | 2,182 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Above Normal | 8 | 10 | 10 | 9 | 7 | 5 | 4 | 4 | 4 | 4 | 2 | 2 |
| Below Normal | 6 | 7 | 7 | 6 | 6 | 6 | 4 | 5 | 5 | 4 | 3 | 3 |
| Dry | 3 | 4 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 |
| Critical Dry | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 9 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Above Normal | 0.4 | 0.4 | 0.5 | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |
| Below Normal | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 |
| Dry | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Critical Dry | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |

The following changes in Trinity Lake storage and surface water elevation would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years and dry years, storage would be similar in all months.
- In above-normal years, storage would be similar in January through October and increased in November and December (up to 6.0 percent).
- In below-normal years, storage would be similar in January through October and increased in November and December (up to 5.2 percent).
- In critical dry years, storage would be increased in all months (up to 11.5 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes would occur on the Trinity River under Alternative 1 as compared to the No Action Alternative, as shown on Figures 5.53 through 5.55.

- Over long-term conditions, flows would be similar in March through November and increased in December through February (up to 10.5 percent).
- In wet years, flows would be similar in April through November and increased in December through March (up to 12.6 percent).
- In dry years, flows would be similar all months.

*Central Valley Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

*Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.30 and 5.31. Changes in flows in the Sacramento River downstream of Keswick Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized following Table 5.31.

**Table 5.30 Changes in Shasta Lake Storage under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 2,817 | 2,926 | 3,154 | 3,406 | 3,597 | 3,841 | 4,301 | 4,453 | 4,228 | 3,733 | 3,362 | 3,252 |
| Above Normal | 2,499 | 2,578 | 2,808 | 3,313 | 3,515 | 4,038 | 4,416 | 4,417 | 3,979 | 3,347 | 2,975 | 2,921 |
| Below Normal | 2,826 | 2,846 | 2,977 | 3,299 | 3,646 | 3,966 | 4,164 | 4,042 | 3,599 | 3,010 | 2,601 | 2,574 |
| Dry | 2,409 | 2,431 | 2,578 | 2,755 | 3,168 | 3,644 | 3,861 | 3,774 | 3,333 | 2,800 | 2,539 | 2,496 |
| Critical Dry | 1,873 | 1,826 | 1,911 | 2,050 | 2,222 | 2,460 | 2,386 | 2,270 | 1,861 | 1,409 | 1,151 | 1,086 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,700 | 2,719 | 3,077 | 3,384 | 3,589 | 3,836 | 4,298 | 4,460 | 4,242 | 3,735 | 3,410 | 2,985 |
| Above Normal | 2,369 | 2,385 | 2,600 | 3,167 | 3,453 | 4,021 | 4,404 | 4,429 | 4,039 | 3,407 | 3,069 | 2,834 |
| Below Normal | 2,587 | 2,548 | 2,686 | 3,062 | 3,442 | 3,814 | 4,026 | 3,957 | 3,588 | 3,002 | 2,643 | 2,608 |
| Dry | 2,345 | 2,283 | 2,428 | 2,621 | 3,034 | 3,505 | 3,737 | 3,668 | 3,284 | 2,767 | 2,496 | 2,462 |
| Critical Dry | 1,702 | 1,633 | 1,717 | 1,871 | 2,031 | 2,274 | 2,202 | 2,088 | 1,719 | 1,253 | 986 | 937 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 117 | 208 | 77 | 22 | 8 | 5 | 3 | -7 | -14 | -2 | -49 | 267 |
| Above Normal | 130 | 193 | 208 | 146 | 62 | 17 | 12 | -11 | -60 | -60 | -94 | 87 |
| Below Normal | 239 | 298 | 291 | 237 | 204 | 152 | 138 | 86 | 10 | 8 | -42 | -33 |
| Dry | 64 | 148 | 150 | 135 | 134 | 139 | 123 | 106 | 48 | 33 | 42 | 35 |
| Critical Dry | 171 | 193 | 194 | 179 | 190 | 186 | 184 | 183 | 142 | 155 | 165 | 149 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 4.3 | 7.6 | 2.5 | 0.6 | 0.2 | 0.1 | 0.1 | -0.2 | -0.3 | -0.1 | -1.4 | 8.9 |
| Above Normal | 5.5 | 8.1 | 8.0 | 4.6 | 1.8 | 0.4 | 0.3 | -0.3 | -1.5 | -1.8 | -3.1 | 3.1 |
| Below Normal | 9.3 | 11.7 | 10.8 | 7.7 | 5.9 | 4.0 | 3.4 | 2.2 | 0.3 | 0.3 | -1.6 | -1.3 |
| Dry | 2.7 | 6.5 | 6.2 | 5.1 | 4.4 | 4.0 | 3.3 | 2.9 | 1.5 | 1.2 | 1.7 | 1.4 |
| Critical Dry | 10.1 | 11.8 | 11.3 | 9.6 | 9.4 | 8.2 | 8.4 | 8.7 | 8.3 | 12.4 | 16.8 | 16.0 |

**Table 5.31 Changes in Shasta Lake Elevation under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,037 | 1,022 | 1,017 |
| Above Normal | 974 | 978 | 992 | 1,019 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,005 | 1,003 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,053 | 1,049 | 1,031 | 1,006 | 987 | 986 |
| Dry | 972 | 974 | 982 | 992 | 1,012 | 1,032 | 1,041 | 1,038 | 1,020 | 997 | 984 | 982 |
| Critical Dry | 938 | 935 | 941 | 950 | 961 | 977 | 974 | 967 | 943 | 910 | 889 | 884 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 986 | 985 | 991 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 989 | 987 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,034 | 1,018 | 995 | 982 | 980 |
| Critical Dry | 927 | 923 | 929 | 939 | 951 | 968 | 965 | 958 | 935 | 899 | 876 | 872 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 6 | 10 | 4 | 1 | 0 | 0 | 0 | 0 | -1 | 0 | -2 | 12 |
| Above Normal | 7 | 10 | 10 | 7 | 3 | 1 | 0 | 0 | -2 | -3 | -4 | 4 |
| Below Normal | 11 | 14 | 13 | 10 | 9 | 6 | 5 | 4 | 1 | 1 | -2 | -1 |
| Dry | 3 | 7 | 7 | 6 | 6 | 6 | 5 | 4 | 2 | 2 | 3 | 2 |
| Critical Dry | 11 | 12 | 12 | 11 | 10 | 9 | 9 | 9 | 8 | 11 | 13 | 12 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.6 | 1.0 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | -0.2 | 1.2 |
| Above Normal | 0.7 | 1.0 | 1.0 | 0.7 | 0.3 | 0.1 | 0.0 | 0.0 | -0.2 | -0.3 | -0.4 | 0.4 |
| Below Normal | 1.1 | 1.4 | 1.3 | 1.0 | 0.8 | 0.6 | 0.5 | 0.3 | 0.1 | 0.1 | -0.2 | -0.1 |
| Dry | 0.3 | 0.7 | 0.7 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.2 | 0.2 | 0.3 | 0.2 |
| Critical Dry | 1.2 | 1.3 | 1.3 | 1.2 | 1.0 | 0.9 | 1.0 | 1.0 | 0.8 | 1.2 | 1.5 | 1.4 |

The following changes in Shasta Lake storage and surface water elevations would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, storage would be similar in December through August and October and increased in September and November (up to 8.9 percent).
- In above-normal years, storage would be similar in January through September and increased in October through December (up to 8.1 percent).
- In below-normal years, storage would be similar in March through September and increased in October through February (up to 11.7 percent).

- In dry years, storage would be similar in February through October and increased in November through January (up to 6.5 percent).
- In critical dry years, storage would be increased under all months (up to 16.8 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Sacramento River flows would occur under Alternative 1 as compared to the No Action Alternative, as shown on Figures 5.56 through 5.61.

- Sacramento River downstream of Keswick Dam (Figures 5.56 through 5.58).
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 27.4 percent); and increased flows in December, January, and June (up to 8.4 percent).
  - In wet years, similar flows would occur in January through July; reduced flows in September through November (up to 43.7 percent); and increased flows in December and August (up to 17.0 percent).
  - In dry years, similar flows would occur in July through October, December through March, and May; reduced flows in November (25.0 percent); and increased flows in April and June (up to 7.8 percent).
- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61).
  - Over long-term conditions, similar flows would occur in October, December through May, and August; reduced flows in September, November, and July (up to 30.2 percent); and increased flows in June (12.8 percent).
  - In wet years, similar flows would occur in January through June and October; reduced flows in July through September and November (up to 47.4 percent); and increased flows in December (6.6 percent).
  - In dry years, similar flows would occur in August through October and December through April; reduced flows in November and July (up to 13.6 percent); and increased flows in May and June (up to 13.5 percent).

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.32 and 5.33. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized following Table 5.33.

**Table 5.32 Changes in Lake Oroville Storage under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 1,936 | 1,984 | 2,354 | 2,636 | 2,871 | 2,942 | 3,300 | 3,477 | 3,402 | 2,976 | 2,728 | 2,569 |
| Above Normal | 1,465 | 1,523 | 1,702 | 2,173 | 2,648 | 2,937 | 3,271 | 3,357 | 3,081 | 2,493 | 2,087 | 1,827 |
| Below Normal | 1,823 | 1,783 | 1,831 | 2,037 | 2,361 | 2,627 | 2,875 | 2,836 | 2,461 | 1,930 | 1,637 | 1,424 |
| Dry | 1,371 | 1,324 | 1,344 | 1,473 | 1,764 | 2,120 | 2,363 | 2,357 | 2,031 | 1,688 | 1,427 | 1,261 |
| Critical Dry | 1,117 | 1,044 | 1,041 | 1,125 | 1,235 | 1,406 | 1,423 | 1,407 | 1,219 | 1,027 | 911 | 839 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,691 | 1,732 | 2,189 | 2,554 | 2,832 | 2,942 | 3,300 | 3,488 | 3,445 | 2,964 | 2,626 | 2,109 |
| Above Normal | 1,279 | 1,322 | 1,485 | 1,959 | 2,519 | 2,892 | 3,247 | 3,393 | 3,232 | 2,600 | 2,117 | 1,659 |
| Below Normal | 1,542 | 1,497 | 1,507 | 1,719 | 2,122 | 2,397 | 2,653 | 2,714 | 2,530 | 1,923 | 1,513 | 1,307 |
| Dry | 1,206 | 1,158 | 1,177 | 1,305 | 1,582 | 1,938 | 2,178 | 2,210 | 1,951 | 1,478 | 1,287 | 1,144 |
| Critical Dry | 1,092 | 1,029 | 1,019 | 1,108 | 1,223 | 1,381 | 1,408 | 1,392 | 1,243 | 1,018 | 917 | 865 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 245 | 252 | 165 | 82 | 39 | 0 | 0 | -10 | -43 | 12 | 102 | 459 |
| Above Normal | 187 | 201 | 217 | 214 | 129 | 44 | 24 | -37 | -150 | -107 | -29 | 167 |
| Below Normal | 281 | 285 | 324 | 318 | 239 | 230 | 222 | 122 | -69 | 7 | 125 | 117 |
| Dry | 165 | 165 | 167 | 168 | 182 | 182 | 185 | 147 | 80 | 210 | 140 | 117 |
| Critical Dry | 25 | 15 | 22 | 17 | 12 | 25 | 16 | 15 | -25 | 8 | -6 | -26 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 14.5 | 14.6 | 7.6 | 3.2 | 1.4 | 0.0 | 0.0 | -0.3 | -1.2 | 0.4 | 3.9 | 21.8 |
| Above Normal | 14.6 | 15.2 | 14.6 | 10.9 | 5.1 | 1.5 | 0.8 | -1.1 | -4.6 | -4.1 | -1.4 | 10.1 |
| Below Normal | 18.2 | 19.1 | 21.5 | 18.5 | 11.2 | 9.6 | 8.4 | 4.5 | -2.7 | 0.4 | 8.2 | 8.9 |
| Dry | 13.7 | 14.3 | 14.2 | 12.9 | 11.5 | 9.4 | 8.5 | 6.6 | 4.1 | 14.2 | 10.8 | 10.2 |
| Critical Dry | 2.3 | 1.5 | 2.2 | 1.5 | 1.0 | 1.8 | 1.1 | 1.1 | -2.0 | 0.8 | -0.7 | -3.0 |

**Table 5.33 Changes in Lake Oroville Elevation under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 768 | 773 | 810 | 837 | 854 | 859 | 884 | 896 | 891 | 861 | 844 | 831 |
| Above Normal | 717 | 723 | 745 | 796 | 838 | 859 | 882 | 888 | 869 | 826 | 790 | 763 |
| Below Normal | 757 | 752 | 757 | 779 | 812 | 834 | 854 | 852 | 823 | 775 | 743 | 719 |
| Dry | 706 | 701 | 705 | 721 | 755 | 791 | 814 | 813 | 784 | 748 | 718 | 698 |
| Critical Dry | 677 | 668 | 668 | 680 | 694 | 715 | 716 | 714 | 691 | 664 | 647 | 636 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 743 | 748 | 794 | 829 | 852 | 859 | 884 | 897 | 894 | 861 | 836 | 790 |
| Above Normal | 698 | 703 | 722 | 776 | 828 | 856 | 880 | 890 | 879 | 835 | 794 | 746 |
| Below Normal | 730 | 725 | 726 | 751 | 793 | 818 | 838 | 842 | 828 | 773 | 729 | 704 |
| Dry | 688 | 683 | 686 | 704 | 737 | 775 | 798 | 800 | 775 | 724 | 702 | 684 |
| Critical Dry | 674 | 667 | 664 | 678 | 693 | 712 | 715 | 712 | 693 | 663 | 648 | 640 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 24 | 25 | 16 | 8 | 3 | 0 | 0 | -1 | -3 | 0 | 8 | 41 |
| Above Normal | 19 | 21 | 24 | 20 | 10 | 3 | 2 | -3 | -10 | -10 | -4 | 18 |
| Below Normal | 27 | 27 | 31 | 28 | 20 | 17 | 16 | 9 | -5 | 1 | 14 | 14 |
| Dry | 18 | 18 | 18 | 17 | 18 | 16 | 15 | 14 | 9 | 24 | 17 | 15 |
| Critical Dry | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | -2 | 0 | -1 | -4 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 3.3 | 3.3 | 2.0 | 0.9 | 0.3 | 0.0 | 0.0 | -0.1 | -0.3 | 0.1 | 1.0 | 5.2 |
| Above Normal | 2.7 | 2.9 | 3.3 | 2.6 | 1.2 | 0.4 | 0.2 | -0.3 | -1.2 | -1.1 | -0.5 | 2.4 |
| Below Normal | 3.7 | 3.8 | 4.2 | 3.7 | 2.5 | 2.0 | 1.9 | 1.1 | -0.6 | 0.2 | 2.0 | 2.0 |
| Dry | 2.6 | 2.6 | 2.7 | 2.5 | 2.5 | 2.1 | 1.9 | 1.7 | 1.2 | 3.3 | 2.4 | 2.1 |
| Critical Dry | 0.4 | 0.2 | 0.5 | 0.4 | 0.2 | 0.4 | 0.2 | 0.3 | -0.4 | 0.0 | -0.2 | -0.6 |

The following changes in Lake Oroville storage and surface water elevations would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, storage would be similar in January through August and reduced in September through December (up to 21.8 percent).
- In above-normal years, storage would be similar in February through August and reduced in September through January (up to 15.2 percent).
- In below-normal years, storage would be similar in May through July and reduced in August through April (up to 21.5 percent).

- In dry years, storage would be similar in June and reduced in all other months (up to 14.2 percent).
- In critical dry years, storage would be similar under all months.
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Feather River flows would occur under Alternative 1 as compared to the No Action Alternative, as shown in Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in November and April; reduced flows in July through September (up to 43.2 percent); and increased flows in October, December through March, May, and June (up to 37.4 percent).
- In wet years, similar flows would occur in October, November, and March through May; reduced flows in July through September (up to 64.9 percent); and increased flows in December through February and June (up to 35.1 percent).
- In dry years, similar flows would occur in December through April; reduced flows in July (34.4 percent); and increased flows in August through October, May, and June (up to 38.1 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.34 and 5.35. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized following Table 5.35.

**Table 5.34 Changes in Folsom Lake Storage under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 483 | 470 | 522 | 524 | 515 | 632 | 785 | 951 | 937 | 793 | 688 | 646 |
| Above Normal | 390 | 412 | 467 | 537 | 538 | 640 | 787 | 946 | 857 | 591 | 522 | 485 |
| Below Normal | 506 | 489 | 502 | 514 | 541 | 626 | 761 | 847 | 739 | 475 | 408 | 387 |
| Dry | 405 | 399 | 423 | 437 | 486 | 585 | 698 | 769 | 664 | 486 | 432 | 408 |
| Critical Dry | 339 | 317 | 323 | 325 | 369 | 436 | 469 | 482 | 430 | 352 | 288 | 258 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 29 | 35 | 8 | 6 | 0 | 0 | 0 | 0 | -4 | -7 | -25 | 70 |
| Above Normal | 13 | 33 | 38 | 24 | 7 | 0 | 0 | -1 | -30 | -31 | -30 | 8 |
| Below Normal | 59 | 58 | 35 | 30 | 8 | 7 | 4 | 4 | -41 | -52 | -64 | -66 |
| Dry | 12 | 16 | 15 | 14 | 7 | 6 | 7 | 9 | 5 | -9 | -11 | -11 |
| Critical Dry | 14 | 11 | 9 | 5 | 3 | 3 | -6 | -4 | 16 | 25 | 21 | 28 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 29 | 35 | 8 | 6 | 0 | 0 | 0 | 0 | -4 | -7 | -25 | 70 |
| Above Normal | 13 | 33 | 38 | 24 | 7 | 0 | 0 | -1 | -30 | -31 | -30 | 8 |
| Below Normal | 59 | 58 | 35 | 30 | 8 | 7 | 4 | 4 | -41 | -52 | -64 | -66 |
| Dry | 12 | 16 | 15 | 14 | 7 | 6 | 7 | 9 | 5 | -9 | -11 | -11 |
| Critical Dry | 14 | 11 | 9 | 5 | 3 | 3 | -6 | -4 | 16 | 25 | 21 | 28 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 6.5 | 8.0 | 1.5 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | -0.5 | -0.9 | -3.5 | 12.1 |
| Above Normal | 3.5 | 8.6 | 8.9 | 4.7 | 1.3 | 0.0 | 0.0 | -0.1 | -3.4 | -5.0 | -5.4 | 1.7 |
| Below Normal | 13.3 | 13.5 | 7.5 | 6.1 | 1.4 | 1.1 | 0.5 | 0.5 | -5.2 | -9.9 | -13.5 | -14.6 |
| Dry | 2.9 | 4.2 | 3.6 | 3.3 | 1.4 | 1.0 | 1.1 | 1.2 | 0.8 | -1.8 | -2.5 | -2.7 |
| Critical Dry | 4.4 | 3.7 | 2.8 | 1.6 | 0.7 | 0.7 | -1.2 | -0.8 | 3.8 | 7.7 | 7.8 | 12.1 |

**Table 5.35 Changes in Folsom Lake Elevation under Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 412 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 464 | 449 | 438 | 433 |
| Above Normal | 397 | 400 | 410 | 421 | 421 | 433 | 448 | 465 | 456 | 427 | 419 | 414 |
| Below Normal | 415 | 414 | 416 | 417 | 421 | 432 | 446 | 455 | 443 | 410 | 401 | 398 |
| Dry | 401 | 401 | 405 | 407 | 414 | 427 | 439 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 389 | 386 | 390 | 391 | 397 | 406 | 410 | 411 | 404 | 391 | 378 | 372 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 464 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 430 | 422 | 413 |
| Below Normal | 408 | 406 | 411 | 414 | 420 | 431 | 445 | 454 | 447 | 418 | 411 | 409 |
| Dry | 400 | 399 | 403 | 405 | 413 | 426 | 438 | 445 | 434 | 414 | 408 | 405 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 411 | 412 | 401 | 386 | 374 | 366 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 4 | 5 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | -1 | -3 | 8 |
| Above Normal | 2 | 5 | 5 | 3 | 1 | 0 | 0 | 1 | -3 | -4 | -4 | 1 |
| Below Normal | 7 | 7 | 4 | 4 | 1 | 1 | 1 | 1 | -4 | -8 | -10 | -10 |
| Dry | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | -1 | -1 | -1 |
| Critical Dry | 3 | 2 | 2 | 1 | 0 | 0 | -1 | 0 | 2 | 5 | 4 | 6 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.9 | 1.1 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | -0.2 | -0.6 | 1.9 |
| Above Normal | 0.6 | 1.4 | 1.3 | 0.7 | 0.2 | 0.0 | 0.0 | 0.1 | -0.6 | -0.8 | -0.8 | 0.2 |
| Below Normal | 1.8 | 1.8 | 1.1 | 0.9 | 0.2 | 0.2 | 0.1 | 0.2 | -0.9 | -1.9 | -2.5 | -2.6 |
| Dry | 0.3 | 0.5 | 0.5 | 0.5 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | -0.3 | -0.3 | -0.4 |
| Critical Dry | 0.7 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | -0.2 | -0.1 | 0.6 | 1.2 | 1.1 | 1.8 |

The following changes in Folsom Lake storage would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, storage would be similar in December through August and increased in September through December (up to 12.1 percent).
- In above-normal years, storage would be similar in January through July and September through October; increased in November and December (up to 8.9 percent); and reduced in August (5.4 percent).
- In below-normal years, storage would be similar in February through May; reduced in June through September (up to 14.6 percent); and increased in October through January (up to 13.5 percent).

- In dry years, storage would be similar in all months.
- In critical dry years, storage would be similar in October through June and increased in July through September (up to 12.1 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in American River flows would occur under Alternative 1 as compared to the No Action Alternative, as shown on Figures 5.65 through 5.67.

- Over long-term conditions, similar flows would occur in November through May and July; reduced flows in September and October (up to 30.9 percent); and increased flows in June (5.4 percent).
- In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (47.7 percent); and increased flows in August (12.0 percent).
- In dry years, similar flows would occur in November through January, March through June, August, and September; reduced flows in October (14.1 percent); and increased flows in February and July (up to 7.9 percent).

*Clear Creek*

Changes in flows in Clear Creek downstream of Whiskeytown Dam are summarized in Table 5.36.

Monthly Clear Creek flows under Alternative 1 as compared to the No Action Alternative are identical except in May. In May, under Alternative 1, flows are up to 28.9 percent lower than under the No Action Alternative.

**Table 5.36 Changes in Clear Creek Flows below Whiskeytown Dam under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 175 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -78 | 0 | 0 | 0 | 0 |
| Dry | 3 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -47 | 0 | 0 | 0 | 0 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -27.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -27.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -28.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -28.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -22.1 | 0.0 | 0.0 | 0.0 | 0.0 |

*New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.37 and 5.38. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized following Table 5.38.

**Table 5.37 Changes in New Melones Reservoir Storage under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 1,443 | 1,446 | 1,502 | 1,606 | 1,709 | 1,794 | 1,833 | 1,962 | 1,994 | 1,917 | 1,803 | 1,731 |
| Above Normal | 1,092 | 1,116 | 1,175 | 1,261 | 1,360 | 1,455 | 1,481 | 1,543 | 1,516 | 1,419 | 1,321 | 1,274 |
| Below Normal | 1,364 | 1,366 | 1,378 | 1,397 | 1,453 | 1,479 | 1,461 | 1,447 | 1,415 | 1,322 | 1,228 | 1,183 |
| Dry | 1,149 | 1,143 | 1,149 | 1,161 | 1,191 | 1,221 | 1,210 | 1,176 | 1,131 | 1,039 | 956 | 912 |
| Critical Dry | 667 | 663 | 674 | 680 | 696 | 690 | 646 | 585 | 557 | 498 | 449 | 426 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,379 | 1,390 | 1,454 | 1,562 | 1,666 | 1,724 | 1,758 | 1,878 | 1,968 | 1,890 | 1,773 | 1,703 |
| Above Normal | 1,029 | 1,060 | 1,125 | 1,214 | 1,317 | 1,406 | 1,413 | 1,484 | 1,467 | 1,372 | 1,277 | 1,232 |
| Below Normal | 1,294 | 1,305 | 1,326 | 1,351 | 1,413 | 1,438 | 1,390 | 1,383 | 1,359 | 1,268 | 1,175 | 1,133 |
| Dry | 1,094 | 1,094 | 1,106 | 1,121 | 1,156 | 1,188 | 1,154 | 1,132 | 1,087 | 997 | 914 | 871 |
| Critical Dry | 624 | 623 | 638 | 645 | 661 | 656 | 602 | 554 | 526 | 476 | 431 | 408 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 64 | 56 | 49 | 44 | 43 | 70 | 75 | 84 | 25 | 27 | 30 | 28 |
| Above Normal | 62 | 56 | 50 | 46 | 43 | 48 | 68 | 59 | 49 | 46 | 44 | 42 |
| Below Normal | 69 | 61 | 52 | 46 | 40 | 41 | 71 | 63 | 55 | 54 | 52 | 51 |
| Dry | 55 | 49 | 43 | 40 | 35 | 33 | 56 | 45 | 44 | 43 | 42 | 42 |
| Critical Dry | 44 | 40 | 37 | 36 | 35 | 34 | 45 | 31 | 31 | 23 | 18 | 18 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 4.7 | 4.0 | 3.3 | 2.8 | 2.6 | 4.1 | 4.3 | 4.5 | 1.3 | 1.4 | 1.7 | 1.6 |
| Above Normal | 6.0 | 5.3 | 4.4 | 3.8 | 3.3 | 3.4 | 4.8 | 4.0 | 3.4 | 3.4 | 3.5 | 3.4 |
| Below Normal | 5.4 | 4.7 | 4.0 | 3.4 | 2.8 | 2.9 | 5.1 | 4.6 | 4.1 | 4.2 | 4.5 | 4.5 |
| Dry | 5.0 | 4.5 | 3.9 | 3.5 | 3.1 | 2.7 | 4.8 | 3.9 | 4.0 | 4.3 | 4.6 | 4.8 |
| Critical Dry | 7.0 | 6.4 | 5.8 | 5.5 | 5.2 | 5.2 | 7.5 | 5.6 | 5.9 | 4.8 | 4.2 | 4.4 |

**Table 5.38 Changes in New Melones Reservoir Elevation under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 989 | 990 | 997 | 1,009 | 1,021 | 1,030 | 1,034 | 1,047 | 1,050 | 1,043 | 1,032 | 1,025 |
| Above Normal | 941 | 944 | 951 | 966 | 979 | 992 | 995 | 1,003 | 1,001 | 990 | 978 | 901 |
| Below Normal | 977 | 977 | 979 | 982 | 991 | 994 | 994 | 993 | 991 | 980 | 968 | 962 |
| Dry | 951 | 950 | 950 | 953 | 957 | 962 | 963 | 960 | 954 | 941 | 929 | 922 |
| Critical Dry | 866 | 866 | 870 | 872 | 878 | 879 | 871 | 856 | 850 | 835 | 823 | 817 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 980 | 982 | 990 | 1,004 | 1,016 | 1,023 | 1,026 | 1,039 | 1,047 | 1,040 | 1,029 | 1,022 |
| Above Normal | 932 | 937 | 945 | 960 | 974 | 986 | 988 | 997 | 996 | 985 | 973 | 897 |
| Below Normal | 968 | 969 | 972 | 975 | 985 | 988 | 985 | 985 | 983 | 972 | 960 | 955 |
| Dry | 943 | 943 | 944 | 947 | 951 | 957 | 955 | 953 | 948 | 934 | 922 | 915 |
| Critical Dry | 856 | 856 | 862 | 864 | 870 | 871 | 860 | 848 | 840 | 828 | 818 | 812 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 9 | 8 | 7 | 6 | 5 | 8 | 8 | 8 | 3 | 3 | 3 | 3 |
| Above Normal | 9 | 7 | 6 | 6 | 6 | 6 | 8 | 7 | 5 | 5 | 5 | 5 |
| Below Normal | 9 | 8 | 7 | 7 | 6 | 6 | 9 | 8 | 7 | 8 | 8 | 8 |
| Dry | 8 | 7 | 6 | 6 | 5 | 5 | 8 | 7 | 7 | 7 | 7 | 7 |
| Critical Dry | 10 | 10 | 9 | 8 | 8 | 8 | 11 | 8 | 10 | 6 | 5 | 6 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | 0.8 | 0.8 | 0.8 | 0.3 | 0.3 | 0.3 | 0.3 |
| Above Normal | 1.0 | 0.8 | 0.7 | 0.6 | 0.6 | 0.6 | 0.8 | 0.7 | 0.5 | 0.6 | 0.5 | 0.5 |
| Below Normal | 1.0 | 0.9 | 0.7 | 0.7 | 0.6 | 0.6 | 0.9 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 |
| Dry | 0.9 | 0.8 | 0.7 | 0.7 | 0.6 | 0.5 | 0.9 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 |
| Critical Dry | 1.2 | 1.1 | 1.0 | 1.0 | 0.9 | 0.9 | 1.3 | 1.0 | 1.2 | 0.8 | 0.6 | 0.7 |

The following changes in New Melones Reservoir storage would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, storage would be similar in all months.
- In above-normal years, storage would be similar in December through September and increased in October and November (up to 6.0 percent).
- In below-normal years, storage would be similar in November through September and increased in October (5.4 percent).
- In dry years, storage would be similar in all months.

- In critical dry years, storage would be similar in July through September and increased in October through June (up to 7.5 percent).
- In all months, in all water year types, surface water elevations would be similar.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in these rivers are summarized below.

- Over long-term conditions, similar flows would occur in July through September; reduced flows in October, March, and April (up to 59.8 percent); and increased flows in November through February and June (up to 51.1 percent).
- In wet years, similar flows would occur in February and April; reduced flows in October, March, May, July, and August (up to 53.9 percent); and increased flows in September, November through January, and June (up to 103.2 percent).
- In dry years, similar flows would occur in July through September; reduced flows in October and April (up to 60.7 percent); and increased flows in November through March, May, and June (up to 55.5 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions, similar flows would occur in July through September and November through May; reduced flows in October (16.1 percent); and increased flows in June (8.4 percent).
- In wet years, similar flows would occur in July through September and November through May; reduced flows in October (14.4 percent); and increased flows in June (10.4 percent).
- In dry years, similar flows would occur in November through March and May through September; and reduced flows in October and April (up to 15.3 percent).

*San Luis Reservoir*

Storage levels and surface water elevations in San Luis Reservoir under Alternative 1 as compared to the No Action Alternative are summarized in Tables 5.39 and 5.40. The results are summarized following Table 5.40.

**Table 5.39 Changes in San Luis Reservoir Storage under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 790 | 1,017 | 1,365 | 1,748 | 1,965 | 2,033 | 2,031 | 1,852 | 1,487 | 1,167 | 889 | 925 |
| Above Normal | 658 | 883 | 1,213 | 1,671 | 1,913 | 2,001 | 1,995 | 1,717 | 1,263 | 861 | 612 | 631 |
| Below Normal | 854 | 1,064 | 1,334 | 1,742 | 1,908 | 1,980 | 1,908 | 1,628 | 1,251 | 964 | 635 | 591 |
| Dry | 617 | 764 | 998 | 1,427 | 1,728 | 1,925 | 1,870 | 1,665 | 1,341 | 1,007 | 660 | 596 |
| Critical Dry | 622 | 709 | 910 | 1,257 | 1,556 | 1,664 | 1,623 | 1,451 | 1,168 | 808 | 545 | 472 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 555 | 681 | 931 | 1,236 | 1,526 | 1,788 | 1,598 | 1,251 | 946 | 741 | 628 | 679 |
| Above Normal | 490 | 649 | 957 | 1,223 | 1,441 | 1,661 | 1,444 | 1,048 | 666 | 466 | 433 | 513 |
| Below Normal | 525 | 624 | 907 | 1,141 | 1,314 | 1,473 | 1,312 | 967 | 555 | 500 | 426 | 467 |
| Dry | 476 | 590 | 867 | 1,150 | 1,339 | 1,494 | 1,413 | 1,167 | 840 | 763 | 476 | 469 |
| Critical Dry | 478 | 556 | 752 | 1,040 | 1,204 | 1,252 | 1,192 | 1,028 | 739 | 544 | 343 | 323 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 234 | 336 | 433 | 513 | 439 | 245 | 433 | 601 | 541 | 426 | 261 | 245 |
| Above Normal | 168 | 234 | 257 | 448 | 471 | 341 | 551 | 669 | 598 | 395 | 179 | 117 |
| Below Normal | 329 | 439 | 427 | 601 | 594 | 507 | 596 | 660 | 696 | 465 | 209 | 124 |
| Dry | 141 | 174 | 130 | 277 | 390 | 431 | 457 | 498 | 501 | 244 | 185 | 127 |
| Critical Dry | 144 | 153 | 158 | 217 | 352 | 412 | 431 | 423 | 429 | 263 | 202 | 149 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 59.8 | 81.8 | 84.4 | 64.5 | 40.1 | 18.2 | 35.5 | 74.9 | 108.8 | 88.0 | 53.1 | 41.5 |
| Above Normal | 38.9 | 62.8 | 46.6 | 55.6 | 43.8 | 26.0 | 45.6 | 90.9 | 151.4 | 110.8 | 53.6 | 20.2 |
| Below Normal | 91.6 | 125.0 | 85.3 | 85.6 | 66.4 | 45.6 | 56.5 | 93.5 | 203.1 | 136.2 | 61.6 | 35.9 |
| Dry | 29.4 | 34.9 | 15.4 | 31.1 | 38.5 | 35.4 | 37.2 | 52.7 | 70.3 | 26.1 | 33.5 | 18.8 |
| Critical Dry | 38.7 | 39.5 | 25.0 | 24.4 | 37.8 | 39.5 | 40.3 | 43.8 | 57.1 | 38.6 | 46.2 | 20.1 |

**Table 5.40 Changes in San Luis Reservoir Elevation under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 426 | 451 | 485 | 520 | 538 | 543 | 543 | 529 | 497 | 468 | 440 | 443 |
| Above Normal | 412 | 437 | 470 | 513 | 534 | 541 | 540 | 518 | 477 | 437 | 409 | 411 |
| Below Normal | 435 | 457 | 483 | 519 | 533 | 539 | 533 | 510 | 476 | 448 | 412 | 406 |
| Dry | 407 | 425 | 450 | 492 | 518 | 535 | 530 | 513 | 484 | 453 | 415 | 406 |
| Critical Dry | 409 | 419 | 441 | 475 | 502 | 512 | 509 | 494 | 468 | 432 | 400 | 389 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 399 | 414 | 443 | 473 | 500 | 523 | 507 | 475 | 444 | 422 | 409 | 416 |
| Above Normal | 391 | 411 | 445 | 472 | 492 | 512 | 493 | 456 | 415 | 389 | 386 | 398 |
| Below Normal | 397 | 410 | 442 | 465 | 481 | 496 | 481 | 448 | 400 | 393 | 383 | 389 |
| Dry | 391 | 406 | 437 | 466 | 484 | 498 | 490 | 468 | 434 | 426 | 390 | 389 |
| Critical Dry | 390 | 400 | 423 | 454 | 470 | 475 | 469 | 453 | 422 | 399 | 369 | 366 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 26 | 37 | 42 | 46 | 38 | 20 | 36 | 53 | 53 | 46 | 30 | 27 |
| Above Normal | 21 | 26 | 25 | 41 | 41 | 29 | 47 | 61 | 62 | 48 | 23 | 14 |
| Below Normal | 38 | 47 | 42 | 54 | 52 | 43 | 52 | 62 | 76 | 56 | 30 | 17 |
| Dry | 17 | 19 | 12 | 25 | 34 | 37 | 40 | 45 | 51 | 27 | 25 | 18 |
| Critical Dry | 19 | 20 | 18 | 21 | 32 | 38 | 40 | 41 | 45 | 32 | 32 | 24 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 6.6 | 8.9 | 9.6 | 9.8 | 7.5 | 3.9 | 7.2 | 11.2 | 12.0 | 10.9 | 7.4 | 6.6 |
| Above Normal | 5.4 | 6.4 | 5.7 | 8.8 | 8.4 | 5.6 | 9.5 | 13.4 | 15.0 | 12.3 | 6.0 | 3.4 |
| Below Normal | 9.5 | 11.4 | 9.4 | 11.6 | 10.8 | 8.7 | 10.8 | 13.8 | 19.0 | 14.2 | 7.8 | 4.3 |
| Dry | 4.2 | 4.6 | 2.8 | 5.4 | 7.1 | 7.4 | 8.1 | 9.7 | 11.6 | 6.3 | 6.3 | 4.5 |
| Critical Dry | 4.9 | 4.9 | 4.2 | 4.7 | 6.8 | 7.9 | 8.4 | 9.0 | 10.8 | 8.0 | 8.6 | 6.6 |

The following changes in San Luis Reservoir storage would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, storage would be increased in all months (up to 108.8 percent). Water storage elevations would be increased in all months (up to 12.0 percent).
- In above-normal years, storage would be increased in all months (up to 151.4 percent). Water storage elevations would be increased in all months (up to 15.0 percent).
- In below-normal years, storage would be increased in all months (up to 203.1 percent). Water storage elevations would be increased in all months (up to 19.0 percent).
- In dry years, storage would be increased in all months (up to 70.3 percent). Water storage elevations would be increased in all months (up to 11.6 percent).
- In critical dry years, storage would be increased in all months (up to 57.1 percent). Water storage elevations would be increased in all months (up to 10.8 percent).

*Changes in Flows into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 1 as compared to the No Action Alternative are summarized in Table 5.41. The results are summarized following Table 5.41.

**Table 5.41 Changes in Flows into the Yolo Bypass at Fremont Weir under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 147 | 996 | 9,888 | 25,442 | 30,547 | 18,997 | 5,602 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,659 | 6,349 | 15,114 | 8,566 | 1,765 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,256 | 4,057 | 1,166 | 292 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 932 | 2,032 | 1,411 | 411 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 542 | 533 | 408 | 106 | 100 | 100 | 0 | 0 | 100 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 183 | 910 | 8,420 | 24,291 | 29,547 | 18,493 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,765 | 5,997 | 13,013 | 7,928 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,031 | 883 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 322 | 902 | 2,024 | 1,393 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 528 | 534 | 396 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -37 | 86 | 1,468 | 1,151 | 1,000 | 504 | -25 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | -106 | 352 | 2,102 | 638 | 77 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 20 | 253 | 1,026 | 283 | -1 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | 20 | 30 | 7 | 17 | 4 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 1 | 15 | -1 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -20.0 | 9.5 | 17.4 | 4.7 | 3.4 | 2.7 | -0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | -3.8 | 5.9 | 16.2 | 8.0 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 8.1 | 25.2 | 33.9 | 32.1 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 6.2 | 3.3 | 0.4 | 1.2 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.5 | 2.8 | -0.2 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The following changes in flows from the Sacramento River into Yolo Bypass at Fremont Weir would occur under Alternative 1 as compared to the No Action Alternative.

- In wet years, flows into Yolo Bypass would be similar in January through September; reduced in October (20 percent); and increased in November and December (up to 17.4 percent).
- In above-normal years, flows into Yolo Bypass would be similar in April through December; and increased in January through March (up to 16.2 percent).

- In below-normal years, flows into Yolo Bypass would be similar in April through November; and increased in December through March (up to 33.9 percent).
- In dry years, flows into Yolo Bypass would be similar in January through November; and increased in December (6.2 percent).
- In critical dry years, flows into Yolo Bypass would be similar in all months.

*Changes in Delta Conditions*

Delta outflow under Alternative 1 as compared to the No Action Alternative are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow would increase in December, February, March, and June (up to 1,492 cfs) and decrease in July through November, January, April, and May (up to 13,683 cfs).
- In dry years, average monthly Delta outflow would be similar in September; decrease in July, August, and October through May (up to 3,114 cfs); and increase in June (385 cfs).

The OMR conditions under Alternative 1 are shown on Figures 5.77 through 5.79.

- In all water years, average monthly OMR flows would be negative in all months under Alternative 1. Under the No Action Alternative, OMR flows would be positive only in wet and above normal years in April and May and April in above normal years.
- In wet years, average monthly OMR flows, would be more positive in June through August and March (up to 923 cfs); and more negative in April through June and September through February (up to 10,005 cfs).
- In dry years, average monthly OMR flows would be positive in July (up to 2,073 cfs), and more negative in August through June (up to 3,489 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under Alternative 1 as compared to the No Action Alternative are summarized in Table 5.42.

**Table 5.42 Changes in Exports at Jones and Banks Pumping Plants under the Alternative 1 as Compared to the No Action Alternative**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 1** | | | | | | | | | | | | |
| Wet | 549 | 619 | 716 | 724 | 609 | 543 | 476 | 430 | 456 | 632 | 655 | 660 |
| Above Normal | 428 | 521 | 641 | 716 | 584 | 570 | 453 | 363 | 415 | 572 | 647 | 651 |
| Below Normal | 548 | 595 | 623 | 674 | 497 | 500 | 337 | 304 | 414 | 629 | 517 | 539 |
| Dry | 435 | 475 | 546 | 579 | 518 | 493 | 259 | 228 | 274 | 403 | 325 | 438 |
| Critical Dry | 340 | 345 | 455 | 433 | 406 | 266 | 134 | 121 | 132 | 139 | 203 | 249 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 410 | 497 | 564 | 513 | 537 | 594 | 204 | 207 | 445 | 669 | 717 | 638 |
| Above Normal | 376 | 450 | 562 | 406 | 401 | 496 | 130 | 105 | 315 | 587 | 709 | 628 |
| Below Normal | 386 | 456 | 590 | 387 | 354 | 394 | 134 | 100 | 209 | 657 | 622 | 542 |
| Dry | 374 | 398 | 510 | 392 | 315 | 318 | 153 | 126 | 194 | 541 | 296 | 426 |
| Critical Dry | 314 | 293 | 384 | 349 | 250 | 179 | 93 | 90 | 64 | 223 | 176 | 242 |
| **Alternative 1 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 139 | 123 | 152 | 211 | 72 | -51 | 272 | 223 | 11 | -37 | -63 | 21 |
| Above Normal | 52 | 71 | 78 | 311 | 183 | 73 | 322 | 257 | 100 | -15 | -61 | 23 |
| Below Normal | 162 | 139 | 33 | 287 | 143 | 106 | 203 | 204 | 205 | -28 | -105 | -4 |
| Dry | 61 | 77 | 36 | 187 | 202 | 175 | 105 | 102 | 80 | -138 | 30 | 12 |
| Critical Dry | 26 | 52 | 71 | 84 | 156 | 87 | 41 | 31 | 67 | -84 | 26 | 8 |
| **Alternative 1 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 33.8 | 24.7 | 26.9 | 41.1 | 13.3 | -8.6 | 133.6 | 107.5 | 2.4 | -5.5 | -8.7 | 3.4 |
| Above Normal | 13.8 | 15.8 | 13.9 | 76.6 | 45.5 | 14.8 | 247.0 | 244.4 | 31.8 | -2.5 | -8.7 | 3.6 |
| Below Normal | 42.0 | 30.5 | 5.5 | 74.3 | 40.3 | 26.9 | 150.9 | 203.9 | 98.1 | -4.3 | -16.9 | -0.6 |
| Dry | 16.2 | 19.4 | 7.1 | 47.7 | 64.2 | 55.1 | 68.7 | 81.5 | 41.4 | -25.5 | 10.1 | 2.8 |
| Critical Dry | 8.4 | 17.9 | 18.6 | 24.1 | 62.2 | 48.5 | 44.3 | 33.9 | 104.4 | -37.6 | 14.9 | 3.1 |

The following changes would occur in CVP and SWP exports under Alternative 1 as compared to the No Action Alternative.

- Long-term average annual exports would be 1,051 TAF (22 percent) more under Alternative 1 as compared to the No Action Alternative.
- In wet years, total exports would be similar in June and September; increased in October through February, April through May (up to 133.6 percent); and reduced in March, July, and August (up to 8.7 percent).
- In above-normal years, total exports would be similar in July and September; increased in October through June (up to 244 percent); and reduced in August (8.7 percent).

- In below-normal years, total exports would be similar in July and September; increased in October through June (up to 203.9 percent); and reduced in August (16.9 percent).
- In dry years, total exports would be similar in September; increased in October through June and August (up to 81.5 percent); and reduced in July (25.5 percent).
- In critical dry years, total exports would be similar in September; increased in October through June and August (up to 104.4 percent); and reduced in July (37.6 percent).

Deliveries to CVP and SWP water users increase under Alternative 1 as compared to the No Action Alternative, as summarized in Tables 5.43 and 5.44, respectively, due to increased water supply availability and less export limitations.

**Table 5.43 Changes CVP Water Deliveries under the Alternative 1 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 1 as compared to the No Action Alternative | |
| | | Alternative 1 | No Action Alternative | Difference | Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 219 | 185 | 34 | 18 |
| | Dry | 122 | 86 | 37 | 43 |
| | Critical Dry | 35 | 24 | 12 | 50 |
| CVPM&I (Including American Risver Contractors and Contra Costa Water District) | Long Term | 392 | 386 | 7 | 2 |
| | Dry | 390 | 385 | 5 | 1 |
| | Critical Dry | 383 | 383 | -1 | 0 |
| CVP M&I American River Contractors | Long Term | 120 | 113 | 7 | 6 |
| | Dry | 105 | 97 | 8 | 8 |
| | Critical Dry | 79 | 75 | 5 | 7 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,858 | 1,859 | -1 | 0 |
| | Dry | 1,905 | 1,906 | -1 | 0 |
| | Critical Dry | 1,732 | 1,737 | -5 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 155 | 146 | 8 | 5 |
| | Dry | 151 | 146 | 5 | 3 |
| | Critical Dry | 105 | 102 | 3 | 3 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 1 | No Action Alternative | Alternative 1 as compared to the No Action Alternative | |
| | | | | Difference | Percent Change |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 2,624 | 2,576 | 48 | 2 |
| | Dry | 2,568 | 2,523 | 45 | 2 |
| | Critical Dry | 2,255 | 2,246 | 9 | 0 |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 1,100 | 847 | 253 | 30 |
| | Dry | 650 | 445 | 206 | 46 |
| | Critical Dry | 195 | 131 | 64 | 49 |
| CVP M&I Users | Long Term | 125 | 112 | 13 | 12 |
| | Dry | 109 | 99 | 10 | 10 |
| | Critical Dry | 85 | 80 | 4 | 5 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 272 | 273 | -1 | 0 |
| | Dry | 280 | 281 | -1 | 0 |
| | Critical Dry | 232 | 234 | -3 | -1 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 2,349 | 2,084 | 265 | 13 |
| | Dry | 1,914 | 1,700 | 214 | 13 |
| | Critical Dry | 1,253 | 1,186 | 67 | 6 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 514 | 508 | 6 | 1 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 486 | 445 | 42 | 9 |
| CVP Water Service Contracts | Long Term | 118 | 104 | 15 | 14 |
| | Dry | 98 | 84 | 13 | 15 |
| | Critical Dry | 25 | 4 | 21 | 525 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 1 as compared to the No Action Alternative | |
| | | Alternative 1 | No Action Alternative | Difference | Percent Change |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 632 | 612 | 20 | 3 |
| | Dry | 622 | 608 | 14 | 2 |
| | Critical Dry | 511 | 449 | 62 | 14 |

The following changes in CVP water deliveries would occur under Alternative 1 as compared to the No Action Alternative.

- Deliveries to CVP North of Delta agricultural water service contractors would be increased by 18 percent over the long-term conditions, 43 percent in dry years, and 50 percent in critical dry years.
- Deliveries to CVP North of Delta M&I contractors would be similar in total, however, deliveries to the American River CVP contractors would be increased by 6 percent over the long-term conditions, 8 percent in dry years, and 7 percent in critical dry years.
- Deliveries to CVP South of Delta agricultural water service contractors would be increased by 30 percent over the long-term conditions, 46 percent in dry years, and 49 percent in critical dry years.
- Deliveries to CVP South of Delta M&I contractors would be increased by 12 percent over the long-term conditions, 10 percent in dry years, and 5 percent in critical dry years.
- Deliveries to the Eastside contractors would be similar under long-term conditions and in dry years and increase by 14 percent in critical dry years.

**Table 5.44 Changes SWP Water Deliveries under the Alternative 1 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 1 as compared to the No Action Alternative | |
| | | Alternative 1 | No Action Alternative | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 83 | 68 | 15 | 22 |
| | Dry | 62 | 51 | 11 | 22 |
| | Critical Dry | 53 | 43 | 11 | 25 |
| SWP M&I Article 21 Deliveries | Long Term | 12 | 13 | -1 | -9 |
| | Dry | 13 | 14 | -1 | -6 |
| | Critical Dry | 12 | 13 | -1 | -9 |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 83 | 68 | 15 | 22 |
| | Dry | 62 | 51 | 11 | 22 |
| | Critical Dry | 53 | 43 | 11 | 25 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 12 | 13 | -1 | -9 |
| | Dry | 13 | 14 | -1 | -6 |
| | Critical Dry | 12 | 13 | -1 | -9 |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 750 | 610 | 139 | 23 |
| | Dry | 567 | 455 | 112 | 25 |
| | Critical Dry | 484 | 378 | 106 | 28 |
| SWP Agricultural Article 21 Deliveries | Long Term | 178 | 27 | 152 | 569 |
| | Dry | 143 | 5 | 138 | 2690 |
| | Critical Dry | 100 | 7 | 93 | 1339 |
| SWP M&I Users (without Article 21) | Long Term | 2,183 | 1,800 | 383 | 21 |
| | Dry | 1,732 | 1,406 | 327 | 23 |
| | Critical Dry | 1,494 | 1,173 | 321 | 27 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 1 | No Action Alternative | Alternative 1 as compared to the No Action Alternative | |
| | | | | Difference | Percent Change |
| SWP M&I Article 21 Deliveries | Long Term | 104 | 20 | 84 | 418 |
| | Dry | 86 | 5 | 82 | 1788 |
| | Critical Dry | 58 | 5 | 53 | 1054 |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,933 | 2,410 | 523 | 22 |
| | Dry | 2,299 | 1,861 | 439 | 24 |
| | Critical Dry | 1,978 | 1,551 | 427 | 28 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 282 | 47 | 236 | 504 |
| | Dry | 229 | 10 | 219 | 2265 |
| | Critical Dry | 158 | 12 | 146 | 1219 |

The following changes in SWP water deliveries would occur under Alternative 1 as compared to the No Action Alternative.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be increased by 22 percent over the long-term conditions; 22 percent in dry years; and 25 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be increased by 22 percent over the long-term conditions; 24 percent in dry years; and 28 percent in critical dry years.
- Deliveries of Article 21 water to SWP North of Delta water contractors would be reduced by 9 percent over the long-term conditions; 6 percent in dry years; and 9 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be increased by 504 percent over the long-term conditions; 2,265 percent in dry years; and 1,219 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns; the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 1 and the No Action Alternative.

Under Alternative 1, water could be transferred throughout the year. As indicated in Table 5.42, capacity would be available under Alternative 1 in all months of all water year types without a maximum volume of transferred water. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September, and the volume would be limited to 600,000 acre-feet per year in drier years and 360,000 acre-feet in all other years, in accordance with the 2008 USFWS BO and 2009 NMFS BO. As indicated in Table 5.42, capacity would be available under the No Action Alternative between July and September for water transfers in all water year types.

Overall, the potential for water transfer conveyance would be greater under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability CVP and SWP water supplies for storage in these reservoirs under Alternative 1 as compared to the No Action Alternative would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.43 and 5.44.

- Deliveries to CVP South of Delta M&I contractors would be increased by 11 percent over the long-term conditions; 10 percent in dry years; and 7 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be increased by 22 percent over the long-term conditions; 24 percent in dry years; and 28 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be increased by 504 percent over the long-term conditions; 2,265 percent in dry years; and 1,219 percent in critical dry years.

*Changes in CVP and SWP Exports and Deliveries*

Deliveries to CVP and SWP water users are described above in the Central Valley Region.

#### 5.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *5.4.3.3 Alternative 2*

Surface water resources conditions under Alternative 2 would be identical to the surface water resources conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 5.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to surface water resources conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 5.4.3.1, No Action Alternative.

### *5.4.3.4 Alternative 3*

CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified OMR flow criteria and New Melones Reservoir operations. Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 TAF per year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF per year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 5.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.45 and 5.45. The results are summarized following Table 5.45.

**Table 5.45 Changes in Trinity Lake Storage under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,502 | 1,537 | 1,643 | 1,766 | 1,928 | 2,053 | 2,224 | 2,248 | 2,192 | 2,067 | 1,936 | 1,805 |
| Above Normal | 1,197 | 1,230 | 1,349 | 1,511 | 1,707 | 1,891 | 2,071 | 2,045 | 1,949 | 1,806 | 1,646 | 1,513 |
| Below Normal | 1,434 | 1,457 | 1,477 | 1,542 | 1,629 | 1,717 | 1,858 | 1,786 | 1,680 | 1,509 | 1,334 | 1,199 |
| Dry | 1,173 | 1,179 | 1,206 | 1,226 | 1,318 | 1,450 | 1,585 | 1,537 | 1,468 | 1,301 | 1,152 | 1,056 |
| Critical Dry | 829 | 803 | 817 | 829 | 871 | 952 | 1,003 | 968 | 936 | 813 | 664 | 600 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,490 | 1,516 | 1,630 | 1,756 | 1,921 | 2,053 | 2,220 | 2,245 | 2,190 | 2,067 | 1,939 | 1,784 |
| Above Normal | 1,159 | 1,178 | 1,286 | 1,455 | 1,658 | 1,847 | 2,025 | 1,999 | 1,907 | 1,773 | 1,619 | 1,495 |
| Below Normal | 1,393 | 1,400 | 1,417 | 1,488 | 1,575 | 1,662 | 1,817 | 1,743 | 1,637 | 1,470 | 1,304 | 1,185 |
| Dry | 1,152 | 1,148 | 1,174 | 1,182 | 1,274 | 1,403 | 1,539 | 1,490 | 1,413 | 1,253 | 1,104 | 1,008 |
| Critical Dry | 747 | 731 | 746 | 750 | 790 | 872 | 923 | 888 | 862 | 745 | 612 | 536 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 11 | 21 | 13 | 10 | 7 | 0 | 3 | 4 | 3 | 0 | -3 | 21 |
| Above Normal | 38 | 53 | 63 | 56 | 49 | 45 | 46 | 46 | 42 | 33 | 27 | 18 |
| Below Normal | 41 | 57 | 60 | 54 | 55 | 55 | 40 | 43 | 43 | 38 | 30 | 13 |
| Dry | 21 | 31 | 32 | 45 | 44 | 47 | 46 | 47 | 55 | 48 | 48 | 48 |
| Critical Dry | 82 | 73 | 71 | 79 | 81 | 81 | 80 | 80 | 73 | 68 | 53 | 64 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.7 | 1.4 | 0.8 | 0.6 | 0.4 | 0.0 | 0.1 | 0.2 | 0.1 | 0.0 | -0.2 | 1.2 |
| Above Normal | 3.3 | 4.5 | 4.9 | 3.8 | 2.9 | 2.4 | 2.3 | 2.3 | 2.2 | 1.8 | 1.7 | 1.2 |
| Below Normal | 3.0 | 4.1 | 4.2 | 3.6 | 3.5 | 3.3 | 2.2 | 2.5 | 2.6 | 2.6 | 2.3 | 1.1 |
| Dry | 1.8 | 2.7 | 2.7 | 3.8 | 3.5 | 3.4 | 3.0 | 3.1 | 3.9 | 3.9 | 4.3 | 4.8 |
| Critical Dry | 11.0 | 10.0 | 9.5 | 10.5 | 10.2 | 9.3 | 8.7 | 9.0 | 8.5 | 9.1 | 8.6 | 11.9 |

**Table 5.46 Changes in Trinity Lake Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,268 | 2,271 | 2,284 | 2,301 | 2,319 | 2,334 | 2,347 | 2,345 | 2,339 | 2,328 | 2,315 | 2,304 |
| Below Normal | 2,293 | 2,295 | 2,297 | 2,304 | 2,312 | 2,319 | 2,330 | 2,325 | 2,317 | 2,302 | 2,286 | 2,274 |
| Dry | 2,265 | 2,268 | 2,271 | 2,273 | 2,283 | 2,296 | 2,309 | 2,305 | 2,299 | 2,284 | 2,269 | 2,260 |
| Critical Dry | 2,226 | 2,220 | 2,222 | 2,225 | 2,231 | 2,244 | 2,252 | 2,248 | 2,244 | 2,229 | 2,204 | 2,193 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,324 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,327 |
| Above Normal | 2,261 | 2,264 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,341 | 2,335 | 2,325 | 2,313 | 2,302 |
| Below Normal | 2,289 | 2,289 | 2,291 | 2,299 | 2,307 | 2,315 | 2,327 | 2,321 | 2,313 | 2,299 | 2,283 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,264 | 2,254 |
| Critical Dry | 2,210 | 2,207 | 2,210 | 2,213 | 2,220 | 2,235 | 2,242 | 2,238 | 2,235 | 2,220 | 2,196 | 2,182 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Above Normal | 7 | 8 | 8 | 7 | 5 | 4 | 4 | 4 | 4 | 3 | 2 | 2 |
| Below Normal | 4 | 5 | 6 | 5 | 5 | 5 | 3 | 4 | 4 | 3 | 3 | 2 |
| Dry | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 6 |
| Critical Dry | 16 | 13 | 13 | 12 | 11 | 10 | 9 | 9 | 9 | 9 | 8 | 11 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Above Normal | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| Below Normal | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| Dry | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| Critical Dry | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 |

The following changes in Trinity Lake storage would occur under Alternative 3 as compared to the No Action Alternative.

- In wet, above-normal years, below-normal, and dry years, storage would be similar in all months.
- In critical dry years, storage would be increased in all months (up to 11.9 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes would occur on the Trinity River under Alternative 3 as compared to the No Action Alternative, as summarized in Figures 5.53 through 5.55.

- Over long-term conditions, flows would be similar in March through November and increased in December through February (up to 11.8 percent).
- In wet years, flows would be similar in April through October; reduced in November (7.0 percent) and increased in December through March (up to 15.1 percent).
- In dry years, flows would be similar in all months.

#### *Central Valley Region*

##### *Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

###### *Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.47 and 5.48. Changes in flows in the Sacramento River downstream of Keswick Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized following Table 5.48.

## Table 5.47 Changes in Shasta Lake Storage under Alternative 3 as Compared to the No Action Alternative

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 2,816 | 2,932 | 3,161 | 3,408 | 3,597 | 3,841 | 4,301 | 4,453 | 4,221 | 3,720 | 3,370 | 3,244 |
| Above Normal | 2,475 | 2,555 | 2,783 | 3,303 | 3,509 | 4,023 | 4,403 | 4,401 | 3,975 | 3,350 | 2,998 | 2,946 |
| Below Normal | 2,818 | 2,851 | 2,983 | 3,302 | 3,650 | 3,971 | 4,176 | 4,056 | 3,631 | 3,036 | 2,669 | 2,562 |
| Dry | 2,431 | 2,451 | 2,590 | 2,770 | 3,189 | 3,662 | 3,885 | 3,798 | 3,359 | 2,826 | 2,542 | 2,500 |
| Critical Dry | 1,833 | 1,793 | 1,877 | 2,024 | 2,184 | 2,424 | 2,354 | 2,237 | 1,836 | 1,406 | 1,129 | 1,066 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,700 | 2,719 | 3,077 | 3,384 | 3,589 | 3,836 | 4,298 | 4,460 | 4,242 | 3,735 | 3,410 | 2,985 |
| Above Normal | 2,369 | 2,385 | 2,600 | 3,167 | 3,453 | 4,021 | 4,404 | 4,429 | 4,039 | 3,407 | 3,069 | 2,834 |
| Below Normal | 2,587 | 2,548 | 2,686 | 3,062 | 3,442 | 3,814 | 4,026 | 3,957 | 3,588 | 3,002 | 2,643 | 2,608 |
| Dry | 2,345 | 2,283 | 2,428 | 2,621 | 3,034 | 3,505 | 3,737 | 3,668 | 3,284 | 2,767 | 2,496 | 2,462 |
| Critical Dry | 1,702 | 1,633 | 1,717 | 1,871 | 2,031 | 2,274 | 2,202 | 2,088 | 1,719 | 1,253 | 986 | 937 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 116 | 214 | 84 | 24 | 8 | 5 | 2 | -7 | -21 | -16 | -41 | 260 |
| Above Normal | 106 | 170 | 183 | 136 | 56 | 2 | -1 | -27 | -64 | -57 | -71 | 112 |
| Below Normal | 231 | 302 | 296 | 240 | 208 | 157 | 150 | 99 | 42 | 34 | 26 | -46 |
| Dry | 86 | 168 | 162 | 149 | 155 | 156 | 148 | 130 | 74 | 58 | 45 | 38 |
| Critical Dry | 131 | 160 | 160 | 153 | 152 | 149 | 152 | 149 | 117 | 153 | 143 | 129 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 4.3 | 7.9 | 2.7 | 0.7 | 0.2 | 0.1 | 0.1 | -0.2 | -0.5 | -0.4 | -1.2 | 8.7 |
| Above Normal | 4.5 | 7.1 | 7.0 | 4.3 | 1.6 | 0.1 | 0.0 | -0.6 | -1.6 | -1.7 | -2.3 | 4.0 |
| Below Normal | 8.9 | 11.9 | 11.0 | 7.9 | 6.0 | 4.1 | 3.7 | 2.5 | 1.2 | 1.1 | 1.0 | -1.8 |
| Dry | 3.7 | 7.4 | 6.7 | 5.7 | 5.1 | 4.5 | 4.0 | 3.5 | 2.3 | 2.1 | 1.8 | 1.6 |
| Critical Dry | 7.7 | 9.8 | 9.3 | 8.2 | 7.5 | 6.6 | 6.9 | 7.1 | 6.8 | 12.2 | 14.5 | 13.8 |

**Table 5.48 Changes in Shasta Lake Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,036 | 1,022 | 1,017 |
| Above Normal | 973 | 976 | 990 | 1,018 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,006 | 1,004 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,054 | 1,049 | 1,032 | 1,008 | 991 | 986 |
| Dry | 974 | 976 | 983 | 993 | 1,013 | 1,033 | 1,042 | 1,039 | 1,021 | 998 | 985 | 983 |
| Critical Dry | 935 | 933 | 939 | 948 | 960 | 975 | 972 | 966 | 941 | 910 | 888 | 882 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 986 | 985 | 991 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 989 | 987 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,034 | 1,018 | 995 | 982 | 980 |
| Critical Dry | 927 | 923 | 929 | 939 | 951 | 968 | 965 | 958 | 935 | 899 | 876 | 872 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 6 | 10 | 4 | 1 | 0 | 0 | 0 | 0 | -1 | -1 | -2 | 12 |
| Above Normal | 5 | 8 | 8 | 6 | 2 | 0 | 0 | -1 | -2 | -2 | -3 | 5 |
| Below Normal | 11 | 14 | 13 | 10 | 9 | 6 | 6 | 4 | 2 | 2 | 2 | -2 |
| Dry | 5 | 9 | 8 | 7 | 7 | 6 | 6 | 5 | 3 | 3 | 3 | 2 |
| Critical Dry | 8 | 10 | 10 | 9 | 8 | 7 | 8 | 8 | 7 | 11 | 11 | 11 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.6 | 1.0 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 | -0.2 | 1.2 |
| Above Normal | 0.6 | 0.8 | 0.9 | 0.6 | 0.2 | 0.0 | 0.0 | -0.1 | -0.2 | -0.2 | -0.3 | 0.5 |
| Below Normal | 1.1 | 1.4 | 1.3 | 1.0 | 0.9 | 0.6 | 0.5 | 0.4 | 0.2 | 0.2 | 0.2 | -0.2 |
| Dry | 0.5 | 0.9 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.5 | 0.3 | 0.3 | 0.3 | 0.2 |
| Critical Dry | 0.9 | 1.1 | 1.0 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 1.2 | 1.3 | 1.2 |

The following changes in Shasta Lake storage and surface water elevations would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, storage would be similar in December through August and increased in September and November (up to 8.7 percent).
- In above-normal years, storage would be similar in January through October and increased in November and December (up to 7.1 percent).
- In below-normal years, storage would be similar in March through September and increased in October through February (up to 11.9 percent).

- In dry years, storage would be similar in March through October and increased in November through January (up to 7.4 percent).
- In critical dry years, storage would increase in all months (up to 12.2 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Sacramento River flows would occur under Alternative 3 as compared to the No Action Alternative, as shown on Figures 5.56 through 5.61.

- Sacramento River downstream of Keswick Dam (Figures 5.56 through 5.58).
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 20.1 percent); and increased flows in December, January, and June (up to 8.9 percent).
  - In wet years, similar flows would occur in February through August; reduced flows in September through November (up to 42.1 percent); and increased flows in December and January (up to 16.9 percent).
  - In dry years, similar flows would occur in July through September and December through May; reduced flows in November (24.6 percent); and increased flows in January and June (up to 7.3 percent).
- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61).
  - Over long-term conditions, similar flows would occur in October, December through May, July, and August; reduced flows in September and November (up to 30.1 percent); and increased flows in June (12.1 percent).
  - In wet years, similar flows would occur in January through May, July, and October; reduced flows in August, September, and November (up to 48.1 percent); and increased flows in December and June (up to 6.6 percent).
  - In dry years, similar flows would occur in July through October and December through April; reduced flows in November (14.2 percent); and increased flows in May and June (up to 15.7 percent).

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.49 and 5.50. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized following Table 5.50.

**Table 5.49 Changes in Lake Oroville Storage under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,893 | 1,931 | 2,315 | 2,608 | 2,854 | 2,942 | 3,300 | 3,473 | 3,375 | 2,902 | 2,630 | 2,499 |
| Above Normal | 1,405 | 1,448 | 1,623 | 2,109 | 2,623 | 2,945 | 3,280 | 3,371 | 3,129 | 2,494 | 2,039 | 1,778 |
| Below Normal | 1,839 | 1,801 | 1,846 | 2,054 | 2,370 | 2,636 | 2,879 | 2,883 | 2,610 | 1,971 | 1,520 | 1,354 |
| Dry | 1,332 | 1,288 | 1,322 | 1,454 | 1,733 | 2,088 | 2,329 | 2,319 | 1,980 | 1,548 | 1,343 | 1,198 |
| Critical Dry | 1,129 | 1,067 | 1,067 | 1,156 | 1,275 | 1,429 | 1,449 | 1,437 | 1,236 | 1,029 | 918 | 862 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,691 | 1,732 | 2,189 | 2,554 | 2,832 | 2,942 | 3,300 | 3,488 | 3,445 | 2,964 | 2,626 | 2,109 |
| Above Normal | 1,279 | 1,322 | 1,485 | 1,959 | 2,519 | 2,892 | 3,247 | 3,393 | 3,232 | 2,600 | 2,117 | 1,659 |
| Below Normal | 1,542 | 1,497 | 1,507 | 1,719 | 2,122 | 2,397 | 2,653 | 2,714 | 2,530 | 1,923 | 1,513 | 1,307 |
| Dry | 1,206 | 1,158 | 1,177 | 1,305 | 1,582 | 1,938 | 2,178 | 2,210 | 1,951 | 1,478 | 1,287 | 1,144 |
| Critical Dry | 1,092 | 1,029 | 1,019 | 1,108 | 1,223 | 1,381 | 1,408 | 1,392 | 1,243 | 1,018 | 917 | 865 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 201 | 199 | 126 | 54 | 23 | 0 | 0 | -15 | -70 | -62 | 4 | 390 |
| Above Normal | 126 | 127 | 138 | 151 | 105 | 53 | 33 | -22 | -102 | -106 | -78 | 118 |
| Below Normal | 297 | 303 | 339 | 335 | 248 | 240 | 225 | 169 | 80 | 48 | 8 | 47 |
| Dry | 127 | 130 | 145 | 149 | 151 | 150 | 151 | 109 | 29 | 70 | 55 | 55 |
| Critical Dry | 37 | 38 | 48 | 48 | 52 | 48 | 41 | 45 | -8 | 10 | 1 | -3 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 11.9 | 11.5 | 5.8 | 2.1 | 0.8 | 0.0 | 0.0 | -0.4 | -2.0 | -2.1 | 0.1 | 18.5 |
| Above Normal | 9.9 | 9.6 | 9.3 | 7.7 | 4.2 | 1.8 | 1.0 | -0.7 | -3.2 | -4.1 | -3.7 | 7.1 |
| Below Normal | 19.3 | 20.2 | 22.5 | 19.5 | 11.7 | 10.0 | 8.5 | 6.2 | 3.2 | 2.5 | 0.5 | 3.6 |
| Dry | 10.5 | 11.2 | 12.3 | 11.4 | 9.6 | 7.7 | 6.9 | 4.9 | 1.5 | 4.7 | 4.3 | 4.8 |
| Critical Dry | 3.4 | 3.7 | 4.7 | 4.3 | 4.2 | 3.5 | 2.9 | 3.2 | -0.6 | 1.0 | 0.1 | -0.3 |

**Table 5.50 Changes in Lake Oroville Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 763 | 767 | 805 | 834 | 853 | 859 | 884 | 895 | 889 | 856 | 836 | 825 |
| Above Normal | 711 | 717 | 738 | 791 | 836 | 859 | 882 | 889 | 872 | 827 | 786 | 758 |
| Below Normal | 758 | 754 | 759 | 781 | 813 | 835 | 854 | 855 | 836 | 780 | 730 | 710 |
| Dry | 702 | 697 | 703 | 720 | 752 | 789 | 811 | 810 | 779 | 733 | 709 | 691 |
| Critical Dry | 679 | 671 | 671 | 684 | 699 | 718 | 719 | 718 | 693 | 665 | 648 | 640 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 743 | 748 | 794 | 829 | 852 | 859 | 884 | 897 | 894 | 861 | 836 | 790 |
| Above Normal | 698 | 703 | 722 | 776 | 828 | 856 | 880 | 890 | 879 | 835 | 794 | 746 |
| Below Normal | 730 | 725 | 726 | 751 | 793 | 818 | 838 | 842 | 828 | 773 | 729 | 704 |
| Dry | 688 | 683 | 686 | 704 | 737 | 775 | 798 | 800 | 775 | 724 | 702 | 684 |
| Critical Dry | 674 | 667 | 664 | 678 | 693 | 712 | 715 | 712 | 693 | 663 | 648 | 640 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 19 | 19 | 11 | 5 | 2 | 0 | 0 | -1 | -5 | -5 | 0 | 35 |
| Above Normal | 13 | 14 | 16 | 15 | 9 | 4 | 2 | -2 | -7 | -9 | -9 | 13 |
| Below Normal | 28 | 29 | 32 | 30 | 21 | 17 | 16 | 13 | 8 | 6 | 1 | 6 |
| Dry | 14 | 14 | 16 | 16 | 15 | 13 | 13 | 10 | 3 | 8 | 7 | 7 |
| Critical Dry | 5 | 5 | 7 | 7 | 6 | 6 | 5 | 6 | 0 | 2 | 0 | 0 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 2.6 | 2.6 | 1.4 | 0.6 | 0.2 | 0.0 | 0.0 | -0.1 | -0.5 | -0.6 | 0.0 | 4.4 |
| Above Normal | 1.9 | 2.0 | 2.2 | 1.9 | 1.0 | 0.4 | 0.3 | -0.2 | -0.8 | -1.0 | -1.1 | 1.7 |
| Below Normal | 3.9 | 4.0 | 4.5 | 4.0 | 2.6 | 2.1 | 1.9 | 1.5 | 1.0 | 0.8 | 0.2 | 0.8 |
| Dry | 2.0 | 2.1 | 2.4 | 2.2 | 2.1 | 1.7 | 1.6 | 1.2 | 0.4 | 1.2 | 1.0 | 1.0 |
| Critical Dry | 0.7 | 0.7 | 1.0 | 1.0 | 0.9 | 0.8 | 0.6 | 0.8 | 0.0 | 0.3 | 0.1 | 0.0 |

The following changes in Lake Oroville storage and surface water elevations would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, storage would be similar in January through August and increased in September through December (up to 18.5 percent).
- In above-normal years, storage would be similar in February through August and increased in September through January (up to 18.5 percent).
- In below-normal years, storage would be similar in June through September and increased in October through May (up to 22.5 percent).

- In dry years, storage would be similar in May through September and increased in October through April (up to 12.3 percent).
- In critical dry years, storage would be similar under all months.
- In all months, in all water year types, surface water elevations would be similar.

The following changes in Feather River flows would occur under Alternative 3 as compared to the No Action Alternative, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in October, November, March, April, and July; reduced flows in August and September (up to 49.4 percent); and increased flows in December through February, May, and June (up to 33.9 percent).
- In wet years, similar flows would occur in October, November, February through May, and July; reduced flows in August and September (up to 70.0 percent) and increased flows in December, January, and June (up to 28.1 percent).
- In dry years, similar flows would occur in September and January through April; reduced flows in October through December and July (up to 14.5 percent); and increased flows in May, June, and August (36.9 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.51 and 5.52. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized following Table 5.52.

### Table 5.51 Changes in Folsom Lake Storage under Alternative 3 as Compared to the No Action Alternative

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 486 | 473 | 525 | 524 | 515 | 632 | 785 | 951 | 929 | 790 | 690 | 645 |
| Above Normal | 388 | 404 | 454 | 537 | 539 | 640 | 787 | 946 | 851 | 580 | 516 | 479 |
| Below Normal | 513 | 496 | 505 | 514 | 542 | 627 | 764 | 844 | 766 | 506 | 436 | 407 |
| Dry | 405 | 398 | 420 | 434 | 482 | 580 | 692 | 761 | 654 | 491 | 436 | 411 |
| Critical Dry | 331 | 314 | 322 | 325 | 370 | 436 | 474 | 485 | 431 | 343 | 291 | 257 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 454 | 435 | 514 | 518 | 515 | 632 | 785 | 951 | 941 | 800 | 712 | 576 |
| Above Normal | 377 | 380 | 429 | 513 | 531 | 640 | 787 | 946 | 887 | 621 | 552 | 477 |
| Below Normal | 446 | 431 | 467 | 484 | 533 | 619 | 757 | 843 | 780 | 527 | 472 | 453 |
| Dry | 394 | 383 | 408 | 423 | 479 | 579 | 691 | 760 | 658 | 495 | 443 | 419 |
| Critical Dry | 324 | 305 | 315 | 320 | 366 | 432 | 475 | 486 | 415 | 327 | 267 | 231 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 33 | 38 | 11 | 6 | 0 | 0 | 0 | 0 | -12 | -10 | -22 | 69 |
| Above Normal | 11 | 24 | 25 | 25 | 8 | 0 | 0 | 0 | -36 | -41 | -36 | 2 |
| Below Normal | 67 | 64 | 38 | 30 | 9 | 8 | 6 | 1 | -14 | -21 | -36 | -45 |
| Dry | 11 | 15 | 12 | 11 | 3 | 1 | 1 | 1 | -4 | -4 | -7 | -8 |
| Critical Dry | 7 | 8 | 8 | 5 | 3 | 3 | -1 | -1 | 16 | 16 | 25 | 27 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 7.2 | 8.8 | 2.1 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | -1.3 | -1.3 | -3.1 | 12.0 |
| Above Normal | 2.8 | 6.3 | 5.8 | 4.8 | 1.5 | 0.0 | 0.0 | 0.0 | -4.1 | -6.7 | -6.6 | 0.5 |
| Below Normal | 15.0 | 14.9 | 8.2 | 6.2 | 1.6 | 1.3 | 0.8 | 0.1 | -1.8 | -3.9 | -7.6 | -10.0 |
| Dry | 2.8 | 3.9 | 2.9 | 2.6 | 0.6 | 0.2 | 0.1 | 0.2 | -0.6 | -0.8 | -1.6 | -1.9 |
| Critical Dry | 2.1 | 2.7 | 2.5 | 1.6 | 0.9 | 0.7 | -0.2 | -0.1 | 3.9 | 4.9 | 9.2 | 11.6 |

**Table 5.52 Changes in Folsom Lake Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 413 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 463 | 448 | 438 | 433 |
| Above Normal | 395 | 397 | 408 | 421 | 421 | 433 | 448 | 465 | 455 | 425 | 418 | 413 |
| Below Normal | 416 | 415 | 416 | 417 | 421 | 432 | 446 | 454 | 446 | 415 | 404 | 401 |
| Dry | 401 | 401 | 405 | 407 | 414 | 426 | 438 | 445 | 434 | 414 | 407 | 404 |
| Critical Dry | 388 | 386 | 390 | 390 | 396 | 406 | 411 | 411 | 403 | 389 | 379 | 372 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 464 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 430 | 422 | 413 |
| Below Normal | 408 | 406 | 411 | 414 | 420 | 431 | 445 | 454 | 447 | 418 | 411 | 409 |
| Dry | 400 | 399 | 403 | 405 | 413 | 426 | 438 | 445 | 434 | 414 | 408 | 405 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 411 | 412 | 401 | 386 | 374 | 366 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 4 | 5 | 1 | 1 | 0 | 0 | 0 | 1 | -1 | -1 | -3 | 8 |
| Above Normal | 0 | 2 | 3 | 3 | 1 | 0 | 0 | 1 | -3 | -5 | -4 | 0 |
| Below Normal | 8 | 8 | 5 | 4 | 1 | 1 | 1 | 1 | -1 | -3 | -7 | -8 |
| Dry | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -1 |
| Critical Dry | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 5 | 6 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 1.0 | 1.2 | 0.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | -0.1 | -0.3 | -0.6 | 1.9 |
| Above Normal | 0.1 | 0.6 | 0.6 | 0.7 | 0.2 | 0.0 | 0.0 | 0.1 | -0.7 | -1.2 | -1.0 | 0.1 |
| Below Normal | 2.1 | 2.0 | 1.2 | 0.9 | 0.3 | 0.2 | 0.2 | 0.1 | -0.3 | -0.7 | -1.6 | -1.9 |
| Dry | 0.3 | 0.5 | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.1 | -0.1 | -0.1 | -0.2 | -0.3 |
| Critical Dry | 0.4 | 0.5 | 0.4 | 0.2 | 0.1 | 0.0 | -0.1 | -0.1 | 0.5 | 0.7 | 1.5 | 1.7 |

The following changes in Folsom Lake storage would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, storage would be similar in December through August and increased in September through December (up to 12.1 percent).
- In above-normal years, storage would be similar in January through June, September, and October; and increased in November and December (up to 6.3 percent); and reduced in July and August (up to 6.7 percent).
- In below-normal years, storage would be similar in February through July; reduced in August and September (up to 10.0 percent); and increased in October through January (up to 15.0 percent).

- In dry years, storage would be similar in all months.
- In critical dry years, storage would be similar in October through July and increased in August and September (up to 11.6 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes in American River flows would occur under Alternative 3 as compared to the No Action Alternative, as shown on Figures 5.65 through 5.67.

- Over long-term conditions, similar flows would occur in November, January through May, July, and August; reduced flows in September and October (up to 28.7 percent); and increased flows in June (5.8 percent).
- In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (45.9 percent); and increased flows in August and December (up to 8.5 percent).
- In dry years, similar flows would occur in November through January and March through September; reduced flows in October (11.2 percent); and increased flows in February (6.1 percent).

*Clear Creek*

Changes in flows in Clear Creek downstream of Whiskeytown Dam are summarized in Table 5.53.

Monthly Clear Creek flows under Alternative 3 as compared to the No Action Alternative are identical except in May. In May, under Alternative 3, flows are up to 28.9 percent lower than under the No Action Alternative.

**Table 5.53 Changes in Clear Creek Flows below Whiskeytown Dam under Alternative 3 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 175 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -78 | 0 | 0 | 0 | 0 |
| Dry | 3 | 0 | 0 | 0 | 0 | 0 | 0 | -77 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -47 | 0 | 0 | 0 | 0 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -27.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -27.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -28.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -28.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -22.1 | 0.0 | 0.0 | 0.0 | 0.0 |

### *New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.54 and 5.55. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized following Table 5.55.

**Table 5.54 Changes in New Melones Reservoir Storage under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,562 | 1,567 | 1,618 | 1,720 | 1,792 | 1,871 | 1,906 | 2,049 | 2,146 | 2,057 | 1,934 | 1,855 |
| Above Normal | 1,269 | 1,295 | 1,356 | 1,442 | 1,530 | 1,620 | 1,634 | 1,713 | 1,720 | 1,627 | 1,529 | 1,481 |
| Below Normal | 1,530 | 1,536 | 1,550 | 1,570 | 1,620 | 1,650 | 1,614 | 1,617 | 1,599 | 1,501 | 1,403 | 1,357 |
| Dry | 1,327 | 1,320 | 1,326 | 1,342 | 1,378 | 1,409 | 1,380 | 1,360 | 1,319 | 1,224 | 1,137 | 1,091 |
| Critical Dry | 828 | 824 | 836 | 846 | 866 | 860 | 803 | 751 | 719 | 653 | 593 | 563 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,379 | 1,390 | 1,454 | 1,562 | 1,666 | 1,724 | 1,758 | 1,878 | 1,968 | 1,890 | 1,773 | 1,703 |
| Above Normal | 1,029 | 1,060 | 1,125 | 1,214 | 1,317 | 1,406 | 1,413 | 1,484 | 1,467 | 1,372 | 1,277 | 1,232 |
| Below Normal | 1,294 | 1,305 | 1,326 | 1,351 | 1,413 | 1,438 | 1,390 | 1,383 | 1,359 | 1,268 | 1,175 | 1,133 |
| Dry | 1,094 | 1,094 | 1,106 | 1,121 | 1,156 | 1,188 | 1,154 | 1,132 | 1,087 | 997 | 914 | 871 |
| Critical Dry | 624 | 623 | 638 | 645 | 661 | 656 | 602 | 554 | 526 | 476 | 431 | 408 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 183 | 177 | 165 | 158 | 126 | 147 | 149 | 172 | 178 | 168 | 161 | 152 |
| Above Normal | 239 | 235 | 231 | 228 | 213 | 213 | 220 | 229 | 253 | 255 | 252 | 250 |
| Below Normal | 236 | 231 | 224 | 219 | 207 | 212 | 224 | 234 | 239 | 233 | 228 | 224 |
| Dry | 232 | 226 | 220 | 220 | 222 | 221 | 226 | 228 | 232 | 228 | 223 | 221 |
| Critical Dry | 205 | 201 | 198 | 201 | 204 | 204 | 202 | 197 | 193 | 177 | 162 | 154 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 13.3 | 12.7 | 11.3 | 10.1 | 7.6 | 8.5 | 8.4 | 9.1 | 9.0 | 8.9 | 9.1 | 8.9 |
| Above Normal | 23.3 | 22.1 | 20.5 | 18.7 | 16.2 | 15.2 | 15.6 | 15.4 | 17.2 | 18.6 | 19.7 | 20.3 |
| Below Normal | 18.2 | 17.7 | 16.9 | 16.2 | 14.7 | 14.7 | 16.1 | 16.9 | 17.6 | 18.4 | 19.4 | 19.8 |
| Dry | 21.2 | 20.7 | 19.9 | 19.7 | 19.2 | 18.6 | 19.5 | 20.1 | 21.3 | 22.8 | 24.4 | 25.3 |
| Critical Dry | 32.8 | 32.3 | 31.1 | 31.1 | 30.9 | 31.1 | 33.6 | 35.5 | 36.7 | 37.3 | 37.6 | 37.8 |

**Table 5.55 Changes in New Melones Reservoir Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,003 | 1,004 | 1,010 | 1,022 | 1,030 | 1,038 | 1,042 | 1,055 | 1,064 | 1,056 | 1,045 | 1,037 |
| Above Normal | 964 | 967 | 974 | 987 | 999 | 1,009 | 1,012 | 1,021 | 1,022 | 1,013 | 1,002 | 924 |
| Below Normal | 998 | 998 | 1,000 | 1,002 | 1,011 | 1,014 | 1,011 | 1,012 | 1,010 | 1,000 | 989 | 983 |
| Dry | 974 | 973 | 974 | 977 | 981 | 985 | 983 | 982 | 978 | 966 | 954 | 948 |
| Critical Dry | 899 | 899 | 902 | 904 | 909 | 909 | 899 | 889 | 883 | 870 | 858 | 852 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 980 | 982 | 990 | 1,004 | 1,016 | 1,023 | 1,026 | 1,039 | 1,047 | 1,040 | 1,029 | 1,022 |
| Above Normal | 932 | 937 | 945 | 960 | 974 | 986 | 988 | 997 | 996 | 985 | 973 | 897 |
| Below Normal | 968 | 969 | 972 | 975 | 985 | 988 | 985 | 985 | 983 | 972 | 960 | 955 |
| Dry | 943 | 943 | 944 | 947 | 951 | 957 | 955 | 953 | 948 | 934 | 922 | 915 |
| Critical Dry | 856 | 856 | 862 | 864 | 870 | 871 | 860 | 848 | 840 | 828 | 818 | 812 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 23 | 22 | 20 | 18 | 14 | 16 | 15 | 16 | 17 | 16 | 16 | 16 |
| Above Normal | 32 | 30 | 29 | 28 | 25 | 23 | 24 | 24 | 27 | 28 | 29 | 27 |
| Below Normal | 30 | 29 | 28 | 27 | 26 | 26 | 26 | 27 | 27 | 28 | 28 | 28 |
| Dry | 32 | 31 | 30 | 30 | 30 | 29 | 29 | 29 | 31 | 31 | 32 | 33 |
| Critical Dry | 43 | 43 | 40 | 40 | 38 | 38 | 39 | 41 | 43 | 41 | 40 | 40 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 2.3 | 2.2 | 2.0 | 1.8 | 1.4 | 1.5 | 1.5 | 1.6 | 1.6 | 1.5 | 1.6 | 1.5 |
| Above Normal | 3.4 | 3.2 | 3.1 | 2.9 | 2.6 | 2.4 | 2.4 | 2.4 | 2.7 | 2.9 | 3.0 | 3.0 |
| Below Normal | 3.1 | 3.0 | 2.9 | 2.8 | 2.6 | 2.6 | 2.7 | 2.7 | 2.8 | 2.9 | 3.0 | 3.0 |
| Dry | 3.3 | 3.3 | 3.2 | 3.2 | 3.2 | 3.0 | 3.0 | 3.1 | 3.2 | 3.4 | 3.5 | 3.6 |
| Critical Dry | 5.1 | 5.0 | 4.7 | 4.6 | 4.4 | 4.3 | 4.5 | 4.9 | 5.1 | 5.0 | 4.9 | 4.9 |

The following changes in New Melones Reservoir storage would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, storage would be increased in all months (up to 13.3 percent).
- In above-normal years, storage would be increased in all months (up to 23.3 percent).
- In below-normal years, storage would be increased in all months (up to 19.8 percent).
- In dry years, storage would be increased in all months (up to 25.3 percent).
- In critical dry years, storage would be increased in all months (up to 37.8 percent).
- In all months, in all water year types, surface water elevations would be similar.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in these rivers are summarized below.

- Over long-term conditions, reduced flows would occur in October and March through June (up to 58.3 percent); and increased flows in November through February and July through September (up to 36.81 percent).
- In wet years, similar flows would occur in April; reduced flows in October, March, and May (up to 52.9 percent); and increased flows in June through September and November through February (up to 67.8 percent).
- In dry years, similar flows would occur in March and July through September; reduced flows in October and April through June (up to 59.6 percent); and increased flows in November through February (up to 37.0 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis under Alternative 3 as compared to the No Action Alternative are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions, similar flows would occur in November through September and reduced flows in October (15.7 percent).
- In wet years, similar flows would occur in November through August; reduced flows in October (14.1 percent); and increased flows in September (5.7 percent).
- In dry years, similar flows would occur in November through March and July through September and reduced flows in October and April through June (up to 15.2 percent).

*San Luis Reservoir*

Storage levels and surface water elevations in San Luis Reservoir under Alternative 3 as compared to the No Action Alternative are summarized in Tables 5.56 and 5.57. The results are summarized following Table 5.57.

**Table 5.56 Changes in San Luis Reservoir Storage under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 810 | 1,033 | 1,276 | 1,555 | 1,810 | 1,957 | 1,975 | 1,851 | 1,540 | 1,228 | 961 | 980 |
| Above Normal | 619 | 844 | 1,109 | 1,342 | 1,571 | 1,756 | 1,763 | 1,575 | 1,155 | 830 | 674 | 703 |
| Below Normal | 834 | 1,043 | 1,305 | 1,489 | 1,623 | 1,736 | 1,651 | 1,338 | 899 | 737 | 585 | 561 |
| Dry | 634 | 804 | 1,052 | 1,302 | 1,455 | 1,608 | 1,593 | 1,413 | 1,128 | 926 | 590 | 535 |
| Critical Dry | 548 | 632 | 804 | 1,076 | 1,216 | 1,256 | 1,227 | 1,069 | 838 | 572 | 380 | 351 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 555 | 681 | 931 | 1,236 | 1,526 | 1,788 | 1,598 | 1,251 | 946 | 741 | 628 | 679 |
| Above Normal | 490 | 649 | 957 | 1,223 | 1,441 | 1,661 | 1,444 | 1,048 | 666 | 466 | 433 | 513 |
| Below Normal | 525 | 624 | 907 | 1,141 | 1,314 | 1,473 | 1,312 | 967 | 555 | 500 | 426 | 467 |
| Dry | 476 | 590 | 867 | 1,150 | 1,339 | 1,494 | 1,413 | 1,167 | 840 | 763 | 476 | 469 |
| Critical Dry | 478 | 556 | 752 | 1,040 | 1,204 | 1,252 | 1,192 | 1,028 | 739 | 544 | 343 | 323 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 255 | 351 | 345 | 320 | 284 | 170 | 377 | 599 | 593 | 487 | 334 | 300 |
| Above Normal | 130 | 194 | 153 | 119 | 129 | 95 | 319 | 526 | 489 | 363 | 241 | 190 |
| Below Normal | 309 | 419 | 399 | 348 | 309 | 263 | 339 | 371 | 344 | 237 | 160 | 94 |
| Dry | 158 | 214 | 185 | 152 | 117 | 114 | 180 | 246 | 288 | 163 | 114 | 66 |
| Critical Dry | 70 | 76 | 53 | 37 | 12 | 4 | 35 | 40 | 99 | 28 | 38 | 28 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 55.3 | 76.6 | 58.4 | 38.6 | 25.4 | 12.5 | 31.2 | 68.0 | 96.3 | 84.6 | 58.6 | 43.5 |
| Above Normal | 30.9 | 56.4 | 31.9 | 21.8 | 20.6 | 11.1 | 31.0 | 71.0 | 111.4 | 93.4 | 63.4 | 34.8 |
| Below Normal | 73.2 | 106.9 | 71.2 | 45.4 | 32.8 | 23.5 | 31.7 | 45.1 | 81.6 | 69.1 | 59.6 | 30.0 |
| Dry | 39.1 | 52.1 | 30.6 | 18.3 | 11.8 | 10.0 | 14.5 | 24.2 | 38.5 | 19.4 | 18.5 | 4.4 |
| Critical Dry | 28.6 | 28.3 | 10.8 | 5.5 | 1.9 | 0.8 | 2.5 | 2.9 | 16.3 | 10.1 | 25.1 | 29.2 |

**Table 5.57 Changes in San Luis Reservoir Elevation under Alternative 3 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 427 | 452 | 477 | 503 | 525 | 537 | 539 | 529 | 502 | 473 | 447 | 449 |
| Above Normal | 406 | 431 | 459 | 482 | 504 | 520 | 521 | 505 | 467 | 433 | 417 | 420 |
| Below Normal | 431 | 454 | 480 | 497 | 509 | 519 | 512 | 484 | 440 | 423 | 405 | 401 |
| Dry | 410 | 430 | 456 | 480 | 494 | 508 | 506 | 490 | 464 | 444 | 405 | 397 |
| Critical Dry | 399 | 409 | 430 | 458 | 472 | 475 | 473 | 457 | 434 | 403 | 375 | 371 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 399 | 414 | 443 | 473 | 500 | 523 | 507 | 475 | 444 | 422 | 409 | 416 |
| Above Normal | 391 | 411 | 445 | 472 | 492 | 512 | 493 | 456 | 415 | 389 | 386 | 398 |
| Below Normal | 397 | 410 | 442 | 465 | 481 | 496 | 481 | 448 | 400 | 393 | 383 | 389 |
| Dry | 391 | 406 | 437 | 466 | 484 | 498 | 490 | 468 | 434 | 426 | 390 | 389 |
| Critical Dry | 390 | 400 | 423 | 454 | 470 | 475 | 469 | 453 | 422 | 399 | 369 | 366 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 28 | 38 | 34 | 29 | 24 | 14 | 32 | 53 | 58 | 52 | 38 | 33 |
| Above Normal | 14 | 21 | 15 | 11 | 11 | 8 | 28 | 49 | 51 | 44 | 31 | 23 |
| Below Normal | 33 | 44 | 39 | 32 | 28 | 23 | 30 | 36 | 40 | 30 | 23 | 12 |
| Dry | 19 | 24 | 18 | 14 | 10 | 10 | 16 | 23 | 30 | 18 | 15 | 9 |
| Critical Dry | 9 | 10 | 6 | 4 | 2 | 1 | 4 | 4 | 12 | 4 | 6 | 5 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 6.9 | 9.1 | 7.6 | 6.2 | 4.9 | 2.7 | 6.2 | 11.2 | 13.0 | 12.2 | 9.3 | 7.9 |
| Above Normal | 3.7 | 5.0 | 3.3 | 2.3 | 2.3 | 1.6 | 5.6 | 10.6 | 12.4 | 11.3 | 8.1 | 5.7 |
| Below Normal | 8.4 | 10.7 | 8.8 | 6.9 | 5.8 | 4.6 | 6.3 | 8.0 | 10.1 | 7.6 | 5.9 | 3.2 |
| Dry | 4.9 | 5.8 | 4.2 | 3.0 | 2.2 | 2.0 | 3.2 | 4.8 | 6.8 | 4.2 | 3.9 | 2.2 |
| Critical Dry | 2.3 | 2.4 | 1.5 | 0.9 | 0.4 | 0.2 | 0.8 | 1.0 | 2.8 | 0.9 | 1.7 | 1.4 |

The following changes in San Luis Reservoir storage would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, storage would be increased in all months (up to 96.3 percent). Water storage elevations would be increased in all months (up to 13.0 percent).
- In above-normal years, storage would be increased in all months (up to 111.4 percent). Water storage elevations would be similar in October through March and increased in April through September (up to 11.3 percent).
- In below-normal years, storage would be increased in all months (up to 106.9 percent). Water storage elevations would be similar in September and increased in October through August (up to 10.7 percent).
- In dry years, storage would be similar in September and increased in October through August (up to 52.1 percent). Water storage elevations would be similar December through May and July through October and increased in November and June (up to 6.8 percent).
- In critical dry years, storage would be similar in February through May and increased in June through January (up to 29.2 percent). Water storage elevations would be similar in all months.

*Changes in Flows into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 3 as compared to the No Action Alternative are summarized in Table 5.58. The results are summarized following Table 5.58.

**Table 5.58 Changes in Flows into the Yolo Bypass at Fremont Weir under Alternative 3 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 139 | 973 | 9,693 | 25,241 | 30,361 | 18,837 | 5,617 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,686 | 6,188 | 14,531 | 8,490 | 1,768 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,250 | 4,001 | 1,153 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 923 | 2,007 | 1,406 | 410 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 150 | 534 | 545 | 397 | 106 | 100 | 100 | 0 | 0 | 100 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 183 | 910 | 8,420 | 24,291 | 29,547 | 18,493 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,765 | 5,997 | 13,013 | 7,928 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,031 | 883 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 322 | 902 | 2,024 | 1,393 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 528 | 534 | 396 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -45 | 64 | 1,273 | 950 | 813 | 344 | -10 | 1 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | -78 | 192 | 1,519 | 562 | 80 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 20 | 247 | 970 | 271 | -1 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | 19 | 22 | -17 | 13 | 3 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 1 | 7 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -24.5 | 7.0 | 15.1 | 3.9 | 2.8 | 1.9 | -0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | -2.8 | 3.2 | 11.7 | 7.1 | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 8.3 | 24.6 | 32.0 | 30.7 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 6.0 | 2.4 | -0.8 | 0.9 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.8 | 1.2 | 2.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The following changes in flows from the Sacramento River into Yolo Bypass at Fremont Weir would occur under Alternative 3 as compared to the No Action Alternative.

- In wet years, flows into Yolo Bypass would be similar in January through September; reduced in October (24.5 percent) and increased in November and December (up to 15.1 percent).
- In above-normal years, storage would be similar in April through January and increased in February and March (up to 11.7 percent).
- In below-normal years, flows into Yolo Bypass would be similar in April through November and increased in December through March (up to 32.0 percent).
- In dry years, flows into Yolo Bypass would be similar in January through November and increased in December (6.0 percent).
- In critical dry years, flows into Yolo Bypass would be similar in all months.

*Changes in Delta Conditions*

Delta outflow under Alternative 3 as compared to the No Action Alternative are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow would increase in December through March (up to 3,307 cfs) and decrease in April through November (up to 13,678 cfs).
- In dry years, average monthly Delta outflow would increase January, February, June, and July (up to 277 cfs) and decrease in August through December and March through May (up to 2,902 cfs).

The OMR conditions under Alternative 3 as compared to the No Action Alternative are shown on Figures 5.77 through 5.79.

- Under Alternative 3, OMR flows are negative in all months of all water year types except in April in a wet year (405 cfs). Under the No Action Alternative, OMR flows are negative except in April and May of wet and above-normal years and April of below-normal years.
- In wet years, average monthly OMR flows would be more positive in July and August (up to 800 cfs) and more negative in September through June (up to 4,477 cfs).
- In dry years, average monthly OMR flows would be more positive in July and January (up to 728 cfs) and more negative in August through December and February through June (up to 1,847 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under Alternative 3 as compared to the No Action Alternative are summarized in Table 5.59.

**Table 5.59 Changes in Exports at Jones and Banks Pumping Plants under Alternative 3 as Compared to the No Action Alternative**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 544 | 615 | 601 | 559 | 594 | 589 | 494 | 490 | 519 | 648 | 667 | 654 |
| Above Normal | 430 | 533 | 574 | 414 | 469 | 566 | 441 | 413 | 397 | 586 | 680 | 647 |
| Below Normal | 524 | 587 | 607 | 394 | 373 | 448 | 312 | 266 | 330 | 683 | 650 | 588 |
| Dry | 440 | 471 | 523 | 389 | 314 | 337 | 270 | 242 | 292 | 492 | 318 | 426 |
| Critical Dry | 321 | 319 | 401 | 355 | 251 | 180 | 127 | 100 | 131 | 158 | 196 | 245 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 410 | 497 | 564 | 513 | 537 | 594 | 204 | 207 | 445 | 669 | 717 | 638 |
| Above Normal | 376 | 450 | 562 | 406 | 401 | 496 | 130 | 105 | 315 | 587 | 709 | 628 |
| Below Normal | 386 | 456 | 590 | 387 | 354 | 394 | 134 | 100 | 209 | 657 | 622 | 542 |
| Dry | 374 | 398 | 510 | 392 | 315 | 318 | 153 | 126 | 194 | 541 | 296 | 426 |
| Critical Dry | 314 | 293 | 384 | 349 | 250 | 179 | 93 | 90 | 64 | 223 | 176 | 242 |
| **Alternative 3 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 134 | 118 | 37 | 45 | 57 | -4 | 290 | 283 | 74 | -21 | -51 | 16 |
| Above Normal | 54 | 83 | 12 | 8 | 68 | 69 | 311 | 308 | 81 | -2 | -28 | 19 |
| Below Normal | 138 | 132 | 17 | 8 | 19 | 54 | 178 | 166 | 121 | 26 | 27 | 45 |
| Dry | 66 | 74 | 14 | -3 | -1 | 19 | 117 | 116 | 98 | -49 | 22 | 0 |
| Critical Dry | 7 | 27 | 18 | 6 | 0 | 1 | 35 | 10 | 67 | -64 | 19 | 3 |
| **Alternative 3 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 32.7 | 23.8 | 6.6 | 8.8 | 10.6 | -0.7 | 142.4 | 136.5 | 16.7 | -3.1 | -7.1 | 2.5 |
| Above Normal | 14.4 | 18.4 | 2.2 | 2.0 | 16.9 | 13.9 | 238.3 | 292.1 | 25.9 | -0.3 | -4.0 | 3.0 |
| Below Normal | 35.8 | 28.9 | 2.9 | 2.0 | 5.3 | 13.7 | 132.2 | 166.5 | 58.2 | 3.9 | 4.4 | 8.4 |
| Dry | 17.7 | 18.5 | 2.7 | -0.7 | -0.3 | 6.1 | 76.2 | 92.5 | 50.5 | -9.0 | 7.6 | 0.1 |
| Critical Dry | 2.2 | 9.2 | 4.6 | 1.7 | 0.1 | 0.4 | 37.3 | 11.0 | 104.1 | -28.9 | 10.9 | 1.4 |

The following changes would occur in CVP and SWP exports under Alternative 3 as compared to the No Action Alternative.

- Long-term average annual exports would be 726 TAF (15 percent) more under Alternative 3 as compared to the No Action Alternative.
- In wet years, total exports would be similar in March, July, and September; increased in October, February and April through June (up to 142.4 percent); and reduced in August (7.1 percent).
- In above-normal years, total exports would be similar in December, January, and July through September and increased in October, November, and February through June (up to 292 percent).
- In below-normal years, total exports would be similar in December, January, July, and August and increased in September through November and February through June (up to 166.5 percent).
- In dry years, total exports would be similar in September and December, and July; increased in October, November, March through June, and August (up to 92.5 percent); and reduced in July (7.6 percent).
- In critical dry years, total exports would be similar in September, October, and December through March; increased in November, April through June and August (up to 104.1 percent); and reduced in July (28.9 percent).

Deliveries to CVP and SWP water users increase under Alternative 3 as compared to the No Action Alternative, as summarized in Tables 5.60 and 5.61, respectively, due to increased water supply availability and export limitations.

**Table 5.60 Changes CVP Water Deliveries under Alternative 3 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 3 | No Action Alternative | Alternative 3 as compared to the No Action Alternative: Difference | Alternative 3 as compared to the No Action Alternative: Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 209 | 185 | 24 | 13 |
| | Dry | 111 | 86 | 25 | 29 |
| | Critical Dry | 31 | 24 | 7 | 29 |
| CVP M&I (Including American River Contractors and Contra Costa Water District) | Long Term | 392 | 386 | 6 | 2 |
| | Dry | 390 | 385 | 6 | 2 |
| | Critical Dry | 384 | 383 | 1 | 0 |
| CVP M&I American River Contractors | Long Term | 118 | 113 | 6 | 5 |
| | Dry | 104 | 97 | 7 | 7 |
| | Critical Dry | 78 | 75 | 3 | 4 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,860 | 1,859 | 1 | 0 |
| | Dry | 1,906 | 1,906 | 0 | 0 |
| | Critical Dry | 1,742 | 1,737 | 5 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 153 | 146 | 7 | 5 |
| | Dry | 149 | 146 | 4 | 3 |
| | Critical Dry | 103 | 102 | 1 | 1 |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 2,614 | 2,576 | 38 | 1 |
| | Dry | 2,556 | 2,523 | 33 | 1 |
| | Critical Dry | 2,260 | 2,246 | 14 | 1 |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 1,079 | 847 | 233 | 28 |
| | Dry | 596 | 445 | 151 | 34 |
| | Critical Dry | 168 | 131 | 36 | 27 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as compared to the No Action Alternative | |
| | | Alternative 3 | No Action Alternative | Difference | Percent Change |
| CVP M&I Users | Long Term | 122 | 112 | 11 | 10 |
| | Dry | 108 | 99 | 8 | 8 |
| | Critical Dry | 83 | 80 | 2 | 3 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 273 | 273 | 0 | 0 |
| | Dry | 281 | 281 | 0 | 0 |
| | Critical Dry | 234 | 234 | 0 | 0 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 2,326 | 2,084 | 242 | 12 |
| | Dry | 1,860 | 1,700 | 160 | 9 |
| | Critical Dry | 1,226 | 1,186 | 40 | 3 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 513 | 508 | 5 | 1 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 478 | 445 | 33 | 7 |
| CVP Water Service Contracts | Long Term | 123 | 104 | 20 | 19 |
| | Dry | 109 | 84 | 25 | 30 |
| | Critical Dry | 36 | 4 | 32 | 800 |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 636 | 612 | 24 | 4 |
| | Dry | 633 | 608 | 25 | 4 |
| | Critical Dry | 514 | 449 | 65 | 14 |

The following changes in CVP water deliveries would occur under Alternative 3 as compared to the No Action Alternative.

- Deliveries to CVP North of Delta agricultural water service contractors would be increased by 13 percent over the long-term conditions and 29 percent in dry and critical dry years.
- Deliveries to CVP North of Delta M&I contractors would be similar in total; however, deliveries to the American River CVP contractors would increase by 5 percent over the long-term conditions and 7 percent in dry years, and remain similar in critical dry years.
- Deliveries to CVP South of Delta agricultural water service contractors would be increased by 28 percent over the long-term conditions, 34 percent in dry years, and 27 percent in critical dry years.
- Deliveries to CVP South of Delta M&I contractors would be similar in critical dry years and increased by 10 percent over the long-term conditions and 8 percent in dry years.
- Deliveries to the Eastside contractors would be similar under long-term conditions and dry years and increased by 14 percent in critical dry years.

**Table 5.61 Changes SWP Water Deliveries under Alternative 3 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as compared to the No Action Alternative | |
| | | Alternative 3 | No Action Alternative | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 80 | 68 | 11 | 17 |
| | Dry | 60 | 51 | 8 | 17 |
| | Critical Dry | 48 | 43 | 5 | 13 |
| SWP M&I Article 21 Deliveries | Long Term | 12 | 13 | -1 | -4 |
| | Dry | 13 | 14 | -1 | -5 |
| | Critical Dry | 12 | 13 | -1 | -5 |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 80 | 68 | 11 | 17 |
| | Dry | 60 | 51 | 8 | 17 |
| | Critical Dry | 48 | 43 | 5 | 13 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as compared to the No Action Alternative | |
| | | Alternative 3 | No Action Alternative | Difference | Percent Change |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 12 | 13 | -1 | -4 |
| | Dry | 13 | 14 | -1 | -5 |
| | Critical Dry | 12 | 13 | -1 | -5 |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 716 | 610 | 106 | 17 |
| | Dry | 533 | 455 | 78 | 17 |
| | Critical Dry | 430 | 378 | 52 | 14 |
| SWP Agricultural Article 21 Deliveries | Long Term | 73 | 27 | 47 | 175 |
| | Dry | 36 | 5 | 31 | 604 |
| | Critical Dry | 27 | 7 | 21 | 296 |
| SWP M&I Users (without Article 21) | Long Term | 2,106 | 1,800 | 306 | 17 |
| | Dry | 1,649 | 1,406 | 243 | 17 |
| | Critical Dry | 1,340 | 1,173 | 167 | 14 |
| SWP M&I Article 21 Deliveries | Long Term | 33 | 20 | 13 | 65 |
| | Dry | 11 | 5 | 6 | 137 |
| | Critical Dry | 10 | 5 | 5 | 101 |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,822 | 2,410 | 412 | 17 |
| | Dry | 2,182 | 1,861 | 321 | 17 |
| | Critical Dry | 1,770 | 1,551 | 219 | 14 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 106 | 47 | 60 | 128 |
| | Dry | 47 | 10 | 37 | 384 |
| | Critical Dry | 38 | 12 | 26 | 214 |

The following changes in SWP water deliveries would occur under Alternative 3 as compared to the No Action Alternative.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be increased by 17 percent over the long-term conditions and in dry years and 13 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be increased by 17 percent over the long-term conditions and in dry years and 14 percent in critical dry years.
- Deliveries of Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be increased by 128 percent over the long-term conditions, 384 percent in dry years, and 214 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns, the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 3 and the No Action Alternative.

Under Alternative 3, water could be transferred throughout the year. As indicated in Table 5.59, capacity would be available under Alternative 3 in all months of all water year types without a maximum volume of transferred water. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September, and the volume would be limited to 600,000 acre-feet per year in drier years and 360,000 acre-feet in all other years, in accordance with the 2008 USFWS BO and 2009 NMFS BO. As indicated in Table 5.59, capacity would be available under the No Action Alternative between July and September for water transfers in all water year types.

Overall, the potential for water transfer conveyance would be greater under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability CVP and SWP water supplies for storage in these reservoirs under Alternative 3 as compared to the No Action Alternative would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.60 and 5.61.

- Deliveries to CVP South of Delta M&I contractors would be similar in critical dry years; and increased by 9 percent over the long-term conditions and 8 percent in dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be increased by 17 percent over the long-term conditions and in dry years and 14 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be increased by 128 percent over the long-term conditions, 384 percent in dry years, and 214 percent in critical dry years.

*Changes in CVP and SWP Exports and Deliveries*

Deliveries to CVP and SWP water users are described above in the Central Valley Region.

**5.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison**

*Trinity River Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.62 and 5.63. The results are summarized following Table 5.63.

**Table 5.62 Changes in Trinity Lake Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,502 | 1,537 | 1,643 | 1,766 | 1,928 | 2,053 | 2,224 | 2,248 | 2,192 | 2,067 | 1,936 | 1,805 |
| Above Normal | 1,197 | 1,230 | 1,349 | 1,511 | 1,707 | 1,891 | 2,071 | 2,045 | 1,949 | 1,806 | 1,646 | 1,513 |
| Below Normal | 1,434 | 1,457 | 1,477 | 1,542 | 1,629 | 1,717 | 1,858 | 1,786 | 1,680 | 1,509 | 1,334 | 1,199 |
| Dry | 1,173 | 1,179 | 1,206 | 1,226 | 1,318 | 1,450 | 1,585 | 1,537 | 1,468 | 1,301 | 1,152 | 1,056 |
| Critical Dry | 829 | 803 | 817 | 829 | 871 | 952 | 1,003 | 968 | 936 | 813 | 664 | 600 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,501 | 1,535 | 1,644 | 1,767 | 1,931 | 2,055 | 2,224 | 2,250 | 2,194 | 2,068 | 1,939 | 1,805 |
| Above Normal | 1,208 | 1,245 | 1,363 | 1,524 | 1,718 | 1,901 | 2,079 | 2,053 | 1,955 | 1,815 | 1,647 | 1,513 |
| Below Normal | 1,451 | 1,472 | 1,492 | 1,554 | 1,641 | 1,729 | 1,872 | 1,799 | 1,696 | 1,515 | 1,337 | 1,204 |
| Dry | 1,178 | 1,184 | 1,210 | 1,230 | 1,322 | 1,453 | 1,586 | 1,536 | 1,466 | 1,302 | 1,152 | 1,055 |
| Critical Dry | 819 | 803 | 813 | 825 | 868 | 949 | 999 | 962 | 929 | 811 | 667 | 598 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 1 | -1 | -1 | -2 | -1 | -1 | -2 | -1 | 0 | -3 | 0 |
| Above Normal | -11 | -15 | -14 | -13 | -11 | -10 | -8 | -8 | -7 | -9 | 0 | 0 |
| Below Normal | -17 | -15 | -15 | -12 | -12 | -12 | -14 | -13 | -16 | -6 | -3 | -5 |
| Dry | -5 | -5 | -4 | -4 | -4 | -2 | -1 | 0 | 2 | 0 | 0 | 1 |
| Critical Dry | 10 | 1 | 3 | 3 | 3 | 3 | 4 | 6 | 7 | 2 | -3 | 2 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.1 | -0.1 | 0.0 | -0.1 | -0.1 | 0.0 | -0.1 | -0.1 | 0.0 | -0.2 | 0.0 |
| Above Normal | -0.9 | -1.2 | -1.1 | -0.8 | -0.7 | -0.5 | -0.4 | -0.4 | -0.3 | -0.5 | 0.0 | 0.0 |
| Below Normal | -1.2 | -1.0 | -1.0 | -0.8 | -0.7 | -0.7 | -0.8 | -0.7 | -1.0 | -0.4 | -0.2 | -0.4 |
| Dry | -0.4 | -0.4 | -0.4 | -0.3 | -0.3 | -0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Critical Dry | 1.2 | 0.1 | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.6 | 0.7 | 0.3 | -0.5 | 0.4 |

**Table 5.63 Changes in Trinity Lake Elevation under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,268 | 2,271 | 2,284 | 2,301 | 2,319 | 2,334 | 2,347 | 2,345 | 2,339 | 2,328 | 2,315 | 2,304 |
| Below Normal | 2,293 | 2,295 | 2,297 | 2,304 | 2,312 | 2,319 | 2,330 | 2,325 | 2,317 | 2,302 | 2,286 | 2,274 |
| Dry | 2,265 | 2,268 | 2,271 | 2,273 | 2,283 | 2,296 | 2,309 | 2,305 | 2,299 | 2,284 | 2,269 | 2,260 |
| Critical Dry | 2,226 | 2,220 | 2,222 | 2,225 | 2,231 | 2,244 | 2,252 | 2,248 | 2,244 | 2,229 | 2,204 | 2,193 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,270 | 2,273 | 2,286 | 2,303 | 2,320 | 2,335 | 2,347 | 2,346 | 2,339 | 2,329 | 2,315 | 2,304 |
| Below Normal | 2,295 | 2,296 | 2,298 | 2,305 | 2,313 | 2,320 | 2,331 | 2,326 | 2,318 | 2,303 | 2,287 | 2,274 |
| Dry | 2,266 | 2,269 | 2,272 | 2,274 | 2,284 | 2,296 | 2,309 | 2,304 | 2,298 | 2,284 | 2,269 | 2,259 |
| Critical Dry | 2,218 | 2,216 | 2,217 | 2,222 | 2,229 | 2,243 | 2,250 | 2,246 | 2,243 | 2,227 | 2,204 | 2,191 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | -2 | -2 | -2 | -2 | -1 | -1 | -1 | -1 | 0 | -1 | 0 | 0 |
| Below Normal | -2 | -2 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -1 |
| Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 8 | 5 | 5 | 4 | 3 | 2 | 1 | 2 | 2 | 1 | 0 | 2 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | -0.1 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 |

In all months, in all water year types, Trinity Lake storage and surface water elevations would be similar under Alternative 3 as compared to the Second Basis of Comparison. Trinity River flows would be similar in all months under long-term conditions and wet and dry years, as shown on Figures 5.53 through 5.55.

### *Central Valley Region*

#### *Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

##### *Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.64 and 5.65. Changes in flows in the Sacramento River downstream of Keswick

Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized following Table 5.65.

**Table 5.64 Changes in Shasta Lake Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 2,816 | 2,932 | 3,161 | 3,408 | 3,597 | 3,841 | 4,301 | 4,453 | 4,221 | 3,720 | 3,370 | 3,244 |
| Above Normal | 2,475 | 2,555 | 2,783 | 3,303 | 3,509 | 4,023 | 4,403 | 4,401 | 3,975 | 3,350 | 2,998 | 2,946 |
| Below Normal | 2,818 | 2,851 | 2,983 | 3,302 | 3,650 | 3,971 | 4,176 | 4,056 | 3,631 | 3,036 | 2,669 | 2,562 |
| Dry | 2,431 | 2,451 | 2,590 | 2,770 | 3,189 | 3,662 | 3,885 | 3,798 | 3,359 | 2,826 | 2,542 | 2,500 |
| Critical Dry | 1,833 | 1,793 | 1,877 | 2,024 | 2,184 | 2,424 | 2,354 | 2,237 | 1,836 | 1,406 | 1,129 | 1,066 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,817 | 2,926 | 3,154 | 3,406 | 3,597 | 3,841 | 4,301 | 4,453 | 4,228 | 3,733 | 3,362 | 3,252 |
| Above Normal | 2,499 | 2,578 | 2,808 | 3,313 | 3,515 | 4,038 | 4,416 | 4,417 | 3,979 | 3,347 | 2,975 | 2,921 |
| Below Normal | 2,826 | 2,846 | 2,977 | 3,299 | 3,646 | 3,966 | 4,164 | 4,042 | 3,599 | 3,010 | 2,601 | 2,574 |
| Dry | 2,409 | 2,431 | 2,578 | 2,755 | 3,168 | 3,644 | 3,861 | 3,774 | 3,333 | 2,800 | 2,539 | 2,496 |
| Critical Dry | 1,873 | 1,826 | 1,911 | 2,050 | 2,222 | 2,460 | 2,386 | 2,270 | 1,861 | 1,409 | 1,151 | 1,086 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -1 | 6 | 7 | 2 | 0 | 0 | 0 | 0 | -7 | -13 | 8 | -8 |
| Above Normal | -24 | -23 | -25 | -11 | -6 | -15 | -13 | -16 | -4 | 3 | 23 | 25 |
| Below Normal | -9 | 5 | 5 | 3 | 4 | 5 | 12 | 13 | 32 | 26 | 68 | -13 |
| Dry | 22 | 21 | 12 | 15 | 22 | 17 | 24 | 24 | 26 | 25 | 3 | 4 |
| Critical Dry | -40 | -33 | -34 | -26 | -38 | -36 | -32 | -33 | -25 | -2 | -22 | -20 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.4 | 0.2 | -0.2 |
| Above Normal | -1.0 | -0.9 | -0.9 | -0.3 | -0.2 | -0.4 | -0.3 | -0.4 | -0.1 | 0.1 | 0.8 | 0.9 |
| Below Normal | -0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 | 0.3 | 0.9 | 0.9 | 2.6 | -0.5 |
| Dry | 0.9 | 0.9 | 0.5 | 0.5 | 0.7 | 0.5 | 0.6 | 0.6 | 0.8 | 0.9 | 0.1 | 0.1 |
| Critical Dry | -2.1 | -1.8 | -1.8 | -1.3 | -1.7 | -1.5 | -1.3 | -1.5 | -1.3 | -0.2 | -1.9 | -1.9 |

**Table 5.65 Changes in Shasta Lake Elevation under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,036 | 1,022 | 1,017 |
| Above Normal | 973 | 976 | 990 | 1,018 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,006 | 1,004 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,054 | 1,049 | 1,032 | 1,008 | 991 | 986 |
| Dry | 974 | 976 | 983 | 993 | 1,013 | 1,033 | 1,042 | 1,039 | 1,021 | 998 | 985 | 983 |
| Critical Dry | 935 | 933 | 939 | 948 | 960 | 975 | 972 | 966 | 941 | 910 | 888 | 882 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,037 | 1,022 | 1,017 |
| Above Normal | 974 | 978 | 992 | 1,019 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,005 | 1,003 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,053 | 1,049 | 1,031 | 1,006 | 987 | 986 |
| Dry | 972 | 974 | 982 | 992 | 1,012 | 1,032 | 1,041 | 1,038 | 1,020 | 997 | 984 | 982 |
| Critical Dry | 938 | 935 | 941 | 950 | 961 | 977 | 974 | 967 | 943 | 910 | 889 | 884 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 |
| Above Normal | -2 | -2 | -2 | -1 | 0 | -1 | 0 | -1 | 0 | 0 | 1 | 1 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 0 |
| Dry | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Critical Dry | -3 | -2 | -2 | -2 | -2 | -2 | -1 | -1 | -1 | 0 | -1 | -1 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 |
| Above Normal | -0.2 | -0.2 | -0.2 | -0.1 | 0.0 | -0.1 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | 0.1 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.4 | 0.0 |
| Dry | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Critical Dry | -0.3 | -0.3 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | 0.0 | -0.2 | -0.1 |

Shasta Lake storage and surface water elevation would be similar under Alternative 3 as compared to the Second Basis of Comparison in all months and all water years.

The following changes in Sacramento River flows would occur under Alternative 3 as compared to the Second Basis of Comparison, as shown on Figures 5.56 through 5.61.

- Sacramento River downstream of Keswick Dam (Figures 5.56 through 5.58) would be similar in all months over the long-term conditions and in wet and dry years.

- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61).
  - Over long-term conditions and in wet years, flows would be similar in all months.
  - In dry years, similar flows would occur in July through May; and increased flows in June (11 percent).

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.66 and 5.67. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized following Table 5.67.

**Table 5.66 Changes in Lake Oroville Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,893 | 1,931 | 2,315 | 2,608 | 2,854 | 2,942 | 3,300 | 3,473 | 3,375 | 2,902 | 2,630 | 2,499 |
| Above Normal | 1,405 | 1,448 | 1,623 | 2,109 | 2,623 | 2,945 | 3,280 | 3,371 | 3,129 | 2,494 | 2,039 | 1,778 |
| Below Normal | 1,839 | 1,801 | 1,846 | 2,054 | 2,370 | 2,636 | 2,879 | 2,883 | 2,610 | 1,971 | 1,520 | 1,354 |
| Dry | 1,332 | 1,288 | 1,322 | 1,454 | 1,733 | 2,088 | 2,329 | 2,319 | 1,980 | 1,548 | 1,343 | 1,198 |
| Critical Dry | 1,129 | 1,067 | 1,067 | 1,156 | 1,275 | 1,429 | 1,449 | 1,437 | 1,236 | 1,029 | 918 | 862 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,936 | 1,984 | 2,354 | 2,636 | 2,871 | 2,942 | 3,300 | 3,477 | 3,402 | 2,976 | 2,728 | 2,569 |
| Above Normal | 1,465 | 1,523 | 1,702 | 2,173 | 2,648 | 2,937 | 3,271 | 3,357 | 3,081 | 2,493 | 2,087 | 1,827 |
| Below Normal | 1,823 | 1,783 | 1,831 | 2,037 | 2,361 | 2,627 | 2,875 | 2,836 | 2,461 | 1,930 | 1,637 | 1,424 |
| Dry | 1,371 | 1,324 | 1,344 | 1,473 | 1,764 | 2,120 | 2,363 | 2,357 | 2,031 | 1,688 | 1,427 | 1,261 |
| Critical Dry | 1,117 | 1,044 | 1,041 | 1,125 | 1,235 | 1,406 | 1,423 | 1,407 | 1,219 | 1,027 | 911 | 839 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -43 | -53 | -39 | -28 | -17 | 0 | 0 | -5 | -27 | -73 | -98 | -70 |
| Above Normal | -61 | -75 | -78 | -64 | -24 | 8 | 8 | 14 | 48 | 1 | -49 | -49 |
| Below Normal | 16 | 18 | 15 | 17 | 9 | 9 | 3 | 47 | 150 | 41 | -117 | -70 |
| Dry | -38 | -35 | -22 | -19 | -31 | -32 | -34 | -38 | -51 | -140 | -84 | -62 |
| Critical Dry | 12 | 23 | 25 | 31 | 39 | 23 | 25 | 30 | 17 | 2 | 7 | 23 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -2.2 | -2.7 | -1.7 | -1.1 | -0.6 | 0.0 | 0.0 | -0.1 | -0.8 | -2.5 | -3.6 | -2.7 |
| Above Normal | -4.1 | -4.9 | -4.6 | -2.9 | -0.9 | 0.3 | 0.3 | 0.4 | 1.6 | 0.0 | -2.3 | -2.7 |
| Below Normal | 0.9 | 1.0 | 0.8 | 0.8 | 0.4 | 0.4 | 0.1 | 1.7 | 6.1 | 2.1 | -7.2 | -4.9 |
| Dry | -2.8 | -2.7 | -1.6 | -1.3 | -1.8 | -1.5 | -1.4 | -1.6 | -2.5 | -8.3 | -5.9 | -5.0 |
| Critical Dry | 1.1 | 2.2 | 2.4 | 2.8 | 3.2 | 1.6 | 1.8 | 2.1 | 1.4 | 0.2 | 0.8 | 2.8 |

1 **Table 5.67 Changes in Lake Oroville Elevation under Alternative 3 as Compared to**
2 **the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 763 | 767 | 805 | 834 | 853 | 859 | 884 | 895 | 889 | 856 | 836 | 825 |
| Above Normal | 711 | 717 | 738 | 791 | 836 | 859 | 882 | 889 | 872 | 827 | 786 | 758 |
| Below Normal | 758 | 754 | 759 | 781 | 813 | 835 | 854 | 855 | 836 | 780 | 730 | 710 |
| Dry | 702 | 697 | 703 | 720 | 752 | 789 | 811 | 810 | 779 | 733 | 709 | 691 |
| Critical Dry | 679 | 671 | 671 | 684 | 699 | 718 | 719 | 718 | 693 | 665 | 648 | 640 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 768 | 773 | 810 | 837 | 854 | 859 | 884 | 896 | 891 | 861 | 844 | 831 |
| Above Normal | 717 | 723 | 745 | 796 | 838 | 859 | 882 | 888 | 869 | 826 | 790 | 763 |
| Below Normal | 757 | 752 | 757 | 779 | 812 | 834 | 854 | 852 | 823 | 775 | 743 | 719 |
| Dry | 706 | 701 | 705 | 721 | 755 | 791 | 814 | 813 | 784 | 748 | 718 | 698 |
| Critical Dry | 677 | 668 | 668 | 680 | 694 | 715 | 716 | 714 | 691 | 664 | 647 | 636 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -5 | -6 | -4 | -2 | -1 | 0 | 0 | 0 | -2 | -5 | -8 | -6 |
| Above Normal | -6 | -7 | -8 | -5 | -2 | 1 | 1 | 1 | 3 | 1 | -5 | -5 |
| Below Normal | 1 | 2 | 2 | 2 | 1 | 1 | 0 | 3 | 13 | 5 | -13 | -8 |
| Dry | -4 | -4 | -2 | -2 | -3 | -3 | -3 | -4 | -6 | -16 | -10 | -7 |
| Critical Dry | 2 | 3 | 3 | 4 | 5 | 3 | 3 | 4 | 2 | 1 | 1 | 4 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.6 | -0.7 | -0.5 | -0.3 | -0.1 | 0.0 | 0.0 | 0.0 | -0.2 | -0.6 | -0.9 | -0.8 |
| Above Normal | -0.8 | -1.0 | -1.0 | -0.7 | -0.2 | 0.1 | 0.1 | 0.1 | 0.4 | 0.1 | -0.6 | -0.6 |
| Below Normal | 0.2 | 0.3 | 0.2 | 0.3 | 0.1 | 0.1 | 0.0 | 0.4 | 1.6 | 0.6 | -1.8 | -1.2 |
| Dry | -0.6 | -0.5 | -0.3 | -0.2 | -0.4 | -0.4 | -0.3 | -0.5 | -0.7 | -2.1 | -1.4 | -1.1 |
| Critical Dry | 0.3 | 0.5 | 0.5 | 0.6 | 0.7 | 0.4 | 0.4 | 0.5 | 0.3 | 0.2 | 0.2 | 0.6 |

Lake Oroville storage and surface water elevation would be similar under Alternative 3 as compared to the Second Basis of Comparison in all months and all water years.

The following changes in Feather River flows would occur under Alternative 3 as compared to the Second Basis of Comparison, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in November and January through June; reduced flows in October, December, and September (up to 12.5 percent); and increased flows in July and August (up to 17.0 percent).
- In wet years, similar flows would occur in November and January through May; reduced flows in October, December, and September (up to 14.6 percent); and increased flows in June through August (up to 10.9 percent).
- In dry years, similar flows would occur in November and January through June; reduced flows in August through October (up to 21.2 percent); and increased flows in July (37.1 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.68 and 5.69. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized following Table 5.69.

**Table 5.68 Changes in Folsom Lake Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 486 | 473 | 525 | 524 | 515 | 632 | 785 | 951 | 929 | 790 | 690 | 645 |
| Above Normal | 388 | 404 | 454 | 537 | 539 | 640 | 787 | 946 | 851 | 580 | 516 | 479 |
| Below Normal | 513 | 496 | 505 | 514 | 542 | 627 | 764 | 844 | 766 | 506 | 436 | 407 |
| Dry | 405 | 398 | 420 | 434 | 482 | 580 | 692 | 761 | 654 | 491 | 436 | 411 |
| Critical Dry | 331 | 314 | 322 | 325 | 370 | 436 | 474 | 485 | 431 | 343 | 291 | 257 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 483 | 470 | 522 | 524 | 515 | 632 | 785 | 951 | 937 | 793 | 688 | 646 |
| Above Normal | 390 | 412 | 467 | 537 | 538 | 640 | 787 | 946 | 857 | 591 | 522 | 485 |
| Below Normal | 506 | 489 | 502 | 514 | 541 | 626 | 761 | 847 | 739 | 475 | 408 | 387 |
| Dry | 405 | 399 | 423 | 437 | 486 | 585 | 698 | 769 | 664 | 486 | 432 | 408 |
| Critical Dry | 339 | 317 | 323 | 325 | 369 | 436 | 469 | 482 | 430 | 352 | 288 | 258 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 3 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | -8 | -3 | 2 | -1 |
| Above Normal | -3 | -9 | -13 | 1 | 1 | 0 | 0 | 0 | -6 | -10 | -7 | -6 |
| Below Normal | 8 | 6 | 3 | 0 | 1 | 1 | 3 | -3 | 27 | 31 | 28 | 21 |
| Dry | -1 | -1 | -3 | -3 | -4 | -4 | -6 | -7 | -9 | 5 | 4 | 3 |
| Critical Dry | -7 | -3 | -1 | 0 | 1 | 0 | 5 | 3 | 1 | -9 | 4 | -1 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.7 | 0.8 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.8 | -0.4 | 0.3 | -0.1 |
| Above Normal | -0.7 | -2.1 | -2.8 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | -0.8 | -1.8 | -1.3 | -1.2 |
| Below Normal | 1.5 | 1.3 | 0.6 | 0.1 | 0.2 | 0.1 | 0.3 | -0.4 | 3.6 | 6.6 | 6.7 | 5.3 |
| Dry | -0.1 | -0.2 | -0.8 | -0.7 | -0.8 | -0.7 | -0.9 | -1.0 | -1.4 | 1.1 | 0.8 | 0.8 |
| Critical Dry | -2.2 | -1.0 | -0.3 | 0.0 | 0.2 | 0.0 | 1.0 | 0.6 | 0.2 | -2.6 | 1.3 | -0.4 |

**Table 5.69 Changes in Folsom Lake Elevation under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 413 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 463 | 448 | 438 | 433 |
| Above Normal | 395 | 397 | 408 | 421 | 421 | 433 | 448 | 465 | 455 | 425 | 418 | 413 |
| Below Normal | 416 | 415 | 416 | 417 | 421 | 432 | 446 | 454 | 446 | 415 | 404 | 401 |
| Dry | 401 | 401 | 405 | 407 | 414 | 426 | 438 | 445 | 434 | 414 | 407 | 404 |
| Critical Dry | 388 | 386 | 390 | 390 | 396 | 406 | 411 | 411 | 403 | 389 | 379 | 372 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 412 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 464 | 449 | 438 | 433 |
| Above Normal | 397 | 400 | 410 | 421 | 421 | 433 | 448 | 465 | 456 | 427 | 419 | 414 |
| Below Normal | 415 | 414 | 416 | 417 | 421 | 432 | 446 | 455 | 443 | 410 | 401 | 398 |
| Dry | 401 | 401 | 405 | 407 | 414 | 427 | 439 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 389 | 386 | 390 | 391 | 397 | 406 | 410 | 411 | 404 | 391 | 378 | 372 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 |
| Above Normal | -2 | -3 | -3 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -1 | -1 |
| Below Normal | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 3 | 3 |
| Dry | 0 | 0 | 0 | 0 | -1 | -1 | -1 | -1 | -1 | 1 | 0 | 0 |
| Critical Dry | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | 1 | 0 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.1 | 0.0 | 0.0 |
| Above Normal | -0.5 | -0.8 | -0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.3 | -0.2 | -0.2 |
| Below Normal | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | -0.1 | 0.7 | 1.2 | 0.9 | 0.6 |
| Dry | 0.0 | 0.0 | -0.1 | -0.1 | -0.1 | -0.1 | -0.2 | -0.2 | -0.3 | 0.2 | 0.1 | 0.1 |
| Critical Dry | -0.2 | -0.1 | -0.1 | 0.0 | 0.0 | -0.1 | 0.1 | 0.0 | -0.1 | -0.5 | 0.4 | -0.1 |

Folsom Lake storage and surface water elevation would be similar under Alternative 3 as compared to the Second Basis of Comparison in all months and all water years.

The American River flows would be similar in all months over long-term conditions, wet years, and dry years under Alternative 3 as compared to the Second Basis of Comparison, as shown on Figures 5.65 through 5.67.

*Clear Creek*

Flows in Clear Creek downstream of Whiskeytown Dam would be identical under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Table 5.70.

**Table 5.70 Changes in Clear Creek Flows below Whiskeytown Dam under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

### *New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.71 and 5.72. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized following Table 5.72.

**Table 5.71 Changes in New Melones Reservoir Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,562 | 1,567 | 1,618 | 1,720 | 1,792 | 1,871 | 1,906 | 2,049 | 2,146 | 2,057 | 1,934 | 1,855 |
| Above Normal | 1,269 | 1,295 | 1,356 | 1,442 | 1,530 | 1,620 | 1,634 | 1,713 | 1,720 | 1,627 | 1,529 | 1,481 |
| Below Normal | 1,530 | 1,536 | 1,550 | 1,570 | 1,620 | 1,650 | 1,614 | 1,617 | 1,599 | 1,501 | 1,403 | 1,357 |
| Dry | 1,327 | 1,320 | 1,326 | 1,342 | 1,378 | 1,409 | 1,380 | 1,360 | 1,319 | 1,224 | 1,137 | 1,091 |
| Critical Dry | 828 | 824 | 836 | 846 | 866 | 860 | 803 | 751 | 719 | 653 | 593 | 563 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,443 | 1,446 | 1,502 | 1,606 | 1,709 | 1,794 | 1,833 | 1,962 | 1,994 | 1,917 | 1,803 | 1,731 |
| Above Normal | 1,092 | 1,116 | 1,175 | 1,261 | 1,360 | 1,455 | 1,481 | 1,543 | 1,516 | 1,419 | 1,321 | 1,274 |
| Below Normal | 1,364 | 1,366 | 1,378 | 1,397 | 1,453 | 1,479 | 1,461 | 1,447 | 1,415 | 1,322 | 1,228 | 1,183 |
| Dry | 1,149 | 1,143 | 1,149 | 1,161 | 1,191 | 1,221 | 1,210 | 1,176 | 1,131 | 1,039 | 956 | 912 |
| Critical Dry | 667 | 663 | 674 | 680 | 696 | 690 | 646 | 585 | 557 | 498 | 449 | 426 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 119 | 121 | 116 | 114 | 83 | 77 | 73 | 88 | 153 | 141 | 131 | 124 |
| Above Normal | 177 | 179 | 181 | 181 | 170 | 165 | 153 | 170 | 204 | 208 | 207 | 208 |
| Below Normal | 167 | 170 | 172 | 173 | 167 | 170 | 153 | 170 | 184 | 179 | 175 | 174 |
| Dry | 177 | 177 | 177 | 181 | 187 | 188 | 170 | 183 | 188 | 185 | 181 | 179 |
| Critical Dry | 161 | 161 | 162 | 165 | 170 | 170 | 157 | 166 | 162 | 155 | 144 | 137 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 8.2 | 8.4 | 7.7 | 7.1 | 4.8 | 4.3 | 4.0 | 4.5 | 7.7 | 7.3 | 7.3 | 7.2 |
| Above Normal | 16.3 | 16.0 | 15.4 | 14.4 | 12.5 | 11.3 | 10.3 | 11.0 | 13.4 | 14.7 | 15.7 | 16.3 |
| Below Normal | 12.2 | 12.5 | 12.5 | 12.4 | 11.5 | 11.5 | 10.5 | 11.8 | 13.0 | 13.6 | 14.3 | 14.7 |
| Dry | 15.4 | 15.5 | 15.4 | 15.6 | 15.7 | 15.4 | 14.0 | 15.6 | 16.6 | 17.8 | 19.0 | 19.6 |
| Critical Dry | 24.1 | 24.3 | 24.0 | 24.3 | 24.4 | 24.6 | 24.3 | 28.3 | 29.1 | 31.1 | 32.0 | 32.1 |

**Table 5.72 Changes in New Melones Reservoir Elevation under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 1,003 | 1,004 | 1,010 | 1,022 | 1,030 | 1,038 | 1,042 | 1,055 | 1,064 | 1,056 | 1,045 | 1,037 |
| Above Normal | 964 | 967 | 974 | 987 | 999 | 1,009 | 1,012 | 1,021 | 1,022 | 1,013 | 1,002 | 924 |
| Below Normal | 998 | 998 | 1,000 | 1,002 | 1,011 | 1,014 | 1,011 | 1,012 | 1,010 | 1,000 | 989 | 983 |
| Dry | 974 | 973 | 974 | 977 | 981 | 985 | 983 | 982 | 978 | 966 | 954 | 948 |
| Critical Dry | 899 | 899 | 902 | 904 | 909 | 909 | 899 | 889 | 883 | 870 | 858 | 852 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 989 | 990 | 997 | 1,009 | 1,021 | 1,030 | 1,034 | 1,047 | 1,050 | 1,043 | 1,032 | 1,025 |
| Above Normal | 941 | 944 | 951 | 966 | 979 | 992 | 995 | 1,003 | 1,001 | 990 | 978 | 901 |
| Below Normal | 977 | 977 | 979 | 982 | 991 | 994 | 994 | 993 | 991 | 980 | 968 | 962 |
| Dry | 951 | 950 | 950 | 953 | 957 | 962 | 963 | 960 | 954 | 941 | 929 | 922 |
| Critical Dry | 866 | 866 | 870 | 872 | 878 | 879 | 871 | 856 | 850 | 835 | 823 | 817 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 14 | 14 | 13 | 12 | 9 | 8 | 7 | 8 | 14 | 13 | 13 | 12 |
| Above Normal | 23 | 23 | 23 | 21 | 19 | 18 | 16 | 18 | 21 | 23 | 24 | 23 |
| Below Normal | 20 | 21 | 21 | 21 | 20 | 20 | 17 | 19 | 20 | 20 | 21 | 21 |
| Dry | 24 | 24 | 24 | 24 | 25 | 23 | 20 | 23 | 24 | 24 | 25 | 26 |
| Critical Dry | 33 | 33 | 31 | 32 | 31 | 30 | 28 | 33 | 33 | 35 | 35 | 34 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 1.4 | 1.4 | 1.3 | 1.2 | 0.9 | 0.8 | 0.7 | 0.8 | 1.3 | 1.3 | 1.2 | 1.2 |
| Above Normal | 2.4 | 2.4 | 2.4 | 2.2 | 2.0 | 1.8 | 1.6 | 1.7 | 2.1 | 2.3 | 2.4 | 2.5 |
| Below Normal | 2.1 | 2.1 | 2.1 | 2.1 | 2.0 | 2.0 | 1.7 | 1.9 | 2.0 | 2.1 | 2.1 | 2.2 |
| Dry | 2.5 | 2.5 | 2.5 | 2.5 | 2.6 | 2.4 | 2.1 | 2.3 | 2.5 | 2.6 | 2.7 | 2.8 |
| Critical Dry | 3.8 | 3.8 | 3.6 | 3.6 | 3.5 | 3.4 | 3.2 | 3.9 | 3.9 | 4.2 | 4.3 | 4.2 |

The following changes in New Melones Reservoir storage and surface water elevations would occur under Alternative 3 as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in March through May and increased in June through February (up to 8.4 percent).
- In above normal years, storage would be increased in all months (up to 16.3 percent).
- In below normal years, storage would be increased in all months (up to 14.7 percent).
- In dry years, storage would be increased in all months (up to 19.6 percent).
- In critical dry years, storage would be increased in all months (up to 32.1 percent).
- In all months, in all water year types, surface water elevations would be similar.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in the river are summarized below.

- Over long-term conditions, similar flows would occur in October, December, January, and March; reduced flows would occur in November, May, and June (up to 52.3 percent); and increased flows in February, April, July, and August through September (up to 26.8 percent).
- In wet years, similar flows would occur in October, November, January, and April; reduced flows in May and June (up to 44.8 percent); and increased flows in December, February, March, and July through September (up to 68.6 percent).
- In dry years, similar flows would occur in July through October; reduced flows in November through March and May through June (up to 36.0 percent); and increased flows in April (40.2 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis under Alternative 3 as compared to the Second Basis of Comparison are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions, similar flows would occur in July through May and reduced flows in June (11.8 percent).
- In wet years, similar flows would occur in September through January, March through May, and July; reduced flows in June (8.3 percent); and increased flows in August and February (6.2 percent).
- In dry years, similar flows would occur in July through March; reduced flows in May and June (up to 12.3 percent); and increased flows in April (6.6 percent).

### *San Luis Reservoir*

Storage levels and surface water elevations in San Luis Reservoir under Alternative 3 as compared to the Second Basis of Comparison are summarized in Tables 5.73 and 5.74. The results are summarized following Table 5.74.

**Table 5.73 Changes in San Luis Reservoir Storage under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 810 | 1,033 | 1,276 | 1,555 | 1,810 | 1,957 | 1,975 | 1,851 | 1,540 | 1,228 | 961 | 980 |
| Above Normal | 619 | 844 | 1,109 | 1,342 | 1,571 | 1,756 | 1,763 | 1,575 | 1,155 | 830 | 674 | 703 |
| Below Normal | 834 | 1,043 | 1,305 | 1,489 | 1,623 | 1,736 | 1,651 | 1,338 | 899 | 737 | 585 | 561 |
| Dry | 634 | 804 | 1,052 | 1,302 | 1,455 | 1,608 | 1,593 | 1,413 | 1,128 | 926 | 590 | 535 |
| Critical Dry | 548 | 632 | 804 | 1,076 | 1,216 | 1,256 | 1,227 | 1,069 | 838 | 572 | 380 | 351 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 790 | 1,017 | 1,365 | 1,748 | 1,965 | 2,033 | 2,031 | 1,852 | 1,487 | 1,167 | 889 | 925 |
| Above Normal | 658 | 883 | 1,213 | 1,671 | 1,913 | 2,001 | 1,995 | 1,717 | 1,263 | 861 | 612 | 631 |
| Below Normal | 854 | 1,064 | 1,334 | 1,742 | 1,908 | 1,980 | 1,908 | 1,628 | 1,251 | 964 | 635 | 591 |
| Dry | 617 | 764 | 998 | 1,427 | 1,728 | 1,925 | 1,870 | 1,665 | 1,341 | 1,007 | 660 | 596 |
| Critical Dry | 622 | 709 | 910 | 1,257 | 1,556 | 1,664 | 1,623 | 1,451 | 1,168 | 808 | 545 | 472 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 21 | 16 | -88 | -193 | -155 | -76 | -56 | -2 | 53 | 61 | 72 | 55 |
| Above Normal | -38 | -40 | -104 | -329 | -342 | -245 | -233 | -143 | -108 | -32 | 63 | 73 |
| Below Normal | -20 | -20 | -29 | -253 | -285 | -244 | -257 | -290 | -352 | -227 | -50 | -30 |
| Dry | 17 | 40 | 55 | -125 | -273 | -317 | -277 | -252 | -214 | -81 | -70 | -61 |
| Critical Dry | -74 | -77 | -106 | -180 | -340 | -408 | -396 | -383 | -330 | -235 | -164 | -121 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -2.8 | -2.9 | -14.1 | -15.7 | -10.5 | -4.9 | -3.2 | -3.9 | -6.0 | -1.8 | 3.6 | 1.4 |
| Above Normal | -5.8 | -3.9 | -10.0 | -21.7 | -16.1 | -11.8 | -10.0 | -10.4 | -15.9 | -8.3 | 6.4 | 12.1 |
| Below Normal | -9.6 | -8.0 | -7.6 | -21.7 | -20.2 | -15.1 | -15.9 | -25.0 | -40.1 | -28.4 | -1.3 | -4.4 |
| Dry | 7.5 | 12.7 | 13.2 | -9.8 | -19.2 | -18.7 | -16.5 | -18.7 | -18.6 | -5.3 | -11.2 | -12.1 |
| Critical Dry | -7.3 | -8.0 | -11.4 | -15.2 | -26.1 | -27.7 | -27.0 | -28.5 | -26.0 | -20.6 | -14.5 | 7.6 |

**Table 5.74 Changes in San Luis Reservoir Elevation under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 427 | 452 | 477 | 503 | 525 | 537 | 539 | 529 | 502 | 473 | 447 | 449 |
| Above Normal | 406 | 431 | 459 | 482 | 504 | 520 | 521 | 505 | 467 | 433 | 417 | 420 |
| Below Normal | 431 | 454 | 480 | 497 | 509 | 519 | 512 | 484 | 440 | 423 | 405 | 401 |
| Dry | 410 | 430 | 456 | 480 | 494 | 508 | 506 | 490 | 464 | 444 | 405 | 397 |
| Critical Dry | 399 | 409 | 430 | 458 | 472 | 475 | 473 | 457 | 434 | 403 | 375 | 371 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 426 | 451 | 485 | 520 | 538 | 543 | 543 | 529 | 497 | 468 | 440 | 443 |
| Above Normal | 412 | 437 | 470 | 513 | 534 | 541 | 540 | 518 | 477 | 437 | 409 | 411 |
| Below Normal | 435 | 457 | 483 | 519 | 533 | 539 | 533 | 510 | 476 | 448 | 412 | 406 |
| Dry | 407 | 425 | 450 | 492 | 518 | 535 | 530 | 513 | 484 | 453 | 415 | 406 |
| Critical Dry | 409 | 419 | 441 | 475 | 502 | 512 | 509 | 494 | 468 | 432 | 400 | 389 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1 | 1 | **-8** | **-17** | **-13** | **-6** | **-5** | **0** | 5 | 6 | 8 | 6 |
| Above Normal | **-7** | **-6** | **-11** | **-31** | **-30** | **-21** | **-20** | **-13** | **-11** | **-4** | 8 | 9 |
| Below Normal | **-4** | **-3** | **-3** | **-22** | **-24** | **-20** | **-22** | **-26** | **-36** | **-26** | **-7** | **-4** |
| Dry | 3 | 5 | 6 | **-11** | **-24** | **-27** | **-24** | **-23** | **-21** | **-9** | **-9** | **-9** |
| Critical Dry | **-10** | **-10** | **-12** | **-17** | **-30** | **-37** | **-36** | **-36** | **-34** | **-28** | **-25** | **-19** |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.3 | 0.2 | -1.7 | -3.3 | -2.4 | -1.1 | -0.8 | 0.0 | 0.9 | 1.2 | 1.7 | 1.3 |
| Above Normal | -1.6 | -1.3 | -2.3 | -6.0 | -5.6 | -3.8 | -3.6 | -2.5 | -2.2 | -0.9 | 1.9 | 2.3 |
| Below Normal | -0.9 | -0.6 | -0.6 | -4.2 | -4.5 | -3.7 | -4.1 | -5.1 | -7.5 | -5.7 | -1.7 | -1.1 |
| Dry | 0.7 | 1.1 | 1.3 | -2.2 | -4.6 | -5.0 | -4.5 | -4.4 | -4.3 | -2.0 | -2.3 | -2.2 |
| Critical Dry | -2.5 | -2.3 | -2.6 | -3.6 | -6.1 | -7.2 | -7.1 | -7.4 | -7.2 | -6.6 | -6.4 | -4.9 |

The following changes in San Luis Reservoir storage would occur under Alternative 3 as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in July through November and March through May and reduced in December through February and June (up to 15.7 percent). Surface water elevations would be similar in all months.
- In above-normal years, storage would be similar in November; increased in August and September (up to 12.1 percent); and reduced in October and December through July (up to 21.7 percent). Surface water elevations would be similar in March through December and reduced in January and February (up to 6.0 percent).
- In below-normal years, storage would be similar in August and September and reduced in October through July (up to 40.1 percent). Surface water elevations would be similar in all months.
- In dry years, storage would be reduced in January through September (up to 19.2 percent) and increased in October through December (up to 13.2 percent). Surface water elevations would be similar in all months.
- In critical dry years, storage would be reduced in October through August (up to 28.5 percent) and increased in September (7.6 percent). Surface water elevations would be similar September through January and reduced in February through August (up to 7.4 percent).

*Changes in Flows into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 3 as compared to the Second Basis of Comparison are summarized in Table 5.75. The results are summarized following Table 5.75.

**Table 5.75 Changes in Flows into the Yolo Bypass at Fremont Weir under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 139 | 973 | 9,693 | 25,241 | 30,361 | 18,837 | 5,617 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,686 | 6,188 | 14,531 | 8,490 | 1,768 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,250 | 4,001 | 1,153 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 923 | 2,007 | 1,406 | 410 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 150 | 534 | 545 | 397 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 147 | 996 | 9,888 | 25,442 | 30,547 | 18,997 | 5,602 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,659 | 6,349 | 15,114 | 8,566 | 1,765 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,256 | 4,057 | 1,166 | 292 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 932 | 2,032 | 1,411 | 411 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 542 | 533 | 408 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -8 | -23 | -195 | -201 | -187 | -160 | 15 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 28 | -161 | -583 | -76 | 4 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | -6 | -56 | -13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | -1 | -9 | -24 | -4 | -2 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | -8 | 12 | -11 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -5.6 | -2.3 | -2.0 | -0.8 | -0.6 | -0.8 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 1.0 | -2.5 | -3.9 | -0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.2 | -0.5 | -1.4 | -1.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | -0.2 | -0.9 | -1.2 | -0.3 | -0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.2 | -1.5 | 2.2 | -2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The following changes in flows from the Sacramento River into the Yolo Bypass at Fremont Weir would occur under Alternative 3 as compared to the Second Basis of Comparison.

- In wet years, flows into the Yolo Bypass would be similar in November through September and reduced in October (5.6 percent).
- In above-normal, below-normal, dry, and critical dry years, flows into the Yolo Bypass would be similar in all months.

*Changes in Delta Conditions*

Delta outflow under Alternative 3 as compared to the Second Basis of Comparison are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow would increase in November through February and July through September (up to 2,546 cfs) and decrease in October and March through June (up to 1,127 cfs).
- In dry years, average monthly Delta outflow would increase in November through April, July and August (up to 3,391 cfs) and decrease in October, May, and June (up to 373 cfs).

The OMR conditions under Alternative 3 as compared to the Second Basis of Comparison are shown on Figures 5.77 through 5.79.

- Under Alternative 3, OMR flows are negative in all months of all water year types except in April in wet year (405 cfs). Under Second Basis of Comparison, OMR flows are negative in all months of all water year types.
- In wet years, flows would be more positive in September through February, April, and May (up to 5,528 cfs) and more negative in March and June through August (up to 1,453 cfs).
- In dry years, flows would be more positive in August through May (up to 3,249 cfs); and more negative flows in June and July (up to 1,345 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under Alternative 3 as compared to the Second Basis of Comparison are summarized in Table 5.76.

**Table 5.76 Changes in Exports at Jones and Banks Pumping Plants under Alternative 3 as Compared to the Second Basis of Comparison**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 3** | | | | | | | | | | | | |
| Wet | 544 | 615 | 601 | 559 | 594 | 589 | 494 | 490 | 519 | 648 | 667 | 654 |
| Above Normal | 430 | 533 | 574 | 414 | 469 | 566 | 441 | 413 | 397 | 586 | 680 | 647 |
| Below Normal | 524 | 587 | 607 | 394 | 373 | 448 | 312 | 266 | 330 | 683 | 650 | 588 |
| Dry | 440 | 471 | 523 | 389 | 314 | 337 | 270 | 242 | 292 | 492 | 318 | 426 |
| Critical Dry | 321 | 319 | 401 | 355 | 251 | 180 | 127 | 100 | 131 | 158 | 196 | 245 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 549 | 619 | 716 | 724 | 609 | 543 | 476 | 430 | 456 | 632 | 655 | 660 |
| Above Normal | 428 | 521 | 641 | 716 | 584 | 570 | 453 | 363 | 415 | 572 | 647 | 651 |
| Below Normal | 548 | 595 | 623 | 674 | 497 | 500 | 337 | 304 | 414 | 629 | 517 | 539 |
| Dry | 435 | 475 | 546 | 579 | 518 | 493 | 259 | 228 | 274 | 403 | 325 | 438 |
| Critical Dry | 340 | 345 | 455 | 433 | 406 | 266 | 134 | 121 | 132 | 139 | 203 | 249 |
| **Alternative 3 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -5 | -5 | -115 | -165 | -15 | 46 | 18 | 60 | 64 | 16 | 12 | -5 |
| Above Normal | 2 | 12 | -66 | -303 | -115 | -4 | -11 | 50 | -19 | 13 | 33 | -3 |
| Below Normal | -24 | -7 | -16 | -280 | -124 | -52 | -25 | -37 | -83 | 54 | 133 | 49 |
| Dry | 5 | -4 | -23 | -190 | -203 | -156 | 12 | 14 | 18 | 89 | -7 | -12 |
| Critical Dry | -19 | -26 | -54 | -78 | -156 | -86 | -6 | -21 | 0 | 19 | -7 | -4 |
| **Alternative 3 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.8 | -0.7 | -16.0 | -22.8 | -2.4 | 8.6 | 3.7 | 14.0 | 14.0 | 2.5 | 1.8 | -0.8 |
| Above Normal | 0.5 | 2.2 | -10.3 | -42.2 | -19.7 | -0.7 | -2.5 | 13.8 | -4.5 | 2.3 | 5.1 | -0.5 |
| Below Normal | -4.4 | -1.3 | -2.5 | -41.5 | -24.9 | -10.4 | -7.5 | -12.3 | -20.2 | 8.6 | 25.7 | 9.1 |
| Dry | 1.3 | -0.8 | -4.1 | -32.8 | -39.3 | -31.6 | 4.5 | 6.1 | 6.5 | 22.1 | -2.3 | -2.7 |
| Critical Dry | -5.7 | -7.4 | -11.8 | -18.0 | -38.3 | -32.4 | -4.8 | -17.1 | -0.2 | 14.0 | -3.5 | -1.7 |

The following changes would occur in CVP and SWP exports under Alternative 3 as compared to the Second Basis of Comparison.

- Long-term average annual exports would be 326 TAF (6 percent) less under Alternative 3 as compared to the Second Basis of Comparison.
- In wet years, total exports would be similar in July through November, February, and April; increased exports in March, May, and June (up to 14.0 percent); and reduced in December and January (up to 22.8 percent).
- In above-normal years, total exports would be similar in June through November, March, and April; reduced exports in December through February (up to 42.2 percent); and increased in May (up to 13.8 percent).
- In below-normal years, total exports would be similar in October through December; reduced exports in January through June (up to 41.5 percent); and increased in July through September (up to 25.7 percent).
- In dry years, total exports would be similar in August through December and April; reduced exports in January through March (up to 39.3 percent); and increased exports in May through July (up to 22.1 percent).
- In critical dry years, total exports would be similar in April, June, August, and September; reduced exports in October through March and May (up to 38.3 percent); and increased exports in July (14.0 percent).

Deliveries to CVP and SWP water users would be similar under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Tables 5.77 and 5.78.

**Table 5.77 Changes CVP Water Deliveries under Alternative 3 as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | Alternative 3 | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 209 | 219 | -10 | -5 |
| | Dry | 111 | 122 | -11 | -9 |
| | Critical Dry | 31 | 35 | -4 | -11 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | Alternative 3 | Second Basis of Comparison | Difference | Percent Change |
| CVP M&I (Including American River Contractors and Contra Costa Water District) | Long Term | 392 | 392 | 0 | 0 |
| | Dry | 390 | 390 | 0 | 0 |
| | Critical Dry | 384 | 383 | 2 | 1 |
| CVP M&I American River Contractors | Long Term | 118 | 120 | -2 | -2 |
| | Dry | 104 | 105 | -1 | -1 |
| | Critical Dry | 78 | 79 | -2 | -3 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,860 | 1,858 | 2 | 0 |
| | Dry | 1,906 | 1,905 | 1 | 0 |
| | Critical Dry | 1,742 | 1,732 | 10 | 1 |
| CVP Refuge Level 2 Deliveries | Long Term | 153 | 155 | -1 | -1 |
| | Dry | 149 | 151 | -2 | -1 |
| | Critical Dry | 103 | 105 | -2 | -2 |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 602 | 612 | -10 | 0 |
| | Dry | 501 | 512 | -12 | 0 |
| | Critical Dry | 415 | 418 | 5 | 0 |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 1,079 | 1,100 | -20 | -2 |
| | Dry | 596 | 650 | -55 | -8 |
| | Critical Dry | 168 | 195 | -28 | -14 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 3 | Second Basis of Comparison | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | | | Difference | Percent Change |
| CVP M&I Users | Long Term | 122 | 125 | -2 | -2 |
| | Dry | 108 | 109 | -1 | -1 |
| | Critical Dry | 83 | 85 | -2 | -2 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 273 | 272 | 1 | 0 |
| | Dry | 281 | 280 | 1 | 0 |
| | Critical Dry | 234 | 232 | 3 | 1 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 1,202 | 1,225 | -23 | -1 |
| | Dry | 703 | 759 | -54 | -3 |
| | Critical Dry | 250 | 280 | -27 | -2 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 513 | 514 | -1 | 0 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 478 | 486 | -8 | -2 |
| CVP Water Service Contracts | Long Term | 123 | 118 | 5 | 4 |
| | Dry | 109 | 98 | 12 | 12 |
| | Critical Dry | 36 | 25 | 11 | 44 |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 636 | 632 | 4 | 1 |
| | Dry | 633 | 621 | 11 | 2 |
| | Critical Dry | 514 | 511 | 3 | 1 |

The following changes in CVP water deliveries would occur under Alternative 3 as compared to the Second Basis of Comparison.

- Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 5 percent over the long-term conditions, 9 percent in dry years, and 11 percent in critical dry years.
- Deliveries to CVP North of Delta M&I contractors (including American River CVP contractors) would be similar in long-term conditions and dry and critical dry years.
- Deliveries to CVP South of Delta agricultural water service contractors would be similar over the long-term conditions and reduced by 8 percent in dry years and 14 percent in critical dry years.
- Deliveries to CVP South of Delta M&I contractors would be similar in long-term conditions and dry and critical dry years.
- Deliveries to the Eastside contractors would be similar under long-term conditions, dry years, and in critical dry years.

**Table 5.78 Changes SWP Water Deliveries under Alternative 3 as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | Alternative 3 | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 80 | 83 | -3 | -4 |
| | Dry | 60 | 62 | -2 | -4 |
| | Critical Dry | 48 | 53 | -5 | -10 |
| SWP M&I Article 21 Deliveries | Long Term | 12 | 12 | 0 | 5 |
| | Dry | 13 | 13 | 0 | 1 |
| | Critical Dry | 12 | 12 | 0 | 3 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | Alternative 3 | Second Basis of Comparison | Difference | Percent Change |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 80 | 83 | -3 | -4 |
| | Dry | 60 | 62 | -2 | -4 |
| | Critical Dry | 48 | 53 | -5 | -10 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 12 | 12 | 0 | 5 |
| | Dry | 13 | 13 | 0 | 1 |
| | Critical Dry | 12 | 12 | 0 | 3 |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 716 | 750 | -34 | -4 |
| | Dry | 533 | 567 | -34 | -6 |
| | Critical Dry | 430 | 484 | -54 | -11 |
| SWP Agricultural Article 21 Deliveries | Long Term | 73 | 178 | -105 | -59 |
| | Dry | 36 | 143 | -107 | -75 |
| | Critical Dry | 27 | 100 | -73 | -72 |
| SWP M&I Users (without Article 21) | Long Term | 2,106 | 2,183 | -77 | -4 |
| | Dry | 1,649 | 1,732 | -83 | -5 |
| | Critical Dry | 1,340 | 1,494 | -154 | -10 |
| SWP M&I Article 21 Deliveries | Long Term | 33 | 104 | -71 | -68 |
| | Dry | 11 | 86 | -75 | -87 |
| | Critical Dry | 10 | 58 | -48 | -83 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 3 | Second Basis of Comparison | Alternative 3 as Compared to the Second Basis of Comparison | |
| | | | | Difference | Percent Change |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,822 | 2,933 | -111 | -4 |
| | Dry | 2,182 | 2,299 | -117 | -5 |
| | Critical Dry | 1,770 | 1,978 | -208 | -11 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 106 | 282 | -176 | -62 |
| | Dry | 47 | 229 | -182 | -80 |
| | Critical Dry | 38 | 158 | -120 | -76 |

The following changes in SWP water deliveries would occur under Alternative 3 as compared to the Second Basis of Comparison.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry years and reduced by 10 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry years and reduced by 11 percent in critical dry years.
- Deliveries of Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 62 percent over the long-term conditions; 80 percent in dry years; and 76 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns, the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 3 and the Second Basis of Comparison.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year. As indicated in Table 5.76, capacity would be available under Alternative 3 and the Second Basis of Comparison in a similar manner in all months of all water year types.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability CVP and SWP water supplies for storage in these reservoirs under Alternative 3 as compared to the Second Basis of Comparison would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.77 and 5.78.

- Deliveries to CVP South of Delta M&I contractors would be similar in long-term conditions and dry and critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry years and reduced by 11 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 62 percent over the long-term conditions, 80 percent in dry years, and 76 percent in critical dry years.

*Changes in CVP and SWP Exports and Deliveries*

Deliveries to CVP and SWP water users are described above in the Central Valley Region.

### *5.4.3.5 Alternative 4*

Surface water resources conditions under Alternative 4 would be identical to the surface water resources conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

#### 5.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in surface water resources under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 5.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *5.4.3.6 Alternative 5*

CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF per year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF per year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

##### 5.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.79 and 5.80. The results are summarized following Table 5.80.

**Table 5.79 Changes in Trinity Lake Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,494 | 1,520 | 1,635 | 1,759 | 1,926 | 2,056 | 2,222 | 2,246 | 2,191 | 2,068 | 1,940 | 1,781 |
| Above Normal | 1,155 | 1,180 | 1,290 | 1,459 | 1,662 | 1,850 | 2,030 | 2,004 | 1,912 | 1,778 | 1,627 | 1,503 |
| Below Normal | 1,398 | 1,405 | 1,422 | 1,493 | 1,580 | 1,667 | 1,813 | 1,741 | 1,637 | 1,474 | 1,311 | 1,190 |
| Dry | 1,155 | 1,150 | 1,175 | 1,183 | 1,275 | 1,404 | 1,540 | 1,492 | 1,415 | 1,259 | 1,110 | 1,012 |
| Critical Dry | 744 | 726 | 741 | 743 | 784 | 866 | 913 | 878 | 856 | 755 | 622 | 539 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,490 | 1,516 | 1,630 | 1,756 | 1,921 | 2,053 | 2,220 | 2,245 | 2,190 | 2,067 | 1,939 | 1,784 |
| Above Normal | 1,159 | 1,178 | 1,286 | 1,455 | 1,658 | 1,847 | 2,025 | 1,999 | 1,907 | 1,773 | 1,619 | 1,495 |
| Below Normal | 1,393 | 1,400 | 1,417 | 1,488 | 1,575 | 1,662 | 1,817 | 1,743 | 1,637 | 1,470 | 1,304 | 1,185 |
| Dry | 1,152 | 1,148 | 1,174 | 1,182 | 1,274 | 1,403 | 1,539 | 1,490 | 1,413 | 1,253 | 1,104 | 1,008 |
| Critical Dry | 747 | 731 | 746 | 750 | 790 | 872 | 923 | 888 | 862 | 745 | 612 | 536 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 4 | 3 | 5 | 4 | 4 | 2 | 2 | 2 | 2 | 0 | 0 | -2 |
| Above Normal | -4 | 2 | 4 | 4 | 4 | 4 | 6 | 6 | 5 | 5 | 8 | 8 |
| Below Normal | 5 | 5 | 5 | 5 | 5 | 5 | -5 | -2 | 0 | 4 | 7 | 4 |
| Dry | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 6 | 4 |
| Critical Dry | -2 | -5 | -4 | -7 | -6 | -6 | -10 | -10 | -7 | 10 | 11 | 3 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | -0.1 |
| Above Normal | -0.4 | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 |
| Below Normal | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 | -0.3 | -0.1 | 0.0 | 0.3 | 0.5 | 0.4 |
| Dry | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 | 0.5 | 0.4 |
| Critical Dry | -0.3 | -0.6 | -0.6 | -0.9 | -0.7 | -0.7 | -1.1 | -1.1 | -0.8 | 1.3 | 1.8 | 0.5 |

**Table 5.80 Changes in Trinity Lake Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,325 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,326 |
| Above Normal | 2,259 | 2,262 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,342 | 2,335 | 2,326 | 2,313 | 2,303 |
| Below Normal | 2,289 | 2,290 | 2,292 | 2,299 | 2,308 | 2,315 | 2,326 | 2,321 | 2,313 | 2,299 | 2,284 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,265 | 2,254 |
| Critical Dry | 2,209 | 2,206 | 2,209 | 2,212 | 2,220 | 2,234 | 2,241 | 2,237 | 2,235 | 2,221 | 2,199 | 2,183 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,324 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,327 |
| Above Normal | 2,261 | 2,264 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,341 | 2,335 | 2,325 | 2,313 | 2,302 |
| Below Normal | 2,289 | 2,289 | 2,291 | 2,299 | 2,307 | 2,315 | 2,327 | 2,321 | 2,313 | 2,299 | 2,283 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,264 | 2,254 |
| Critical Dry | 2,210 | 2,207 | 2,210 | 2,213 | 2,220 | 2,235 | 2,242 | 2,238 | 2,235 | 2,220 | 2,196 | 2,182 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | -2 | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Below Normal | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Dry | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Critical Dry | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 2 | 3 | 1 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |

Trinity Lake storage and surface water elevations would be similar in all months and all water year types under Alternative 5 as compared to the No Action Alternative.

Trinity River flows would be similar in all months under long-term conditions and wet and dry years, as shown on Figures 5.53 through 5.55.Central Valley Region

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

*Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.81 and 5.82. Changes in flows in the Sacramento River downstream of Keswick Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized following Table 5.82.

**Table 5.81 Changes in Shasta Lake Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 2,704 | 2,716 | 3,078 | 3,385 | 3,590 | 3,836 | 4,299 | 4,461 | 4,243 | 3,736 | 3,410 | 2,989 |
| Above Normal | 2,369 | 2,388 | 2,598 | 3,164 | 3,454 | 4,019 | 4,401 | 4,430 | 4,042 | 3,409 | 3,071 | 2,842 |
| Below Normal | 2,603 | 2,565 | 2,704 | 3,077 | 3,450 | 3,820 | 4,039 | 3,970 | 3,602 | 3,012 | 2,663 | 2,620 |
| Dry | 2,344 | 2,287 | 2,433 | 2,627 | 3,039 | 3,509 | 3,745 | 3,699 | 3,315 | 2,787 | 2,497 | 2,459 |
| Critical Dry | 1,676 | 1,611 | 1,700 | 1,856 | 2,015 | 2,258 | 2,203 | 2,104 | 1,749 | 1,246 | 958 | 910 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 2,700 | 2,719 | 3,077 | 3,384 | 3,589 | 3,836 | 4,298 | 4,460 | 4,242 | 3,735 | 3,410 | 2,985 |
| Above Normal | 2,369 | 2,385 | 2,600 | 3,167 | 3,453 | 4,021 | 4,404 | 4,429 | 4,039 | 3,407 | 3,069 | 2,834 |
| Below Normal | 2,587 | 2,548 | 2,686 | 3,062 | 3,442 | 3,814 | 4,026 | 3,957 | 3,588 | 3,002 | 2,643 | 2,608 |
| Dry | 2,345 | 2,283 | 2,428 | 2,621 | 3,034 | 3,505 | 3,737 | 3,668 | 3,284 | 2,767 | 2,496 | 2,462 |
| Critical Dry | 1,702 | 1,633 | 1,717 | 1,871 | 2,031 | 2,274 | 2,202 | 2,088 | 1,719 | 1,253 | 986 | 937 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 4 | -3 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 |
| Above Normal | 0 | 4 | -2 | -3 | 0 | -1 | -3 | 2 | 3 | 2 | 2 | 8 |
| Below Normal | 16 | 16 | 18 | 16 | 8 | 6 | 13 | 13 | 14 | 10 | 20 | 12 |
| Dry | -1 | 4 | 5 | 6 | 5 | 4 | 8 | 31 | 31 | 20 | 1 | -3 |
| Critical Dry | -25 | -22 | -17 | -15 | -16 | -16 | 1 | 16 | 31 | -7 | -28 | -26 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Above Normal | 0.0 | 0.2 | -0.1 | -0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.3 |
| Below Normal | 0.6 | 0.6 | 0.7 | 0.5 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.3 | 0.8 | 0.5 |
| Dry | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.8 | 0.9 | 0.7 | 0.0 | -0.1 |
| Critical Dry | -1.5 | -1.3 | -1.0 | -0.8 | -0.8 | -0.7 | 0.0 | 0.8 | 1.8 | -0.6 | -2.8 | -2.8 |

**Table 5.82 Changes in Shasta Lake Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 987 | 985 | 992 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 990 | 988 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,035 | 1,019 | 996 | 982 | 980 |
| Critical Dry | 925 | 921 | 928 | 938 | 950 | 967 | 965 | 959 | 937 | 899 | 874 | 869 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 986 | 985 | 991 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 989 | 987 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,034 | 1,018 | 995 | 982 | 980 |
| Critical Dry | 927 | 923 | 929 | 939 | 951 | 968 | 965 | 958 | 935 | 899 | 876 | 872 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| Critical Dry | -2 | -2 | -1 | -1 | -1 | -1 | 0 | 1 | 3 | -1 | -2 | -2 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 |
| Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Critical Dry | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | -0.1 | 0.0 | 0.1 | 0.3 | -0.1 | -0.3 | -0.3 |

Shasta Lake storage and surface water elevations would be similar in all months and all water year types under Alternative 5 as compared to the No Action Alternative.

The following changes in Sacramento River flows would occur under Alternative 5 as compared to the No Action Alternative, as shown on Figures 5.56 through 5.61.

- Sacramento River flows downstream of Keswick Dam (Figures 5.56 through 5.58) would be similar over the long-term conditions and in wet and dry years.
- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61) would be similar over the long-term conditions and in wet and dry years.

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.83 and 5.84. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized following Table 5.84.

**Table 5.83 Changes in Lake Oroville Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,681 | 1,723 | 2,179 | 2,556 | 2,833 | 2,942 | 3,300 | 3,488 | 3,447 | 2,961 | 2,613 | 2,103 |
| Above Normal | 1,275 | 1,310 | 1,471 | 1,948 | 2,512 | 2,892 | 3,247 | 3,401 | 3,241 | 2,608 | 2,125 | 1,668 |
| Below Normal | 1,552 | 1,507 | 1,517 | 1,728 | 2,132 | 2,406 | 2,663 | 2,746 | 2,569 | 1,959 | 1,521 | 1,305 |
| Dry | 1,223 | 1,173 | 1,190 | 1,319 | 1,595 | 1,952 | 2,193 | 2,255 | 1,992 | 1,502 | 1,295 | 1,150 |
| Critical Dry | 1,102 | 1,037 | 1,025 | 1,114 | 1,229 | 1,383 | 1,415 | 1,411 | 1,266 | 1,045 | 929 | 873 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,691 | 1,732 | 2,189 | 2,554 | 2,832 | 2,942 | 3,300 | 3,488 | 3,445 | 2,964 | 2,626 | 2,109 |
| Above Normal | 1,279 | 1,322 | 1,485 | 1,959 | 2,519 | 2,892 | 3,247 | 3,393 | 3,232 | 2,600 | 2,117 | 1,659 |
| Below Normal | 1,542 | 1,497 | 1,507 | 1,719 | 2,122 | 2,397 | 2,653 | 2,714 | 2,530 | 1,923 | 1,513 | 1,307 |
| Dry | 1,206 | 1,158 | 1,177 | 1,305 | 1,582 | 1,938 | 2,178 | 2,210 | 1,951 | 1,478 | 1,287 | 1,144 |
| Critical Dry | 1,092 | 1,029 | 1,019 | 1,108 | 1,223 | 1,381 | 1,408 | 1,392 | 1,243 | 1,018 | 917 | 865 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -10 | -9 | -10 | 1 | 1 | 0 | 0 | 0 | 2 | -3 | -13 | -7 |
| Above Normal | -3 | -12 | -14 | -11 | -7 | 0 | 0 | 8 | 9 | 8 | 8 | 9 |
| Below Normal | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 32 | 39 | 36 | 8 | -1 |
| Dry | 17 | 15 | 13 | 13 | 13 | 13 | 15 | 45 | 41 | 23 | 8 | 6 |
| Critical Dry | 10 | 9 | 6 | 6 | 6 | 3 | 7 | 19 | 22 | 27 | 12 | 8 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -0.6 | -0.5 | -0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | -0.1 | -0.5 | -0.3 |
| Above Normal | -0.3 | -0.9 | -0.9 | -0.6 | -0.3 | 0.0 | 0.0 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 |
| Below Normal | 0.6 | 0.7 | 0.7 | 0.5 | 0.5 | 0.4 | 0.4 | 1.2 | 1.6 | 1.9 | 0.6 | -0.1 |
| Dry | 1.4 | 1.3 | 1.1 | 1.0 | 0.8 | 0.7 | 0.7 | 2.0 | 2.1 | 1.6 | 0.6 | 0.5 |
| Critical Dry | 0.9 | 0.8 | 0.6 | 0.6 | 0.5 | 0.2 | 0.5 | 1.3 | 1.8 | 2.6 | 1.3 | 1.0 |

**Table 5.84 Changes in Lake Oroville Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 742 | 746 | 793 | 829 | 852 | 859 | 884 | 897 | 894 | 860 | 835 | 789 |
| Above Normal | 698 | 701 | 720 | 775 | 827 | 856 | 880 | 891 | 880 | 836 | 795 | 747 |
| Below Normal | 731 | 726 | 728 | 752 | 794 | 818 | 839 | 845 | 831 | 777 | 730 | 704 |
| Dry | 691 | 685 | 688 | 706 | 738 | 777 | 799 | 804 | 779 | 727 | 703 | 685 |
| Critical Dry | 676 | 668 | 665 | 679 | 694 | 712 | 716 | 715 | 696 | 667 | 650 | 642 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 743 | 748 | 794 | 829 | 852 | 859 | 884 | 897 | 894 | 861 | 836 | 790 |
| Above Normal | 698 | 703 | 722 | 776 | 828 | 856 | 880 | 890 | 879 | 835 | 794 | 746 |
| Below Normal | 730 | 725 | 726 | 751 | 793 | 818 | 838 | 842 | 828 | 773 | 729 | 704 |
| Dry | 688 | 683 | 686 | 704 | 737 | 775 | 798 | 800 | 775 | 724 | 702 | 684 |
| Critical Dry | 674 | 667 | 664 | 678 | 693 | 712 | 715 | 712 | 693 | 663 | 648 | 640 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -1 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 |
| Above Normal | 0 | -1 | -2 | -1 | -1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| Below Normal | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 3 | 4 | 1 | 0 |
| Dry | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 4 | 4 | 3 | 1 | 1 |
| Critical Dry | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 2 | 3 | 4 | 2 | 2 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -0.2 | -0.2 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 |
| Above Normal | 0.0 | -0.2 | -0.2 | -0.1 | -0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Below Normal | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.4 | 0.5 | 0.1 | 0.0 |
| Dry | 0.4 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.5 | 0.5 | 0.4 | 0.2 | 0.2 |
| Critical Dry | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.0 | 0.1 | 0.3 | 0.4 | 0.6 | 0.4 | 0.3 |

Lake Oroville storage and surface water elevations would be similar in all months and all water year types under Alternative 5 as compared to the No Action Alternative.

The following changes in Feather River flows would occur under Alternative 5 as compared to the No Action Alternative, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in June through April and reduced flows in May (6.6 percent).
- In wet years, similar flows would occur in all months.
- In dry years, similar flows would occur in September through April and June; reduced flows in May (27.1 percent) and increased flows in July and August (up to 8.9 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.85 and 5.86. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized following Table 5.86.

**Table 5.85 Changes in Folsom Lake Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 454 | 435 | 515 | 518 | 515 | 632 | 785 | 952 | 941 | 794 | 710 | 577 |
| Above Normal | 375 | 379 | 428 | 513 | 532 | 640 | 787 | 946 | 888 | 622 | 554 | 478 |
| Below Normal | 440 | 425 | 461 | 483 | 534 | 620 | 758 | 845 | 783 | 523 | 469 | 450 |
| Dry | 397 | 386 | 411 | 426 | 479 | 579 | 691 | 766 | 664 | 489 | 435 | 410 |
| Critical Dry | 325 | 304 | 314 | 320 | 367 | 433 | 483 | 499 | 411 | 324 | 257 | 231 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 454 | 435 | 514 | 518 | 515 | 632 | 785 | 951 | 941 | 800 | 712 | 576 |
| Above Normal | 377 | 380 | 429 | 513 | 531 | 640 | 787 | 946 | 887 | 621 | 552 | 477 |
| Below Normal | 446 | 431 | 467 | 484 | 533 | 619 | 757 | 843 | 780 | 527 | 472 | 453 |
| Dry | 394 | 383 | 408 | 423 | 479 | 579 | 691 | 760 | 658 | 495 | 443 | 419 |
| Critical Dry | 324 | 305 | 315 | 320 | 366 | 432 | 475 | 486 | 415 | 327 | 267 | 231 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | -6 | -2 | 1 |
| Above Normal | -2 | -1 | -1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 1 |
| Below Normal | -6 | -7 | -6 | -2 | 0 | 0 | 0 | 2 | 3 | -4 | -3 | -3 |
| Dry | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 6 | 6 | -5 | -8 | -9 |
| Critical Dry | 1 | -1 | 0 | 0 | 0 | 0 | 8 | 13 | -4 | -3 | -10 | 0 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | -0.8 | -0.2 | 0.2 |
| Above Normal | -0.7 | -0.4 | -0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.4 | 0.3 |
| Below Normal | -1.4 | -1.5 | -1.3 | -0.3 | 0.0 | 0.1 | 0.1 | 0.3 | 0.4 | -0.7 | -0.6 | -0.7 |
| Dry | 0.7 | 0.8 | 0.6 | 0.5 | 0.0 | 0.0 | 0.0 | 0.8 | 0.8 | -1.1 | -1.9 | -2.1 |
| Critical Dry | 0.2 | -0.2 | -0.1 | 0.0 | 0.1 | 0.1 | 1.7 | 2.8 | -0.9 | -0.9 | -3.9 | 0.2 |

**Table 5.86 Changes in Folsom Lake Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 465 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 431 | 423 | 413 |
| Below Normal | 406 | 405 | 410 | 413 | 420 | 431 | 445 | 454 | 447 | 417 | 411 | 408 |
| Dry | 400 | 400 | 404 | 406 | 413 | 426 | 438 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 412 | 414 | 400 | 385 | 370 | 365 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 464 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 430 | 422 | 413 |
| Below Normal | 408 | 406 | 411 | 414 | 420 | 431 | 445 | 454 | 447 | 418 | 411 | 409 |
| Dry | 400 | 399 | 403 | 405 | 413 | 426 | 438 | 445 | 434 | 414 | 408 | 405 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 411 | 412 | 401 | 386 | 374 | 366 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 |
| Above Normal | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | -2 | -2 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 |
| Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | -1 | -2 | -2 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | -1 | -2 | -3 | 0 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 |
| Above Normal | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| Below Normal | -0.5 | -0.4 | -0.3 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | -0.1 | -0.1 | -0.1 |
| Dry | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | -0.3 | -0.5 | -0.5 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.4 | -0.2 | -0.4 | -0.9 | -0.1 |

Folsom Lake storage and surface water elevations would be similar in all months and all water year types under Alternative 5 as compared to the No Action Alternative.

American River flows would be similar over long-term conditions and in wet and dry years in all months under Alternative 5 as compared to the No Action Alternative, as shown on Figures 5.65 through 5.67.

*Clear Creek*

Monthly Clear Creek flows under Alternative 5 are identical to flows under the No Action Alternative, as summarized in Table 5.87.

**Table 5.87 Changes in Clear Creek Flows below Whiskeytown Dam under Alternative 5 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 175 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 177 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dry | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |

*New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.88 and 5.89. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized following Table 5.89.

**Table 5.88 Changes in New Melones Reservoir Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,309 | 1,321 | 1,388 | 1,496 | 1,602 | 1,668 | 1,704 | 1,812 | 1,906 | 1,833 | 1,722 | 1,653 |
| Above Normal | 983 | 1,014 | 1,079 | 1,168 | 1,271 | 1,361 | 1,363 | 1,413 | 1,396 | 1,302 | 1,207 | 1,162 |
| Below Normal | 1,210 | 1,220 | 1,242 | 1,267 | 1,329 | 1,354 | 1,298 | 1,276 | 1,254 | 1,163 | 1,071 | 1,028 |
| Dry | 1,018 | 1,018 | 1,030 | 1,045 | 1,081 | 1,114 | 1,066 | 1,031 | 990 | 903 | 823 | 781 |
| Critical Dry | 558 | 559 | 570 | 578 | 597 | 591 | 506 | 449 | 433 | 391 | 355 | 336 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 1,379 | 1,390 | 1,454 | 1,562 | 1,666 | 1,724 | 1,758 | 1,878 | 1,968 | 1,890 | 1,773 | 1,703 |
| Above Normal | 1,029 | 1,060 | 1,125 | 1,214 | 1,317 | 1,406 | 1,413 | 1,484 | 1,467 | 1,372 | 1,277 | 1,232 |
| Below Normal | 1,294 | 1,305 | 1,326 | 1,351 | 1,413 | 1,438 | 1,390 | 1,383 | 1,359 | 1,268 | 1,175 | 1,133 |
| Dry | 1,094 | 1,094 | 1,106 | 1,121 | 1,156 | 1,188 | 1,154 | 1,132 | 1,087 | 997 | 914 | 871 |
| Critical Dry | 624 | 623 | 638 | 645 | 661 | 656 | 602 | 554 | 526 | 476 | 431 | 408 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -70 | -69 | -65 | -66 | -64 | -56 | -54 | -65 | -62 | -57 | -51 | -49 |
| Above Normal | -46 | -46 | -46 | -46 | -46 | -46 | -51 | -71 | -71 | -70 | -70 | -70 |
| Below Normal | -84 | -84 | -84 | -84 | -84 | -84 | -93 | -107 | -106 | -105 | -105 | -104 |
| Dry | -77 | -76 | -76 | -76 | -75 | -74 | -88 | -100 | -97 | -94 | -91 | -89 |
| Critical Dry | -66 | -64 | -68 | -66 | -64 | -65 | -95 | -105 | -93 | -84 | -76 | -73 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -5.1 | -5.0 | -4.5 | -4.2 | -3.9 | -3.2 | -3.1 | -3.5 | -3.2 | -3.0 | -2.9 | -2.9 |
| Above Normal | -4.5 | -4.4 | -4.1 | -3.8 | -3.5 | -3.3 | -3.6 | -4.8 | -4.8 | -5.1 | -5.5 | -5.7 |
| Below Normal | -6.5 | -6.5 | -6.4 | -6.2 | -5.9 | -5.8 | -6.7 | -7.7 | -7.8 | -8.3 | -8.9 | -9.2 |
| Dry | -7.0 | -7.0 | -6.9 | -6.8 | -6.5 | -6.2 | -7.6 | -8.9 | -8.9 | -9.4 | -10.0 | -10.2 |
| Critical Dry | -10.5 | -10.3 | -10.6 | -10.3 | -9.8 | -9.9 | -15.8 | -18.9 | -17.6 | -17.7 | -17.7 | -17.8 |

**Table 5.89 Changes in New Melones Reservoir Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 969 | 971 | 980 | 995 | 1,007 | 1,016 | 1,020 | 1,031 | 1,040 | 1,033 | 1,022 | 1,015 |
| Above Normal | 924 | 930 | 939 | 954 | 968 | 980 | 982 | 988 | 987 | 975 | 963 | 890 |
| Below Normal | 954 | 956 | 959 | 962 | 973 | 977 | 972 | 970 | 968 | 957 | 944 | 938 |
| Dry | 930 | 930 | 932 | 934 | 939 | 945 | 940 | 936 | 931 | 918 | 905 | 898 |
| Critical Dry | 837 | 838 | 842 | 845 | 853 | 855 | 834 | 818 | 815 | 804 | 796 | 791 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 980 | 982 | 990 | 1,004 | 1,016 | 1,023 | 1,026 | 1,039 | 1,047 | 1,040 | 1,029 | 1,022 |
| Above Normal | 932 | 937 | 945 | 960 | 974 | 986 | 988 | 997 | 996 | 985 | 973 | 897 |
| Below Normal | 968 | 969 | 972 | 975 | 985 | 988 | 985 | 985 | 983 | 972 | 960 | 955 |
| Dry | 943 | 943 | 944 | 947 | 951 | 957 | 955 | 953 | 948 | 934 | 922 | 915 |
| Critical Dry | 856 | 856 | 862 | 864 | 870 | 871 | 860 | 848 | 840 | 828 | 818 | 812 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -11 | -11 | -10 | -9 | -8 | -7 | -7 | -7 | -7 | -7 | -6 | -6 |
| Above Normal | -8 | -7 | -6 | -6 | -6 | -6 | -6 | -8 | -8 | -9 | -10 | -7 |
| Below Normal | -13 | -13 | -13 | -13 | -12 | -12 | -13 | -15 | -15 | -15 | -16 | -16 |
| Dry | -13 | -13 | -12 | -13 | -12 | -12 | -15 | -17 | -17 | -17 | -17 | -17 |
| Critical Dry | -19 | -18 | -20 | -19 | -17 | -16 | -26 | -30 | -25 | -24 | -22 | -21 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -1.2 | -1.2 | -1.0 | -0.9 | -0.8 | -0.7 | -0.7 | -0.7 | -0.7 | -0.6 | -0.6 | -0.6 |
| Above Normal | -0.8 | -0.7 | -0.7 | -0.6 | -0.6 | -0.6 | -0.6 | -0.8 | -0.8 | -0.9 | -1.0 | -0.7 |
| Below Normal | -1.4 | -1.4 | -1.4 | -1.3 | -1.2 | -1.2 | -1.3 | -1.5 | -1.5 | -1.6 | -1.7 | -1.7 |
| Dry | -1.3 | -1.3 | -1.3 | -1.3 | -1.3 | -1.2 | -1.5 | -1.8 | -1.8 | -1.8 | -1.9 | -1.9 |
| Critical Dry | -2.2 | -2.1 | -2.3 | -2.2 | -2.0 | -1.9 | -3.0 | -3.5 | -3.0 | -2.9 | -2.7 | -2.6 |

The following changes in New Melones Reservoir storage and elevation would occur under Alternative 5 as compared to the No Action Alternative.

- In wet years, storage would be similar in all months.
- In above normal years, storage would be similar in October through June and reduced in July through September (up to 5.7 percent).
- In below normal years, storage would be reduced in all months (up to 9.2 percent).
- In dry years, storage would be reduced in all months (up to 10.2 percent).
- In critical dry years, storage would be reduced in all months (up to 18.9 percent).
- In all months, in all water year types, surface water elevations would be similar.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in these rivers are summarized below.

- Over long-term conditions, flows would be similar in September through February and June; reduced flows would occur in March, July, and August (up to 8.0 percent); and increased flows in April and May (up to 22.4 percent).
- In wet years, similar flows would occur in October, November, January, February, and April through June and reduced flows in December, March, and July through September (up to 18.0 percent).
- In dry years, similar flows would occur in June through March and increased flows in April and May (up to 47.3 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis under Alternative 5 as compared to the No Action Alternative are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions and wet years, similar flows would occur in all months.
- In dry years, similar flows would occur in June through March and increased flows in April and May (up to 15.7 percent).San Luis Reservoir.

Storage levels and surface water elevations in San Luis Reservoir under Alternative 5 as compared to the No Action Alternative are summarized in Tables 5.90 and 5.91. The results are summarized following Table 5.91.

**Table 5.90 Changes in San Luis Reservoir Storage under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 576 | 706 | 958 | 1,251 | 1,539 | 1,804 | 1,624 | 1,279 | 984 | 787 | 680 | 726 |
| Above Normal | 488 | 622 | 932 | 1,213 | 1,440 | 1,660 | 1,447 | 1,046 | 672 | 477 | 442 | 520 |
| Below Normal | 541 | 628 | 923 | 1,157 | 1,335 | 1,496 | 1,305 | 928 | 524 | 476 | 414 | 463 |
| Dry | 464 | 572 | 856 | 1,139 | 1,327 | 1,481 | 1,324 | 1,002 | 691 | 655 | 412 | 418 |
| Critical Dry | 429 | 505 | 698 | 994 | 1,166 | 1,216 | 1,103 | 875 | 600 | 428 | 284 | 270 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 555 | 681 | 931 | 1,236 | 1,526 | 1,788 | 1,598 | 1,251 | 946 | 741 | 628 | 679 |
| Above Normal | 490 | 649 | 957 | 1,223 | 1,441 | 1,661 | 1,444 | 1,048 | 666 | 466 | 433 | 513 |
| Below Normal | 525 | 624 | 907 | 1,141 | 1,314 | 1,473 | 1,312 | 967 | 555 | 500 | 426 | 467 |
| Dry | 476 | 590 | 867 | 1,150 | 1,339 | 1,494 | 1,413 | 1,167 | 840 | 763 | 476 | 469 |
| Critical Dry | 478 | 556 | 752 | 1,040 | 1,204 | 1,252 | 1,192 | 1,028 | 739 | 544 | 343 | 323 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 20 | 25 | 27 | 15 | 13 | 16 | 26 | 28 | 38 | 46 | 52 | 47 |
| Above Normal | -2 | -27 | -24 | -10 | -2 | -1 | 3 | -2 | 6 | 10 | 8 | 7 |
| Below Normal | 16 | 4 | 16 | 17 | 21 | 23 | -7 | -39 | -31 | -24 | -12 | -4 |
| Dry | -12 | -18 | -11 | -11 | -12 | -13 | -89 | -165 | -149 | -107 | -64 | -51 |
| Critical Dry | -50 | -51 | -53 | -46 | -38 | -36 | -89 | -154 | -140 | -116 | -59 | -53 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 7.4 | 6.9 | 5.8 | 1.8 | 1.2 | 1.2 | 2.3 | 3.5 | 6.7 | 8.4 | 10.0 | 9.1 |
| Above Normal | 1.2 | -3.0 | -1.4 | 0.3 | 1.4 | 1.1 | 1.6 | 0.7 | 2.3 | 2.5 | 2.3 | 2.0 |
| Below Normal | 8.3 | 4.4 | 6.8 | 5.1 | 3.3 | 2.9 | -0.6 | -5.1 | -9.2 | -9.0 | -3.1 | -1.3 |
| Dry | -0.4 | -1.0 | 0.6 | 0.4 | 0.2 | -0.1 | -6.5 | -14.6 | -17.3 | -12.7 | -13.5 | -12.3 |
| Critical Dry | -12.6 | -13.9 | -10.4 | -6.3 | -4.3 | -3.5 | -7.1 | -13.0 | -15.6 | -18.2 | -17.6 | -16.9 |

**Table 5.91 Changes in San Luis Reservoir Elevation under Alternative 5 as Compared to the No Action Alternative**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 402 | 417 | 446 | 475 | 501 | 525 | 509 | 478 | 448 | 427 | 416 | 422 |
| Above Normal | 391 | 408 | 443 | 471 | 492 | 512 | 494 | 456 | 416 | 390 | 386 | 398 |
| Below Normal | 399 | 411 | 443 | 467 | 483 | 498 | 481 | 444 | 397 | 390 | 381 | 388 |
| Dry | 389 | 404 | 436 | 465 | 483 | 497 | 482 | 451 | 417 | 413 | 381 | 381 |
| Critical Dry | 383 | 393 | 417 | 450 | 467 | 471 | 460 | 437 | 405 | 383 | 359 | 357 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 399 | 414 | 443 | 473 | 500 | 523 | 507 | 475 | 444 | 422 | 409 | 416 |
| Above Normal | 391 | 411 | 445 | 472 | 492 | 512 | 493 | 456 | 415 | 389 | 386 | 398 |
| Below Normal | 397 | 410 | 442 | 465 | 481 | 496 | 481 | 448 | 400 | 393 | 383 | 389 |
| Dry | 391 | 406 | 437 | 466 | 484 | 498 | 490 | 468 | 434 | 426 | 390 | 389 |
| Critical Dry | 390 | 400 | 423 | 454 | 470 | 475 | 469 | 453 | 422 | 399 | 369 | 366 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 6 |
| Above Normal | **0** | **-3** | **-2** | **-1** | **0** | **0** | 0 | **0** | 1 | 1 | 1 | 1 |
| Below Normal | 2 | 1 | 2 | 2 | 2 | 2 | **-1** | **-4** | **-3** | **-3** | **-2** | **-1** |
| Dry | **-2** | **-2** | **-1** | **-1** | **-1** | **-1** | **-8** | **-16** | **-17** | **-13** | **-9** | **-7** |
| Critical Dry | **-7** | **-7** | **-6** | **-4** | **-3** | **-3** | **-9** | **-16** | **-18** | **-16** | **-10** | **-9** |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | 0.6 | 0.7 | 0.6 | 0.3 | 0.2 | 0.3 | 0.4 | 0.6 | 0.9 | 1.2 | 1.5 | 1.3 |
| Above Normal | -0.1 | -0.7 | -0.5 | -0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.3 | 0.2 | 0.2 |
| Below Normal | 0.4 | 0.2 | 0.4 | 0.3 | 0.4 | 0.4 | -0.1 | -0.9 | -0.9 | -0.7 | -0.4 | -0.1 |
| Dry | -0.4 | -0.5 | -0.3 | -0.2 | -0.2 | -0.2 | -1.6 | -3.5 | -3.9 | -2.9 | -2.3 | -1.9 |
| Critical Dry | -1.8 | -1.6 | -1.4 | -0.9 | -0.7 | -0.7 | -1.9 | -3.6 | -4.2 | -4.1 | -2.7 | -2.4 |

The following changes in San Luis Reservoir storage would occur under Alternative 5 as compared to the No Action Alternative.

- In wet years, storage would be similar in January through May and increased in June through December (up to 10.0 percent).
- In above-normal years, storage would be similar in all months.
- In below-normal years, storage would be similar in November, February through April, August, and September; reduced in June and July (up to 9.2 percent); and increased in October, December, January, and May (up to 8.3 percent).
- In dry years, storage would be similar in October through March and reduced in April through September (up to 17.3 percent).
- In critical dry years, storage would be similar in February and March; and reduced in April through January (up to 18.2 percent).
- Surface water elevations would be similar in all months, in all water years.

*Changes in Flows into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 5 as compared to the No Action Alternative are summarized in Table 5.92. The results are summarized following Table 5.92.

**Table 5.92 Changes in Flows into the Yolo Bypass at Fremont Weir under Alternative 5 as Compared to the No Action Alternative**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 170 | 933 | 8,400 | 24,048 | 29,507 | 18,512 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,786 | 6,000 | 12,885 | 7,895 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,115 | 886 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 317 | 896 | 2,015 | 1,398 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 151 | 525 | 531 | 393 | 106 | 100 | 100 | 0 | 0 | 100 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 183 | 910 | 8,420 | 24,291 | 29,547 | 18,493 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,765 | 5,997 | 13,013 | 7,928 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,031 | 883 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 322 | 902 | 2,024 | 1,393 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 528 | 534 | 396 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -13 | 23 | -20 | -243 | -40 | 18 | 0 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 22 | 4 | -128 | -34 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | -1 | 0 | 84 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | -5 | -6 | -10 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 2 | -3 | -3 | -3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -7.3 | 2.6 | -0.2 | -1.0 | -0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.8 | 0.1 | -1.0 | -0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | -0.2 | 0.0 | 2.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | -1.6 | -0.6 | -0.5 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 1.6 | -0.5 | -0.6 | -0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Flows from the Sacramento River into Yolo Bypass at Fremont Weir would be similar under Alternative 5 and the No Action Alternative.

*Changes in Delta Conditions*

Delta outflow under Alternative 5 as compared to the No Action Alternative are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow would be similar.
- In dry years, average monthly Delta outflow would be similar in July through April and increased in May and June (up to 1,377 cfs).

The OMR conditions under Alternative 5 as compared to the No Action Alternative are shown on Figures 5.77 through 5.79.

- Under Alternative 5, OMR flows would be negative except in April and May of all water year types. Under the No Action Alternative, OMR flows would be negative except in April and May of wet and above normal years and April of below normal years.
- In wet years, OMR flows would be more positive or no change in September, October, January, and April through June (up to 171 cfs) and more negative in November, December, March, and August (up to 124 cfs).
- In dry years, OMR flows would be more positive or no change in October through March (up to 1,359 cfs) and more negative in June through September (up to 568 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under Alternative 5 as compared to the No Action Alternative are summarized in Table 5.93.

1 **Table 5.93 Changes in Exports at Jones and Banks Pumping Plants under**
2 **Alternative 5 as Compared to the No Action Alternative**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 408 | 505 | 564 | 514 | 532 | 592 | 202 | 202 | 444 | 667 | 718 | 627 |
| Above Normal | 376 | 423 | 561 | 407 | 405 | 496 | 127 | 92 | 315 | 590 | 705 | 625 |
| Below Normal | 381 | 456 | 588 | 387 | 359 | 397 | 103 | 55 | 208 | 663 | 632 | 561 |
| Dry | 370 | 394 | 513 | 392 | 315 | 318 | 80 | 41 | 205 | 577 | 333 | 433 |
| Critical Dry | 313 | 293 | 382 | 355 | 249 | 179 | 34 | 20 | 69 | 239 | 222 | 243 |
| **No Action Alternative** | | | | | | | | | | | | |
| Wet | 410 | 497 | 564 | 513 | 537 | 594 | 204 | 207 | 445 | 669 | 717 | 638 |
| Above Normal | 376 | 450 | 562 | 406 | 401 | 496 | 130 | 105 | 315 | 587 | 709 | 628 |
| Below Normal | 386 | 456 | 590 | 387 | 354 | 394 | 134 | 100 | 209 | 657 | 622 | 542 |
| Dry | 374 | 398 | 510 | 392 | 315 | 318 | 153 | 126 | 194 | 541 | 296 | 426 |
| Critical Dry | 314 | 293 | 384 | 349 | 250 | 179 | 93 | 90 | 64 | 223 | 176 | 242 |
| **Alternative 5 as Compared to No Action Alternative** | | | | | | | | | | | | |
| Wet | -2 | 8 | 0 | 0 | -5 | -2 | -2 | -5 | -1 | -1 | 0 | -11 |
| Above Normal | 1 | -28 | -1 | 1 | 4 | 0 | -4 | -14 | 0 | 2 | -4 | -3 |
| Below Normal | -5 | 0 | -2 | 0 | 5 | 4 | -31 | -45 | -1 | 6 | 10 | 18 |
| Dry | -4 | -4 | 4 | 0 | 0 | 0 | -73 | -84 | 11 | 36 | 38 | 8 |
| Critical Dry | -1 | 0 | -2 | 6 | -1 | -1 | -59 | -70 | 4 | 17 | 46 | 1 |
| **Alternative 5 as Compared to No Action Alternative (percent change)** | | | | | | | | | | | | |
| Wet | -0.6 | 1.6 | 0.0 | 0.1 | -0.9 | -0.3 | -1.0 | -2.6 | -0.2 | -0.2 | 0.1 | -1.8 |
| Above Normal | 0.2 | -6.1 | -0.1 | 0.3 | 0.9 | 0.0 | -2.9 | -13.0 | -0.1 | 0.4 | -0.5 | -0.5 |
| Below Normal | -1.3 | 0.0 | -0.4 | 0.0 | 1.4 | 0.9 | -23.4 | -45.4 | -0.3 | 0.8 | 1.6 | 3.4 |
| Dry | -1.1 | -1.0 | 0.7 | -0.1 | -0.1 | 0.0 | -47.6 | -67.0 | 5.7 | 6.7 | 12.8 | 1.8 |
| Critical Dry | -0.2 | 0.1 | -0.4 | 1.8 | -0.4 | -0.4 | -63.8 | -77.5 | 6.9 | 7.6 | 25.9 | 0.6 |

The following changes would occur in CVP and SWP exports under Alternative 5 as compared to the No Action Alternative.

- Long-term average annual exports would be 45 TAF (1 percent) less under Alternative 5 as compared to the No Action Alternative.
- In wet years, total exports would be similar in all months.
- In above-normal years, total exports would be similar in June through April and reduced in May (13.0 percent).
- In below-normal years, total exports would be similar in June through March and reduced in April and May (up to 45.4 percent).
- In dry years, total exports would be similar in June, July, and September through March; reduced in April and May (up to 67.0 percent); and increased in August (12.8 percent).
- In critical dry years, total exports would be similar in June, July, and September through March; reduced in April and May (up to 77.5 percent); and increased August (25.9 percent).

Deliveries to CVP and SWP water users would be similar under Alternative 5 as compared to the No Action Alternative, as summarized in Tables 5.94 and 5.95, respectively.

**Table 5.94 Changes CVP Water Deliveries under Alternative 5 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the No Action Alternative | |
| | | Alternative 5 | No Action Alternative | Difference | Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 185 | 185 | 0 | 0 |
| | Dry | 85 | 86 | 0 | 0 |
| | Critical Dry | 24 | 24 | 0 | 0 |
| CVP M&I (Including American River Contractors and Contra Costa Water District) | Long Term | 386 | 386 | 0 | 0 |
| | Dry | 384 | 385 | 0 | 0 |
| | Critical Dry | 384 | 383 | 1 | 0 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 5 | No Action Alternative | Alternative 5 as compared to the No Action Alternative: Difference | Alternative 5 as compared to the No Action Alternative: Percent Change |
| CVP M&I American River Contractors | Long Term | 112 | 113 | 0 | 0 |
| | Dry | 96 | 97 | 0 | 0 |
| | Critical Dry | 74 | 75 | -1 | -1 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,861 | 1,859 | 2 | 0 |
| | Dry | 1,906 | 1,906 | 0 | 0 |
| | Critical Dry | 1,747 | 1,737 | 10 | 1 |
| CVP Refuge Level 2 Deliveries | Long Term | 146 | 146 | 0 | 0 |
| | Dry | 145 | 146 | 0 | 0 |
| | Critical Dry | 103 | 102 | 1 | 1 |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 2,578 | 2,576 | 2 | 0 |
| | Dry | 2,520 | 2,523 | -3 | 0 |
| | Critical Dry | 2,258 | 2,246 | 12 | 1 |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 834 | 847 | -13 | -2 |
| | Dry | 433 | 445 | -12 | -3 |
| | Critical Dry | 130 | 131 | -1 | -1 |
| CVP M&I Users | Long Term | 112 | 112 | 0 | 0 |
| | Dry | 100 | 99 | 1 | 1 |
| | Critical Dry | 80 | 80 | 0 | 0 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 5 | No Action Alternative | Alternative 5 as compared to the No Action Alternative | |
| | | | | Difference | Percent Change |
| CVP Refuge Level 2 Deliveries | Long Term | 273 | 273 | 0 | 0 |
| | Dry | 281 | 281 | 0 | 0 |
| | Critical Dry | 232 | 234 | -2 | -1 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 2,071 | 2,084 | -13 | -1 |
| | Dry | 1,689 | 1,700 | -11 | -1 |
| | Critical Dry | 1,183 | 1,186 | -3 | 0 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 502 | 508 | -6 | -1 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 406 | 445 | -39 | -9 |
| CVP Water Service Contracts | Long Term | 100 | 104 | -4 | -4 |
| | Dry | 69 | 84 | -16 | -19 |
| | Critical Dry | 8 | 4 | 4 | 100 |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 602 | 612 | -10 | -2 |
| | Dry | 593 | 608 | -15 | -2 |
| | Critical Dry | 414 | 449 | -35 | -8 |

The following changes in CVP water deliveries would occur under Alternative 5 as compared to the No Action Alternative.

- Deliveries to CVP North of Delta agricultural water service contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries to CVP North of Delta M&I contractors would be similar over the long-term conditions and in dry and critical dry years in total and for the American River CVP contractors.
- Deliveries to CVP South of Delta agricultural water service contractors would be similar over the long-term conditions and in dry and critical dry years.

- Deliveries to CVP South of Delta M&I contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries to the Eastside contractors would be similar under long-term conditions and dry years; and reduced by 8 percent in critical dry years.

**Table 5.95 Changes SWP Water Deliveries under the Alternative 5 as Compared to the No Action Alternative**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the No Action Alternative | |
| | | Alternative 5 | No Action Alternative | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 67 | 68 | -1 | -2 |
| | Dry | 51 | 51 | 0 | -1 |
| | Critical Dry | 42 | 43 | -1 | -1 |
| SWP M&I Article 21 Deliveries | Long Term | 13 | 13 | 0 | 3 |
| | Dry | 14 | 14 | 1 | 4 |
| | Critical Dry | 13 | 13 | 1 | 5 |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 67 | 68 | -1 | -2 |
| | Dry | 51 | 51 | 0 | -1 |
| | Critical Dry | 42 | 43 | -1 | -1 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 13 | 13 | 0 | 3 |
| | Dry | 14 | 14 | 1 | 4 |
| | Critical Dry | 13 | 13 | 1 | 5 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 5 | No Action Alternative | Alternative 5 as compared to the No Action Alternative | |
| | | | | Difference | Percent Change |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 598 | 610 | -12 | -2 |
| | Dry | 449 | 455 | -7 | -1 |
| | Critical Dry | 369 | 378 | -9 | -2 |
| SWP Agricultural Article 21 Deliveries | Long Term | 24 | 27 | -2 | -9 |
| | Dry | 6 | 5 | 1 | 20 |
| | Critical Dry | 4 | 7 | -3 | -43 |
| SWP M&I Users (without Article 21) | Long Term | 1,784 | 1,800 | -15 | -1 |
| | Dry | 1,397 | 1,406 | -9 | -1 |
| | Critical Dry | 1,157 | 1,173 | -16 | -1 |
| SWP M&I Article 21 Deliveries | Long Term | 19 | 20 | -1 | -7 |
| | Dry | 5 | 5 | 0 | 4 |
| | Critical Dry | 3 | 5 | -2 | -37 |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,383 | 2,410 | -27 | -1 |
| | Dry | 1,845 | 1,861 | -15 | -1 |
| | Critical Dry | 1,526 | 1,551 | -25 | -2 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 43 | 47 | -4 | -8 |
| | Dry | 11 | 10 | 1 | 12 |
| | Critical Dry | 7 | 12 | -5 | -41 |

The following changes in SWP water deliveries would occur under Alternative 5 as compared to the No Action Alternative.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries of Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 8 percent over the long-term conditions and 41 percent in critical dry years; and increased by 12 percent in dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns, the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 5 and the No Action Alternative.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September, and the volume would be limited to 600,000 acre-feet per year in drier years and 360,000 acre-feet in all other years, in accordance with the 2008 USFWS BO and 2009 NMFS BO. As indicated in Table 5.93, capacity would be available under the No Action Alternative between July and September for water transfers in all water year types.

Overall, the potential for water transfer conveyance would be similar under Alternative 5 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability CVP and SWP water supplies for storage in these reservoirs under Alternative 5 as compared to the No Action Alternative would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.94 and 5.95.

- Deliveries to CVP South of Delta M&I contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 8 percent over the long-term conditions and 41 percent in critical dry years; and increased by 12 percent in dry years.

*Changes in CVP and SWP Exports and Deliveries*

Deliveries to CVP and SWP water users are described above in the Central Valley Region.

#### 5.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

Changes in Trinity Lake storage and surface water elevations under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.96 and 5.97. The results are summarized following Table 5.97.

**Table 5.96 Changes in Trinity Lake Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,494 | 1,520 | 1,635 | 1,759 | 1,926 | 2,056 | 2,222 | 2,246 | 2,191 | 2,068 | 1,940 | 1,781 |
| Above Normal | 1,155 | 1,180 | 1,290 | 1,459 | 1,662 | 1,850 | 2,030 | 2,004 | 1,912 | 1,778 | 1,627 | 1,503 |
| Below Normal | 1,398 | 1,405 | 1,422 | 1,493 | 1,580 | 1,667 | 1,813 | 1,741 | 1,637 | 1,474 | 1,311 | 1,190 |
| Dry | 1,155 | 1,150 | 1,175 | 1,183 | 1,275 | 1,404 | 1,540 | 1,492 | 1,415 | 1,259 | 1,110 | 1,012 |
| Critical Dry | 744 | 726 | 741 | 743 | 784 | 866 | 913 | 878 | 856 | 755 | 622 | 539 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,501 | 1,535 | 1,644 | 1,767 | 1,931 | 2,055 | 2,224 | 2,250 | 2,194 | 2,068 | 1,939 | 1,805 |
| Above Normal | 1,208 | 1,245 | 1,363 | 1,524 | 1,718 | 1,901 | 2,079 | 2,053 | 1,955 | 1,815 | 1,647 | 1,513 |
| Below Normal | 1,451 | 1,472 | 1,492 | 1,554 | 1,641 | 1,729 | 1,872 | 1,799 | 1,696 | 1,515 | 1,337 | 1,204 |
| Dry | 1,178 | 1,184 | 1,210 | 1,230 | 1,322 | 1,453 | 1,586 | 1,536 | 1,466 | 1,302 | 1,152 | 1,055 |
| Critical Dry | 819 | 803 | 813 | 825 | 868 | 949 | 999 | 962 | 929 | 811 | 667 | 598 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -7 | -16 | -9 | -8 | -5 | 1 | -2 | -3 | -3 | 0 | 1 | -23 |
| Above Normal | -53 | -65 | -73 | -65 | -56 | -51 | -49 | -49 | -43 | -37 | -20 | -11 |
| Below Normal | -54 | -67 | -69 | -61 | -62 | -62 | -59 | -58 | -60 | -40 | -26 | -14 |
| Dry | -23 | -35 | -35 | -48 | -47 | -48 | -46 | -45 | -51 | -42 | -42 | -43 |
| Critical Dry | -75 | -77 | -72 | -82 | -84 | -84 | -86 | -84 | -73 | -56 | -45 | -59 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.5 | -1.0 | -0.5 | -0.4 | -0.3 | 0.0 | -0.1 | -0.2 | -0.1 | 0.0 | 0.0 | -1.3 |
| Above Normal | -4.4 | -5.2 | -5.3 | -4.3 | -3.3 | -2.7 | -2.4 | -2.4 | -2.2 | -2.0 | -1.2 | -0.7 |
| Below Normal | -3.7 | -4.6 | -4.7 | -3.9 | -3.7 | -3.6 | -3.2 | -3.2 | -3.5 | -2.7 | -1.9 | -1.2 |
| Dry | -2.0 | -3.0 | -2.9 | -3.9 | -3.5 | -3.3 | -2.9 | -2.9 | -3.5 | -3.3 | -3.6 | -4.1 |
| Critical Dry | -9.1 | -9.6 | -8.8 | -10.0 | -9.6 | -8.8 | -8.6 | -8.8 | -7.9 | -6.9 | -6.7 | -9.8 |

**Table 5.97 Changes in Trinity Lake Elevation under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 2,300 | 2,303 | 2,313 | 2,325 | 2,338 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,326 |
| Above Normal | 2,259 | 2,262 | 2,276 | 2,294 | 2,314 | 2,330 | 2,343 | 2,342 | 2,335 | 2,326 | 2,313 | 2,303 |
| Below Normal | 2,289 | 2,290 | 2,292 | 2,299 | 2,308 | 2,315 | 2,326 | 2,321 | 2,313 | 2,299 | 2,284 | 2,272 |
| Dry | 2,263 | 2,265 | 2,268 | 2,269 | 2,279 | 2,292 | 2,305 | 2,301 | 2,294 | 2,279 | 2,265 | 2,254 |
| Critical Dry | 2,209 | 2,206 | 2,209 | 2,212 | 2,220 | 2,234 | 2,241 | 2,237 | 2,235 | 2,221 | 2,199 | 2,183 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,301 | 2,305 | 2,314 | 2,325 | 2,339 | 2,347 | 2,357 | 2,358 | 2,355 | 2,347 | 2,338 | 2,328 |
| Above Normal | 2,270 | 2,273 | 2,286 | 2,303 | 2,320 | 2,335 | 2,347 | 2,346 | 2,339 | 2,329 | 2,315 | 2,304 |
| Below Normal | 2,295 | 2,296 | 2,298 | 2,305 | 2,313 | 2,320 | 2,331 | 2,326 | 2,318 | 2,303 | 2,287 | 2,274 |
| Dry | 2,266 | 2,269 | 2,272 | 2,274 | 2,284 | 2,296 | 2,309 | 2,304 | 2,298 | 2,284 | 2,269 | 2,259 |
| Critical Dry | 2,218 | 2,216 | 2,217 | 2,222 | 2,229 | 2,243 | 2,250 | 2,246 | 2,243 | 2,227 | 2,204 | 2,191 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -1 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 |
| Above Normal | -10 | -11 | -11 | -9 | -7 | -5 | -4 | -4 | -4 | -3 | -2 | -1 |
| Below Normal | -5 | -6 | -6 | -5 | -5 | -5 | -5 | -5 | -5 | -3 | -3 | -2 |
| Dry | -2 | -3 | -3 | -5 | -4 | -4 | -4 | -4 | -4 | -4 | -5 | -5 |
| Critical Dry | -9 | -9 | -8 | -9 | -9 | -9 | -9 | -9 | -8 | -6 | -5 | -8 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 |
| Above Normal | -0.5 | -0.5 | -0.5 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | 0.0 |
| Below Normal | -0.2 | -0.3 | -0.3 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 |
| Dry | -0.1 | -0.1 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 | -0.2 |
| Critical Dry | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.3 | -0.2 | -0.4 |

The following changes in Trinity Lake storage and surface water elevations would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet, below normal, and dry years, storage would be similar.
- In above normal years, storage would be similar in January through October and reduced in November and December (up to 5.3 percent).
- In critical dry years, storage would be reduced in all months (up to 10.0 percent).
- In all months, in all water year types, surface water elevations would be similar.

The following changes would occur on the Trinity River under Alternative 5 as compared to the Second Basis of Comparison, as summarized on Figures 5.53 through 5.55.

- Over long-term conditions, flows would be similar in March through November and January and reduced in December and February (up to 9.6 percent).
- In wet years, flows would be similar in January and April through November and reduced in December, February, and March (up to 13.9 percent).
- In dry years, flows would be similar in all months.

*Central Valley Region*

*Changes in CVP and SWP Reservoir Storage and Downstream River Flows*

*Shasta Lake and Sacramento River*

Storage levels and surface water elevations in Shasta Lake under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.98 and 5.99. Changes in flows in the Sacramento River downstream of Keswick Dam and at Freeport are shown on Figures 5.56 through 5.61. The results are summarized following Table 5.99.

**Table 5.98 Changes in Shasta Lake Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 2,704 | 2,716 | 3,078 | 3,385 | 3,590 | 3,836 | 4,299 | 4,461 | 4,243 | 3,736 | 3,410 | 2,989 |
| Above Normal | 2,369 | 2,388 | 2,598 | 3,164 | 3,454 | 4,019 | 4,401 | 4,430 | 4,042 | 3,409 | 3,071 | 2,842 |
| Below Normal | 2,603 | 2,565 | 2,704 | 3,077 | 3,450 | 3,820 | 4,039 | 3,970 | 3,602 | 3,012 | 2,663 | 2,620 |
| Dry | 2,344 | 2,287 | 2,433 | 2,627 | 3,039 | 3,509 | 3,745 | 3,699 | 3,315 | 2,787 | 2,497 | 2,459 |
| Critical Dry | 1,676 | 1,611 | 1,700 | 1,856 | 2,015 | 2,258 | 2,203 | 2,104 | 1,749 | 1,246 | 958 | 910 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 2,817 | 2,926 | 3,154 | 3,406 | 3,597 | 3,841 | 4,301 | 4,453 | 4,228 | 3,733 | 3,362 | 3,252 |
| Above Normal | 2,499 | 2,578 | 2,808 | 3,313 | 3,515 | 4,038 | 4,416 | 4,417 | 3,979 | 3,347 | 2,975 | 2,921 |
| Below Normal | 2,826 | 2,846 | 2,977 | 3,299 | 3,646 | 3,966 | 4,164 | 4,042 | 3,599 | 3,010 | 2,601 | 2,574 |
| Dry | 2,409 | 2,431 | 2,578 | 2,755 | 3,168 | 3,644 | 3,861 | 3,774 | 3,333 | 2,800 | 2,539 | 2,496 |
| Critical Dry | 1,873 | 1,826 | 1,911 | 2,050 | 2,222 | 2,460 | 2,386 | 2,270 | 1,861 | 1,409 | 1,151 | 1,086 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -114 | -211 | -76 | -21 | -8 | -5 | -2 | 7 | 15 | 3 | 48 | -263 |
| Above Normal | -130 | -190 | -210 | -149 | -62 | -19 | -15 | 13 | 63 | 62 | 97 | -79 |
| Below Normal | -224 | -281 | -273 | -221 | -196 | -146 | -125 | -72 | 3 | 1 | 62 | 45 |
| Dry | -64 | -144 | -145 | -129 | -129 | -135 | -116 | -75 | -18 | -13 | -41 | -38 |
| Critical Dry | -197 | -215 | -211 | -194 | -207 | -202 | -183 | -166 | -111 | -163 | -193 | -176 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -4.0 | -7.2 | -2.4 | -0.6 | -0.2 | -0.1 | 0.0 | 0.2 | 0.4 | 0.1 | 1.4 | -8.1 |
| Above Normal | -5.2 | -7.4 | -7.5 | -4.5 | -1.8 | -0.5 | -0.3 | 0.3 | 1.6 | 1.8 | 3.3 | -2.7 |
| Below Normal | -7.9 | -9.9 | -9.2 | -6.7 | -5.4 | -3.7 | -3.0 | -1.8 | 0.1 | 0.0 | 2.4 | 1.8 |
| Dry | -2.7 | -5.9 | -5.6 | -4.7 | -4.1 | -3.7 | -3.0 | -2.0 | -0.5 | -0.5 | -1.6 | -1.5 |
| Critical Dry | -10.5 | -11.8 | -11.0 | -9.5 | -9.3 | -8.2 | -7.7 | -7.3 | -6.0 | -11.5 | -16.8 | -16.2 |

**Table 5.99 Changes in Shasta Lake Elevation under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 991 | 992 | 1,008 | 1,023 | 1,031 | 1,041 | 1,058 | 1,064 | 1,056 | 1,037 | 1,024 | 1,005 |
| Above Normal | 967 | 968 | 982 | 1,012 | 1,025 | 1,048 | 1,062 | 1,063 | 1,049 | 1,024 | 1,009 | 999 |
| Below Normal | 987 | 985 | 992 | 1,009 | 1,025 | 1,040 | 1,048 | 1,045 | 1,031 | 1,006 | 990 | 988 |
| Dry | 969 | 967 | 975 | 986 | 1,006 | 1,027 | 1,037 | 1,035 | 1,019 | 996 | 982 | 980 |
| Critical Dry | 925 | 921 | 928 | 938 | 950 | 967 | 965 | 959 | 937 | 899 | 874 | 869 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 997 | 1,002 | 1,012 | 1,024 | 1,032 | 1,041 | 1,058 | 1,063 | 1,055 | 1,037 | 1,022 | 1,017 |
| Above Normal | 974 | 978 | 992 | 1,019 | 1,028 | 1,048 | 1,062 | 1,062 | 1,046 | 1,021 | 1,005 | 1,003 |
| Below Normal | 997 | 998 | 1,004 | 1,019 | 1,034 | 1,046 | 1,053 | 1,049 | 1,031 | 1,006 | 987 | 986 |
| Dry | 972 | 974 | 982 | 992 | 1,012 | 1,032 | 1,041 | 1,038 | 1,020 | 997 | 984 | 982 |
| Critical Dry | 938 | 935 | 941 | 950 | 961 | 977 | 974 | 967 | 943 | 910 | 889 | 884 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -6 | -10 | -4 | -1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | -12 |
| Above Normal | -7 | -10 | -10 | -7 | -3 | -1 | -1 | 0 | 2 | 3 | 4 | -4 |
| Below Normal | -10 | -13 | -12 | -10 | -8 | -6 | -5 | -3 | 0 | 0 | 3 | 2 |
| Dry | -3 | -7 | -7 | -6 | -6 | -5 | -4 | -3 | -1 | -1 | -3 | -2 |
| Critical Dry | -13 | -14 | -14 | -12 | -11 | -10 | -9 | -8 | -5 | -11 | -15 | -14 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.6 | -1.0 | -0.4 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | -1.2 |
| Above Normal | -0.7 | -1.0 | -1.0 | -0.7 | -0.3 | -0.1 | -0.1 | 0.0 | 0.2 | 0.3 | 0.4 | -0.4 |
| Below Normal | -1.0 | -1.3 | -1.2 | -0.9 | -0.8 | -0.6 | -0.4 | -0.3 | 0.0 | 0.0 | 0.3 | 0.2 |
| Dry | -0.3 | -0.7 | -0.7 | -0.6 | -0.6 | -0.5 | -0.4 | -0.3 | -0.1 | -0.1 | -0.3 | -0.2 |
| Critical Dry | -1.4 | -1.5 | -1.4 | -1.3 | -1.1 | -1.0 | -0.9 | -0.9 | -0.5 | -1.2 | -1.7 | -1.6 |

The following changes in Shasta Lake storage and surface water elevation would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in October and December through August and reduced in November and September (up to 8.1 percent).
- In above normal years, storage would be similar in February through September and reduced in October through December (up to 7.5 percent).
- In below normal years, storage would be similar in March through September and reduced in October through February (up to 9.9 percent).
- In dry years, storage would be similar in January through October and reduced in November through December (up to 5.9 percent).
- In critical dry years, storage would be reduced in all months (up to 16.8 percent).
- In all months, in all water year types, surface water elevations are similar.

The following changes in Sacramento River flows would occur under Alternative 5 as compared to the Second Basis of Comparison, as shown on Figures 5.56 through 5.61.

- Sacramento River downstream of Keswick Dam (Figures 5.56 through 5.58).
  - Over long-term conditions, flows would be similar in July, August, October, and February through April; reduced in December, January, May and June (up to 8.2 percent); and increased in September and November (up to 38.5 percent).
  - In wet years, flows would be similar in January through July; reduced in December and August (up to 15.0 percent); and increased in September through November (up to 77.3 percent).
  - In dry years, similar flows would occur in July through October and December through March; reduced in April through June (up to 10.1 percent); and increased flows in November (32.1 percent).
- Sacramento River near Freeport (near the northern boundary of the Delta) (Figures 5.59 through 5.61).
  - Over long-term conditions, flows would be similar in October and December through April; reduced in May and June (up to 11.5 percent); and increased in July through September and November (43.4 percent).
  - In wet years, flows would be similar in October and January through June; reduced in December (6.2 percent); and increased in July through September and November (up to 89.0 percent).
  - In dry years, similar flows would occur in August through October and December through April; reduced in May and June (up to 13.6 percent); and increased flows in July and November (up to 19.3 percent).

*Lake Oroville and Feather River*

Storage levels and surface water elevations in Lake Oroville under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.100 and 5.101. Changes in flows in the Feather River downstream of Thermalito Complex are shown on Figures 5.62 through 5.64. The results are summarized following Table 5.101.

**Table 5.100 Changes in Lake Oroville Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,681 | 1,723 | 2,179 | 2,556 | 2,833 | 2,942 | 3,300 | 3,488 | 3,447 | 2,961 | 2,613 | 2,103 |
| Above Normal | 1,275 | 1,310 | 1,471 | 1,948 | 2,512 | 2,892 | 3,247 | 3,401 | 3,241 | 2,608 | 2,125 | 1,668 |
| Below Normal | 1,552 | 1,507 | 1,517 | 1,728 | 2,132 | 2,406 | 2,663 | 2,746 | 2,569 | 1,959 | 1,521 | 1,305 |
| Dry | 1,223 | 1,173 | 1,190 | 1,319 | 1,595 | 1,952 | 2,193 | 2,255 | 1,992 | 1,502 | 1,295 | 1,150 |
| Critical Dry | 1,102 | 1,037 | 1,025 | 1,114 | 1,229 | 1,383 | 1,415 | 1,411 | 1,266 | 1,045 | 929 | 873 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,936 | 1,984 | 2,354 | 2,636 | 2,871 | 2,942 | 3,300 | 3,477 | 3,402 | 2,976 | 2,728 | 2,569 |
| Above Normal | 1,465 | 1,523 | 1,702 | 2,173 | 2,648 | 2,937 | 3,271 | 3,357 | 3,081 | 2,493 | 2,087 | 1,827 |
| Below Normal | 1,823 | 1,783 | 1,831 | 2,037 | 2,361 | 2,627 | 2,875 | 2,836 | 2,461 | 1,930 | 1,637 | 1,424 |
| Dry | 1,371 | 1,324 | 1,344 | 1,473 | 1,764 | 2,120 | 2,363 | 2,357 | 2,031 | 1,688 | 1,427 | 1,261 |
| Critical Dry | 1,117 | 1,044 | 1,041 | 1,125 | 1,235 | 1,406 | 1,423 | 1,407 | 1,219 | 1,027 | 911 | 839 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -255 | -261 | -175 | -81 | -38 | 0 | 0 | 10 | 45 | -15 | -115 | -466 |
| Above Normal | -190 | -213 | -231 | -225 | -136 | -44 | -24 | 44 | 159 | 115 | 37 | -159 |
| Below Normal | -271 | -275 | -314 | -309 | -228 | -220 | -212 | -90 | 109 | 28 | -116 | -118 |
| Dry | -148 | -151 | -153 | -155 | -169 | -168 | -170 | -102 | -39 | -186 | -132 | -111 |
| Critical Dry | -15 | -7 | -17 | -11 | -7 | -23 | -8 | 4 | 47 | 19 | 18 | 34 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -13.1 | -13.1 | -7.4 | -3.1 | -1.3 | 0.0 | 0.0 | 0.3 | 1.3 | -0.5 | -4.2 | -18.1 |
| Above Normal | -13.0 | -14.0 | -13.6 | -10.4 | -5.1 | -1.5 | -0.7 | 1.3 | 5.2 | 4.6 | 1.8 | -8.7 |
| Below Normal | -14.9 | -15.4 | -17.1 | -15.1 | -9.7 | -8.4 | -7.4 | -3.2 | 4.4 | 1.5 | -7.1 | -8.3 |
| Dry | -10.8 | -11.4 | -11.4 | -10.5 | -9.6 | -7.9 | -7.2 | -4.3 | -1.9 | -11.0 | -9.2 | -8.8 |
| Critical Dry | -1.4 | -0.6 | -1.6 | -0.9 | -0.5 | -1.6 | -0.6 | 0.3 | 3.8 | 1.8 | 2.0 | 4.1 |

**Table 5.101 Changes in Lake Oroville Elevation under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 742 | 746 | 793 | 829 | 852 | 859 | 884 | 897 | 894 | 860 | 835 | 789 |
| Above Normal | 698 | 701 | 720 | 775 | 827 | 856 | 880 | 891 | 880 | 836 | 795 | 747 |
| Below Normal | 731 | 726 | 728 | 752 | 794 | 818 | 839 | 845 | 831 | 777 | 730 | 704 |
| Dry | 691 | 685 | 688 | 706 | 738 | 777 | 799 | 804 | 779 | 727 | 703 | 685 |
| Critical Dry | 676 | 668 | 665 | 679 | 694 | 712 | 716 | 715 | 696 | 667 | 650 | 642 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 768 | 773 | 810 | 837 | 854 | 859 | 884 | 896 | 891 | 861 | 844 | 831 |
| Above Normal | 717 | 723 | 745 | 796 | 838 | 859 | 882 | 888 | 869 | 826 | 790 | 763 |
| Below Normal | 757 | 752 | 757 | 779 | 812 | 834 | 854 | 852 | 823 | 775 | 743 | 719 |
| Dry | 706 | 701 | 705 | 721 | 755 | 791 | 814 | 813 | 784 | 748 | 718 | 698 |
| Critical Dry | 677 | 668 | 668 | 680 | 694 | 715 | 716 | 714 | 691 | 664 | 647 | 636 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -26 | -26 | -16 | -7 | -3 | 0 | 0 | 1 | 3 | -1 | -9 | -42 |
| Above Normal | -19 | -22 | -25 | -21 | -11 | -3 | -2 | 3 | 11 | 10 | 5 | -17 |
| Below Normal | -26 | -26 | -29 | -27 | -19 | -16 | -15 | -7 | 8 | 2 | -13 | -14 |
| Dry | -15 | -16 | -16 | -16 | -17 | -15 | -14 | -9 | -5 | -22 | -15 | -13 |
| Critical Dry | -1 | 0 | -2 | -1 | -1 | -3 | -1 | 1 | 5 | 4 | 3 | 6 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -3.3 | -3.4 | -2.0 | -0.9 | -0.3 | 0.0 | 0.0 | 0.1 | 0.3 | -0.1 | -1.0 | -5.1 |
| Above Normal | -2.7 | -3.1 | -3.4 | -2.7 | -1.3 | -0.4 | -0.2 | 0.3 | 1.3 | 1.2 | 0.6 | -2.2 |
| Below Normal | -3.4 | -3.4 | -3.8 | -3.4 | -2.3 | -1.9 | -1.8 | -0.8 | 1.0 | 0.3 | -1.8 | -2.0 |
| Dry | -2.1 | -2.2 | -2.3 | -2.2 | -2.2 | -1.9 | -1.7 | -1.2 | -0.7 | -2.9 | -2.2 | -1.9 |
| Critical Dry | -0.2 | 0.0 | -0.3 | -0.2 | -0.1 | -0.4 | -0.1 | 0.1 | 0.8 | 0.6 | 0.5 | 0.9 |

The following changes in Lake Oroville storage and surface water elevation would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in January through August and reduced in September through December (up to 18.1 percent).
- In above-normal years, storage would be similar in March through August and reduced in September through February (up to 14.0 percent).
- In below-normal years, storage would be similar in May through July and reduced in August through April (up to 17.1 percent).
- In dry years, storage would be similar in May and June and reduced in July through April (up to 11.4 percent).
- In critical dry years, storage would be similar in all months.
- Surface water elevations would be similar in all months, in all years.

The following changes in Feather River flows would occur under Alternative 5 as compared to the No Action Alternative, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in November and April; reduced flows in October, December through March, May, and June (up to 27.7 percent); and increased flows in July through September (up to 76.2 percent).
- In wet years, similar flows would occur in October, November, March through May; reduced flows in December through February and June (up to 25.6 percent); and increased flows in July through September (up to 181.9 percent).
- In dry years, similar flows would occur in November through April; reduced flows in October, May, June, August, and September (up to 45.4 percent); and increased flows in July (60.4 percent).

*Folsom Lake and American River*

Storage levels and surface water elevations in Folsom Lake under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.102 and 5.103. Changes in flows in the American River downstream of Nimbus Dam are shown on Figures 5.65 through 5.67. The results are summarized below following 5.103.

**Table 5.102 Changes in Folsom Lake Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 454 | 435 | 515 | 518 | 515 | 632 | 785 | 952 | 941 | 794 | 710 | 577 |
| Above Normal | 375 | 379 | 428 | 513 | 532 | 640 | 787 | 946 | 888 | 622 | 554 | 478 |
| Below Normal | 440 | 425 | 461 | 483 | 534 | 620 | 758 | 845 | 783 | 523 | 469 | 450 |
| Dry | 397 | 386 | 411 | 426 | 479 | 579 | 691 | 766 | 664 | 489 | 435 | 410 |
| Critical Dry | 325 | 304 | 314 | 320 | 367 | 433 | 483 | 499 | 411 | 324 | 257 | 231 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 483 | 470 | 522 | 524 | 515 | 632 | 785 | 951 | 937 | 793 | 688 | 646 |
| Above Normal | 390 | 412 | 467 | 537 | 538 | 640 | 787 | 946 | 857 | 591 | 522 | 485 |
| Below Normal | 506 | 489 | 502 | 514 | 541 | 626 | 761 | 847 | 739 | 475 | 408 | 387 |
| Dry | 405 | 399 | 423 | 437 | 486 | 585 | 698 | 769 | 664 | 486 | 432 | 408 |
| Critical Dry | 339 | 317 | 323 | 325 | 369 | 436 | 469 | 482 | 430 | 352 | 288 | 258 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -29 | -35 | -8 | -6 | 0 | 0 | 0 | 0 | 4 | 1 | 23 | -69 |
| Above Normal | -16 | -34 | -39 | -24 | -6 | 0 | 0 | 1 | 30 | 32 | 32 | -7 |
| Below Normal | -66 | -65 | -41 | -31 | -7 | -7 | -3 | -2 | 44 | 49 | 60 | 63 |
| Dry | -9 | -13 | -12 | -12 | -7 | -5 | -7 | -3 | 0 | 4 | 3 | 2 |
| Critical Dry | -14 | -12 | -9 | -5 | -2 | -3 | 14 | 17 | -19 | -28 | -31 | -27 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -6.0 | -7.4 | -1.5 | -1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.1 | -6.0 | -7.4 |
| Above Normal | -4.0 | -8.2 | -8.3 | -4.4 | -1.2 | 0.0 | 0.0 | 0.1 | 3.5 | 5.4 | -4.0 | -8.2 |
| Below Normal | -13.0 | -13.2 | -8.2 | -6.1 | -1.4 | -1.1 | -0.4 | -0.2 | 5.9 | 10.2 | -13.0 | -13.2 |
| Dry | -2.2 | -3.2 | -2.9 | -2.7 | -1.4 | -0.9 | -1.0 | -0.4 | 0.0 | 0.8 | -2.2 | -3.2 |
| Critical Dry | -4.1 | -3.8 | -2.8 | -1.5 | -0.6 | -0.7 | 3.0 | 3.5 | -4.5 | -8.0 | -4.1 | -3.8 |

**Table 5.103 Changes in Folsom Lake Elevation under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 409 | 407 | 418 | 418 | 418 | 432 | 448 | 465 | 464 | 449 | 440 | 425 |
| Above Normal | 394 | 395 | 405 | 418 | 420 | 433 | 449 | 464 | 458 | 431 | 423 | 413 |
| Below Normal | 406 | 405 | 410 | 413 | 420 | 431 | 445 | 454 | 447 | 417 | 411 | 408 |
| Dry | 400 | 400 | 404 | 406 | 413 | 426 | 438 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 386 | 384 | 389 | 390 | 396 | 406 | 412 | 414 | 400 | 385 | 370 | 365 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 412 | 412 | 419 | 419 | 418 | 432 | 448 | 465 | 464 | 449 | 438 | 433 |
| Above Normal | 397 | 400 | 410 | 421 | 421 | 433 | 448 | 465 | 456 | 427 | 419 | 414 |
| Below Normal | 415 | 414 | 416 | 417 | 421 | 432 | 446 | 455 | 443 | 410 | 401 | 398 |
| Dry | 401 | 401 | 405 | 407 | 414 | 427 | 439 | 446 | 435 | 413 | 406 | 403 |
| Critical Dry | 389 | 386 | 390 | 391 | 397 | 406 | 410 | 411 | 404 | 391 | 378 | 372 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -4 | -5 | -1 | -1 | 0 | 0 | 0 | -1 | 0 | 0 | 3 | -8 |
| Above Normal | -3 | -6 | -5 | -3 | -1 | 0 | 0 | -1 | 3 | 4 | 4 | -1 |
| Below Normal | -9 | -9 | -6 | -4 | -1 | -1 | 0 | -1 | 5 | 7 | 10 | 10 |
| Dry | -1 | -1 | -1 | -2 | -1 | -1 | -1 | -1 | 0 | 0 | 0 | 0 |
| Critical Dry | -3 | -3 | -2 | -1 | 0 | 0 | 2 | 2 | -3 | -6 | -8 | -7 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -0.8 | -1.1 | -0.2 | -0.2 | 0.0 | 0.0 | 0.0 | -0.2 | -0.1 | 0.0 | 0.6 | -1.9 |
| Above Normal | -0.7 | -1.4 | -1.3 | -0.7 | -0.2 | 0.0 | 0.0 | -0.1 | 0.6 | 0.9 | 0.9 | -0.2 |
| Below Normal | -2.3 | -2.2 | -1.4 | -1.0 | -0.2 | -0.2 | -0.1 | -0.2 | 1.0 | 1.8 | 2.4 | 2.5 |
| Dry | -0.2 | -0.4 | -0.4 | -0.4 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | 0.0 | -0.1 | -0.1 |
| Critical Dry | -0.7 | -0.7 | -0.4 | -0.2 | 0.0 | -0.1 | 0.4 | 0.5 | -0.8 | -1.6 | -2.0 | -1.8 |

The following changes in Folsom Lake storage and surface water elevation would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, storage would be similar in December through July and reduced in August through November (up to 7.4 percent).
- In above normal years, storage would be similar in January through June, August, and October; reduced in September, November, and December (up to 8.3 percent); and increased in July (5.4 percent).
- In below normal years, storage would be similar in February through May; reduced in August through January (up to 13.2 percent); and increased in June and July (up to 10.2 percent).
- In dry years, storage would be similar in all months.
- In critical dry years, storage would be similar in August and June and reduced in July (8.0 percent).
- Surface water elevations would be similar in all months, in all years.

The following changes in American River flows would occur under Alternative 5 as compared to the Second Basis of Comparison, as shown on Figures 5.62 through 5.64.

- Over long-term conditions, similar flows would occur in November through July; reduced flows in August (5.8 percent) and increased in September and October (42.4 percent).
- In wet years, similar flows would occur in October, November, and January through July; reduced flows in December and August (up to 13.7 percent); and increased flows in September (88.2 percent).
- In dry years, similar flows would occur in November through September and increased flows in October (16.7 percent).

*Clear Creek*

Changes in flows in Clear Creek downstream of Whiskeytown Dam are summarized in Table 5.104.

Monthly Clear Creek flows under Alternative 5 as compared to the Second Basis of Comparison are identical except in May. In May, under Alternative 5, flows are up to 40.7 percent higher than under the Second Basis of Comparison.

**Table 5.104 Changes in Clear Creek Flows below Whiskeytown Dam under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 277 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 277 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 274 | 191 | 85 | 85 | 150 |
| Dry | 177 | 184 | 188 | 190 | 190 | 190 | 190 | 267 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 214 | 111 | 85 | 85 | 133 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 200 | 200 | 200 | 309 | 356 | 272 | 200 | 200 | 200 | 85 | 85 | 150 |
| Above Normal | 181 | 182 | 188 | 192 | 196 | 196 | 196 | 200 | 200 | 85 | 85 | 150 |
| Below Normal | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 191 | 85 | 85 | 150 |
| Dry | 178 | 184 | 188 | 190 | 190 | 190 | 190 | 190 | 183 | 85 | 85 | 150 |
| Critical Dry | 163 | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 111 | 85 | 85 | 133 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 0 | 0 | 0 | 0 |
| Dry | **-1** | 0 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 0 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.3 | 0.0 | 0.0 | 0.1 | 0.0 |

### *New Melones Reservoir and Stanislaus River*

Storage levels and surface water elevations in New Melones Reservoir under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.105 and 5.106. Changes in flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 through 5.70. The results are summarized following Table 5.106.

**Table 5.105 Changes in New Melones Reservoir Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 1,309 | 1,321 | 1,388 | 1,496 | 1,602 | 1,668 | 1,704 | 1,812 | 1,906 | 1,833 | 1,722 | 1,653 |
| Above Normal | 983 | 1,014 | 1,079 | 1,168 | 1,271 | 1,361 | 1,363 | 1,413 | 1,396 | 1,302 | 1,207 | 1,162 |
| Below Normal | 1,210 | 1,220 | 1,242 | 1,267 | 1,329 | 1,354 | 1,298 | 1,276 | 1,254 | 1,163 | 1,071 | 1,028 |
| Dry | 1,018 | 1,018 | 1,030 | 1,045 | 1,081 | 1,114 | 1,066 | 1,031 | 990 | 903 | 823 | 781 |
| Critical Dry | 558 | 559 | 570 | 578 | 597 | 591 | 506 | 449 | 433 | 391 | 355 | 336 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 1,443 | 1,446 | 1,502 | 1,606 | 1,709 | 1,794 | 1,833 | 1,962 | 1,994 | 1,917 | 1,803 | 1,731 |
| Above Normal | 1,092 | 1,116 | 1,175 | 1,261 | 1,360 | 1,455 | 1,481 | 1,543 | 1,516 | 1,419 | 1,321 | 1,274 |
| Below Normal | 1,364 | 1,366 | 1,378 | 1,397 | 1,453 | 1,479 | 1,461 | 1,447 | 1,415 | 1,322 | 1,228 | 1,183 |
| Dry | 1,149 | 1,143 | 1,149 | 1,161 | 1,191 | 1,221 | 1,210 | 1,176 | 1,131 | 1,039 | 956 | 912 |
| Critical Dry | 667 | 663 | 674 | 680 | 696 | 690 | 646 | 585 | 557 | 498 | 449 | 426 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -134 | -125 | -114 | -110 | -108 | -126 | -129 | -149 | -88 | -84 | -81 | -77 |
| Above Normal | -108 | -102 | -96 | -92 | -89 | -94 | -118 | -130 | -120 | -117 | -114 | -112 |
| Below Normal | -154 | -145 | -137 | -130 | -124 | -125 | -164 | -170 | -161 | -159 | -157 | -155 |
| Dry | -132 | -125 | -119 | -116 | -110 | -107 | -144 | -145 | -141 | -136 | -133 | -131 |
| Critical Dry | -109 | -104 | -104 | -102 | -99 | -99 | -140 | -136 | -123 | -107 | -95 | -90 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -9.3 | -8.6 | -7.6 | -6.8 | -6.3 | -7.0 | -7.0 | -7.6 | -4.4 | -4.4 | -4.5 | -4.5 |
| Above Normal | -9.9 | -9.1 | -8.1 | -7.3 | -6.5 | -6.5 | -8.0 | -8.4 | -7.9 | -8.2 | -8.7 | -8.8 |
| Below Normal | -11.3 | -10.6 | -9.9 | -9.3 | -8.5 | -8.5 | -11.2 | -11.8 | -11.4 | -12.0 | -12.8 | -13.1 |
| Dry | -11.5 | -11.0 | -10.4 | -10.0 | -9.3 | -8.7 | -11.9 | -12.3 | -12.5 | -13.1 | -13.9 | -14.3 |
| Critical Dry | -16.4 | -15.7 | -15.5 | -15.0 | -14.2 | -14.4 | -21.7 | -23.2 | -22.2 | -21.5 | -21.1 | -21.2 |

**Table 5.106 Changes in New Melones Reservoir Elevation under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 969 | 971 | 980 | 995 | 1,007 | 1,016 | 1,020 | 1,031 | 1,040 | 1,033 | 1,022 | 1,015 |
| Above Normal | 924 | 930 | 939 | 954 | 968 | 980 | 982 | 988 | 987 | 975 | 963 | 890 |
| Below Normal | 954 | 956 | 959 | 962 | 973 | 977 | 972 | 970 | 968 | 957 | 944 | 938 |
| Dry | 930 | 930 | 932 | 934 | 939 | 945 | 940 | 936 | 931 | 918 | 905 | 898 |
| Critical Dry | 837 | 838 | 842 | 845 | 853 | 855 | 834 | 818 | 815 | 804 | 796 | 791 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 989 | 990 | 997 | 1,009 | 1,021 | 1,030 | 1,034 | 1,047 | 1,050 | 1,043 | 1,032 | 1,025 |
| Above Normal | 941 | 944 | 951 | 966 | 979 | 992 | 995 | 1,003 | 1,001 | 990 | 978 | 901 |
| Below Normal | 977 | 977 | 979 | 982 | 991 | 994 | 994 | 993 | 991 | 980 | 968 | 962 |
| Dry | 951 | 950 | 950 | 953 | 957 | 962 | 963 | 960 | 954 | 941 | 929 | 922 |
| Critical Dry | 866 | 866 | 870 | 872 | 878 | 879 | 871 | 856 | 850 | 835 | 823 | 817 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -20 | -19 | -17 | -15 | -14 | -15 | -15 | -16 | -10 | -10 | -10 | -9 |
| Above Normal | -17 | -14 | -12 | -12 | -12 | -11 | -14 | -15 | -14 | -15 | -15 | -11 |
| Below Normal | -23 | -22 | -20 | -20 | -18 | -18 | -22 | -23 | -22 | -23 | -24 | -24 |
| Dry | -21 | -20 | -19 | -19 | -18 | -17 | -23 | -24 | -23 | -24 | -24 | -25 |
| Critical Dry | -29 | -28 | -29 | -27 | -25 | -24 | -37 | -38 | -35 | -31 | -27 | -27 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -2.1 | -1.9 | -1.7 | -1.4 | -1.4 | -1.4 | -1.4 | -1.5 | -0.9 | -0.9 | -0.9 | -0.9 |
| Above Normal | -1.8 | -1.5 | -1.3 | -1.3 | -1.2 | -1.2 | -1.4 | -1.5 | -1.4 | -1.5 | -1.5 | -1.2 |
| Below Normal | -2.3 | -2.2 | -2.1 | -2.0 | -1.8 | -1.8 | -2.2 | -2.3 | -2.3 | -2.4 | -2.5 | -2.5 |
| Dry | -2.2 | -2.1 | -2.0 | -2.0 | -1.8 | -1.8 | -2.4 | -2.5 | -2.5 | -2.5 | -2.6 | -2.7 |
| Critical Dry | -3.4 | -3.2 | -3.3 | -3.1 | -2.9 | -2.7 | -4.2 | -4.5 | -4.1 | -3.7 | -3.3 | -3.3 |

The following changes in New Melones Reservoir storage would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, storage would be reduced in all months (up to 9.3 percent).
- In above-normal years, storage would be reduced in all months (up to 9.9 percent).
- In below-normal years, storage would be reduced in all months (up to 13.1 percent).
- In dry years, storage would be reduced in all months (up to 14.3 percent).

- In critical dry years, storage would be reduced in all months (up to 23.2 percent).
- Surface water elevations would be similar in all months, in all water year types.

Flows in the Stanislaus River downstream of Goodwin Dam are shown on Figures 5.68 to 5.70. Changes in flows in the river are summarized below.

- Over long-term conditions, similar flows would occur in August; reduced flows would occur in November through February, June, July, August, and September (up to 35.8 percent) and increased flows in October and March through May (up to 144.8 percent).
- In wet years, similar flows would occur in February and April; reduced flows in November through January and June through September (up to 52.8 percent) and increased flows in October and March (up to 113.1 percent).
- In dry years, similar flows would occur in July through September; reduced flows in November through March and June (up to 35.7 percent); and increased flows in October, April, and May (150.1 percent).

*San Joaquin River at Vernalis*

Flows in the San Joaquin River at Vernalis under Alternative 5 as compared to the Second Basis of Comparison are summarized below, as shown on Figures 5.71 through 5.73.

- Over long-term conditions, similar flows would occur in November through March, May, and July through September; reduced flows in June (8.2 percent); and increased flows in October and April (18.7 percent).
- In wet years, similar flows would occur in November through May and July through September; reduced flows in June (9.8 percent); and increased flows in October (16.2 percent).
- In dry years, similar flows would occur in November through March and June through September and increased flows in October, April, and May (up to 24.5 percent).

*San Luis Reservoir*

Storage levels and surface water elevations in San Luis Reservoir under Alternative 5 as compared to the Second Basis of Comparison are summarized in Tables 5.107 and 5.108. The results are summarized following Table 5.108.

**Table 5.107 Changes in San Luis Reservoir Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Storage (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 576 | 706 | 958 | 1,251 | 1,539 | 1,804 | 1,624 | 1,279 | 984 | 787 | 680 | 726 |
| Above Normal | 488 | 622 | 932 | 1,213 | 1,440 | 1,660 | 1,447 | 1,046 | 672 | 477 | 442 | 520 |
| Below Normal | 541 | 628 | 923 | 1,157 | 1,335 | 1,496 | 1,305 | 928 | 524 | 476 | 414 | 463 |
| Dry | 464 | 572 | 856 | 1,139 | 1,327 | 1,481 | 1,324 | 1,002 | 691 | 655 | 412 | 418 |
| Critical Dry | 429 | 505 | 698 | 994 | 1,166 | 1,216 | 1,103 | 875 | 600 | 428 | 284 | 270 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 790 | 1,017 | 1,365 | 1,748 | 1,965 | 2,033 | 2,031 | 1,852 | 1,487 | 1,167 | 889 | 925 |
| Above Normal | 658 | 883 | 1,213 | 1,671 | 1,913 | 2,001 | 1,995 | 1,717 | 1,263 | 861 | 612 | 631 |
| Below Normal | 854 | 1,064 | 1,334 | 1,742 | 1,908 | 1,980 | 1,908 | 1,628 | 1,251 | 964 | 635 | 591 |
| Dry | 617 | 764 | 998 | 1,427 | 1,728 | 1,925 | 1,870 | 1,665 | 1,341 | 1,007 | 660 | 596 |
| Critical Dry | 622 | 709 | 910 | 1,257 | 1,556 | 1,664 | 1,623 | 1,451 | 1,168 | 808 | 545 | 472 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -214 | -311 | -407 | -498 | -426 | -229 | -408 | -573 | -503 | -380 | -210 | -199 |
| Above Normal | -170 | -261 | -281 | -458 | -473 | -342 | -548 | -671 | -591 | -385 | -170 | -111 |
| Below Normal | -313 | -435 | -411 | -584 | -572 | -483 | -603 | -699 | -727 | -489 | -221 | -128 |
| Dry | -153 | -192 | -141 | -289 | -402 | -444 | -546 | -663 | -650 | -352 | -249 | -178 |
| Critical Dry | -193 | -204 | -212 | -263 | -390 | -448 | -520 | -577 | -569 | -379 | -261 | -202 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -32.8 | -41.2 | -42.7 | -38.1 | -27.8 | -14.4 | -24.5 | -40.8 | -48.9 | -42.3 | -28.2 | -22.9 |
| Above Normal | -27.2 | -40.4 | -32.7 | -35.5 | -29.5 | -19.7 | -30.2 | -47.2 | -59.3 | -51.4 | -33.4 | -15.2 |
| Below Normal | -43.5 | -53.6 | -42.3 | -43.4 | -37.9 | -29.3 | -36.5 | -51.0 | -70.0 | -61.5 | -40.1 | -27.4 |
| Dry | -23.0 | -26.7 | -12.8 | -23.4 | -27.7 | -26.2 | -31.9 | -44.1 | -51.4 | -30.7 | -35.2 | -26.2 |
| Critical Dry | -37.0 | -38.2 | -28.3 | -24.7 | -30.5 | -30.8 | -33.8 | -39.5 | -46.3 | -41.0 | -43.7 | -30.8 |

**Table 5.108 Changes in San Luis Elevation Storage under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | End of Month Elevation (Feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 402 | 417 | 446 | 475 | 501 | 525 | 509 | 478 | 448 | 427 | 416 | 422 |
| Above Normal | 391 | 408 | 443 | 471 | 492 | 512 | 494 | 456 | 416 | 390 | 386 | 398 |
| Below Normal | 399 | 411 | 443 | 467 | 483 | 498 | 481 | 444 | 397 | 390 | 381 | 388 |
| Dry | 389 | 404 | 436 | 465 | 483 | 497 | 482 | 451 | 417 | 413 | 381 | 381 |
| Critical Dry | 383 | 393 | 417 | 450 | 467 | 471 | 460 | 437 | 405 | 383 | 359 | 357 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 426 | 451 | 485 | 520 | 538 | 543 | 543 | 529 | 497 | 468 | 440 | 443 |
| Above Normal | 412 | 437 | 470 | 513 | 534 | 541 | 540 | 518 | 477 | 437 | 409 | 411 |
| Below Normal | 435 | 457 | 483 | 519 | 533 | 539 | 533 | 510 | 476 | 448 | 412 | 406 |
| Dry | 407 | 425 | 450 | 492 | 518 | 535 | 530 | 513 | 484 | 453 | 415 | 406 |
| Critical Dry | 409 | 419 | 441 | 475 | 502 | 512 | 509 | 494 | 468 | 432 | 400 | 389 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -24 | -34 | -40 | -45 | -36 | -19 | -34 | -51 | -49 | -41 | -24 | -22 |
| Above Normal | -21 | -29 | -28 | -42 | -41 | -29 | -47 | -62 | -61 | -47 | -23 | -13 |
| Below Normal | -36 | -46 | -40 | -53 | -50 | -41 | -53 | -66 | -80 | -58 | -31 | -17 |
| Dry | -18 | -21 | -14 | -26 | -35 | -38 | -48 | -62 | -68 | -39 | -34 | -25 |
| Critical Dry | -26 | -26 | -24 | -26 | -36 | -41 | -49 | -57 | -63 | -48 | -42 | -33 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -5.6 | -7.6 | -8.2 | -8.6 | -6.8 | -3.5 | -6.3 | -9.6 | -9.9 | -8.7 | -5.5 | -4.9 |
| Above Normal | -5.2 | -6.6 | -5.9 | -8.2 | -7.7 | -5.3 | -8.6 | -11.9 | -12.9 | -10.7 | -5.5 | -3.1 |
| Below Normal | -8.2 | -10.1 | -8.3 | -10.1 | -9.4 | -7.6 | -9.9 | -12.9 | -16.7 | -13.0 | -7.6 | -4.3 |
| Dry | -4.5 | -4.9 | -3.0 | -5.3 | -6.8 | -7.1 | -9.0 | -12.0 | -13.9 | -8.7 | -8.1 | -6.2 |
| Critical Dry | -6.4 | -6.2 | -5.4 | -5.4 | -7.1 | -8.0 | -9.5 | -11.6 | -13.5 | -11.2 | -10.4 | -8.5 |

The following changes in San Luis Reservoir storage and surface water elevations would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, storage would be reduced in all months (up to 48.9 percent). Surface water elevations would be similar in September and March and reduced in October through February and April through August (up to 9.9 percent).
- In above-normal years, storage would be reduced in all months (up to 59.3 percent). Surface water elevations would be similar in September and reduced in October through August (up to 12.9 percent).
- In below-normal years, storage would be reduced in all months (up to 70.0 percent). Surface water elevations would be similar in September and reduced in October through August (up to 16.7 percent).
- In dry years, storage would be reduced in all months (up to 51.4 percent). Surface water elevations would be similar in October through December and reduced in January through September (up to 13.9 percent).
- In critical dry years, storage would be reduced in all months (46.3 percent). Surface water elevations would be reduced in all months (up to 13.5 percent).

*Changes in Flows into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 5 as compared to the Second Basis of Comparison are summarized in Table 5.109. The results are summarized following Table 5.109.

**Table 5.109 Changes in Flows into the Yolo Bypass at Fremont Weir under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | Average Monthly Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 170 | 933 | 8,400 | 24,048 | 29,507 | 18,512 | 5,627 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,786 | 6,000 | 12,885 | 7,895 | 1,688 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 242 | 1,004 | 3,115 | 886 | 293 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 317 | 896 | 2,015 | 1,398 | 407 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 151 | 525 | 531 | 393 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 147 | 996 | 9,888 | 25,442 | 30,547 | 18,997 | 5,602 | 289 | 113 | 0 | 0 | 100 |
| Above Normal | 100 | 100 | 2,659 | 6,349 | 15,114 | 8,566 | 1,765 | 100 | 100 | 0 | 0 | 100 |
| Below Normal | 100 | 100 | 262 | 1,256 | 4,057 | 1,166 | 292 | 100 | 100 | 0 | 0 | 100 |
| Dry | 100 | 100 | 342 | 932 | 2,032 | 1,411 | 411 | 100 | 100 | 0 | 0 | 100 |
| Critical Dry | 100 | 100 | 149 | 542 | 533 | 408 | 106 | 100 | 100 | 0 | 0 | 100 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 23 | -63 | -1,488 | -1,394 | -1,040 | -486 | 25 | 0 | 0 | 0 | 0 | 0 |
| Above Normal | 0 | 0 | 128 | -349 | -2,230 | -671 | -77 | 0 | 0 | 0 | 0 | 0 |
| Below Normal | 0 | 0 | -20 | -252 | -942 | -280 | 1 | 0 | 0 | 0 | 0 | 0 |
| Dry | 0 | 0 | -25 | -36 | -17 | -13 | -4 | 0 | 0 | 0 | 0 | 0 |
| Critical Dry | 0 | 0 | 2 | -17 | -2 | -15 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | 15.8 | -6.3 | -15.0 | -5.5 | -3.4 | -2.6 | 0.4 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 |
| Above Normal | 0.0 | 0.0 | 4.8 | -5.5 | -14.8 | -7.8 | -4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Below Normal | 0.0 | 0.0 | -7.7 | -20.1 | -23.2 | -24.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dry | 0.0 | 0.0 | -7.4 | -3.9 | -0.8 | -0.9 | -0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Critical Dry | 0.0 | 0.0 | 1.0 | -3.2 | -0.4 | -3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The following changes in flows from the Sacramento River into the Yolo Bypass at Fremont Weir would occur under Alternative 5 as compared to the Second Basis of Comparison.

- In wet years, flows would be similar in February through September; reduced flows in November through January (up to 15.0 percent); and increased in October (15.8 percent).
- In above-normal years, flows would be similar in April through December and reduced flows in January through March (up to 14.8 percent).
- In below-normal years, flows would be similar in April through November and reduced flows in December through March (up to 24.0 percent).
- In dry years, flows would be similar in January through November and reduced flows in December (up to 7.4 percent).
- In critical dry years, flows would be similar in all months.

*Changes in Delta Conditions*

Delta outflow under Alternative 5 as compared to the Second Basis of Comparison are summarized below and shown on Figures 5.74 through 5.76.

- In wet years, average monthly Delta outflow would be increased in July through November, January, and April and May (up to 13,666 cfs) and reduced in December, February, March, and June (up to 1,713 cfs).
- In dry years, average monthly Delta outflow would be increased in July through May (up to 3,384 cfs) and reduced in June (526 cfs).

*Changes in OMR Flows*

The OMR conditions under Alternative 5 as compared to the Second Basis of Comparison are shown on Figures 5.77 through 5.79.

- Under Alternative 5, OMR flows would be negative except in April and May of all water year types. Under the Second Basis of Comparison, OMR flows would be negative in all months.
- In wet years, OMR flows would be more positive in September through February, April and May (up to 10,017 cfs) and more negative in March and June through August (up to 964 cfs).
- In dry years, OMR flows would be more positive in September through June (up to 4,724 cfs) and more negative in July and August (up to 2,620 cfs).

*Changes in CVP and SWP Exports and Deliveries*

Delta exports under Alternative 5 as compared to the Second Basis of Comparison are summarized in Table 5.110.

**Table 5.110 Changes in Exports at Jones and Banks Pumping Plants under Alternative 5 as Compared to the Second Basis of Comparison**

| Water Year | Monthly Volume (TAF) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Alternative 5** | | | | | | | | | | | | |
| Wet | 408 | 505 | 564 | 514 | 532 | 592 | 202 | 202 | 444 | 667 | 718 | 627 |
| Above Normal | 376 | 423 | 561 | 407 | 405 | 496 | 127 | 92 | 315 | 590 | 705 | 625 |
| Below Normal | 381 | 456 | 588 | 387 | 359 | 397 | 103 | 55 | 208 | 663 | 632 | 561 |
| Dry | 370 | 394 | 513 | 392 | 315 | 318 | 80 | 41 | 205 | 577 | 333 | 433 |
| Critical Dry | 313 | 293 | 382 | 355 | 249 | 179 | 34 | 20 | 69 | 239 | 222 | 243 |
| **Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | 549 | 619 | 716 | 724 | 609 | 543 | 476 | 430 | 456 | 632 | 655 | 660 |
| Above Normal | 428 | 521 | 641 | 716 | 584 | 570 | 453 | 363 | 415 | 572 | 647 | 651 |
| Below Normal | 548 | 595 | 623 | 674 | 497 | 500 | 337 | 304 | 414 | 629 | 517 | 539 |
| Dry | 435 | 475 | 546 | 579 | 518 | 493 | 259 | 228 | 274 | 403 | 325 | 438 |
| Critical Dry | 340 | 345 | 455 | 433 | 406 | 266 | 134 | 121 | 132 | 139 | 203 | 249 |
| **Alternative 5 as Compared to Second Basis of Comparison** | | | | | | | | | | | | |
| Wet | -141 | -115 | -152 | -210 | -77 | 49 | -274 | -228 | -11 | 35 | 63 | -33 |
| Above Normal | -51 | -99 | -79 | -310 | -179 | -74 | -326 | -271 | -100 | 17 | 58 | -26 |
| Below Normal | -167 | -139 | -35 | -288 | -138 | -102 | -234 | -249 | -205 | 34 | 115 | 22 |
| Dry | -65 | -81 | -33 | -187 | -203 | -175 | -178 | -186 | -69 | 174 | 8 | -5 |
| Critical Dry | -27 | -52 | -73 | -77 | -157 | -88 | -100 | -100 | -63 | 101 | 19 | -6 |
| **Alternative 5 as Compared to Second Basis of Comparison (percent change)** | | | | | | | | | | | | |
| Wet | -25.7 | -18.5 | -21.2 | -29.1 | -12.6 | 9.0 | -57.6 | -53.1 | -2.5 | 5.6 | 9.6 | -5.0 |
| Above Normal | -12.0 | -18.9 | -12.3 | -43.2 | -30.7 | -12.9 | -72.0 | -74.7 | -24.2 | 3.0 | 8.9 | -4.0 |
| Below Normal | -30.5 | -23.4 | -5.6 | -42.6 | -27.7 | -20.5 | -69.5 | -82.0 | -49.7 | 5.4 | 22.3 | 4.0 |
| Dry | -14.9 | -17.1 | -6.0 | -32.3 | -39.2 | -35.5 | -68.9 | -81.8 | -25.3 | 43.2 | 2.4 | -1.0 |
| Critical Dry | -7.9 | -15.1 | -16.0 | -17.9 | -38.6 | -32.9 | -74.9 | -83.2 | -47.7 | 72.3 | 9.6 | -2.5 |

The following changes would occur in CVP and SWP exports under Alternative 5 as compared to the Second Basis of Comparison.

- Long-term average annual exports would be 1,096 TAF (19 percent) less under Alternative 5 as compared to the Second Basis of Comparison.
- In wet years, total exports would be similar in June and September; increased exports in March, July, and August (up to 9.6 percent); and reduced in October through February, April, and May (up to 57.6 percent).
- In above-normal years, total exports would be similar in July and September; increased exports in August (8.9 percent); and reduced in October through June (up to 74.7 percent).
- In below-normal years, total exports would be similar in September; increased exports in July and August (up to 22.3 percent); and reduced in October through June (up to 82.0 percent).
- In dry years, total exports would be similar in August and September; increased in July (43.2 percent); and reduced exports in October through June (up to 81.8 percent).
- In critical dry years, total exports would be similar in September; increased in July and August (up to 72.3 percent); and reduced exports in October through June (up to 83.2 percent).

Deliveries to CVP and SWP water users would decline under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Tables 5.111 and 5.112, respectively, due to reduced water supply availability and export limitations.

**Table 5.111 Changes CVP Water Deliveries under Alternative 5 as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the Second Basis of Comparison | |
| | | Alternative 5 | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| CVP Agricultural Water Service Contractors | Long Term | 185 | 219 | -34 | -16 |
| | Dry | 85 | 122 | -37 | -30 |
| | Critical Dry | 24 | 35 | -11 | -31 |
| CVP M&I (Including American River Contractors and Contra Costa Water District) | Long Term | 386 | 392 | -6 | -2 |
| | Dry | 384 | 390 | -6 | -2 |
| | Critical Dry | 384 | 383 | 1 | 0 |
| CVP M&I American River Contractors | Long Term | 112 | 120 | -7 | -6 |
| | Dry | 96 | 105 | -9 | -9 |
| | Critical Dry | 74 | 79 | -6 | -8 |
| CVP Sacramento River Settlement Contractors | Long Term | 1,861 | 1,858 | 3 | 0 |
| | Dry | 1,906 | 1,905 | 1 | 0 |
| | Critical Dry | 1,747 | 1,732 | 15 | 1 |
| CVP Refuge Level 2 Deliveries | Long Term | 146 | 155 | -8 | -5 |
| | Dry | 145 | 151 | -6 | -4 |
| | Critical Dry | 103 | 105 | -2 | -2 |
| Total CVP Agricultural, M&I, Sacramento River Settlement Contractors, and Refuge Level 2 Deliveries | Long Term | 2,578 | 2,624 | -46 | -2 |
| | Dry | 2,520 | 2,568 | -48 | -2 |
| | Critical Dry | 2,258 | 2,255 | 3 | 0 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the Second Basis of Comparison | |
| | | Alternative 5 | Second Basis of Comparison | Difference | Percent Change |
| **South of Delta (Does not include Eastside Contractors)** | | | | | |
| CVP Agricultural Users Water Service Contractors | Long Term | 834 | 1,100 | -266 | -24 |
| | Dry | 433 | 650 | -217 | -33 |
| | Critical Dry | 130 | 195 | -65 | -33 |
| CVP M&I Users | Long Term | 112 | 125 | -13 | -10 |
| | Dry | 100 | 109 | -9 | -8 |
| | Critical Dry | 80 | 85 | -5 | -6 |
| San Joaquin River Exchange Contractors | Long Term | 852 | 852 | 0 | 0 |
| | Dry | 875 | 875 | 0 | 0 |
| | Critical Dry | 741 | 741 | 0 | 0 |
| CVP Refuge Level 2 Deliveries | Long Term | 273 | 272 | 0 | 0 |
| | Dry | 281 | 280 | 1 | 0 |
| | Critical Dry | 232 | 232 | 0 | 0 |
| Total CVP Agricultural, M&I, San Joaquin River Exchange Contractors, and Refuge Level 2 Deliveries | Long Term | 2,071 | 2,349 | -278 | -12 |
| | Dry | 1,689 | 1,914 | -225 | -12 |
| | Critical Dry | 1,183 | 1,253 | -70 | -6 |
| **Eastside Contractors Deliveries** | | | | | |
| Water Rights | Long Term | 502 | 514 | -12 | -2 |
| | Dry | 524 | 524 | 0 | 0 |
| | Critical Dry | 406 | 486 | -80 | -16 |
| CVP Water Service Contracts | Long Term | 100 | 118 | -19 | -16 |
| | Dry | 69 | 98 | -29 | -30 |
| | Critical Dry | 8 | 25 | -17 | -68 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the Second Basis of Comparison | |
| | | Alternative 5 | Second Basis of Comparison | Difference | Percent Change |
| Total Water Rights and CVP Service Contracts Deliveries | Long Term | 602 | 632 | -30 | -5 |
| | Dry | 593 | 622 | -29 | -5 |
| | Critical Dry | 414 | 511 | -97 | -19 |

The following changes in CVP water deliveries would occur under Alternative 5 as compared to the Second Basis of Comparison.

- Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 16 percent over the long-term conditions, 30 percent in dry years, and 31 percent in critical dry years.
- Deliveries to CVP North of Delta M&I contractors would be similar in long-term conditions and dry and critical dry years; however, American River Contractors would be reduced by 6 percent over the long-term conditions, 9 percent in dry years, and 8 percent in critical dry years.
- Deliveries to CVP South of Delta agricultural water service contractors would be reduced by 24 percent over the long-term conditions, 33 percent in dry years, and 33 percent in critical dry years.
- Deliveries to CVP South of Delta M&I contractors would be reduced by 10 percent in long-term conditions, 8 percent in dry years, and 6 percent in critical dry years.
- Deliveries to the Eastside contractors would be reduced by 5 percent under long-term conditions and dry years and 19 percent in critical dry years.

**Table 5.112 Changes SWP Water Deliveries under Alternative 5 as Compared to the Second Basis of Comparison**

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | | | Alternative 5 as compared to the Second Basis of Comparison | |
| | | Alternative 5 | Second Basis of Comparison | Difference | Percent Change |
| **North of Delta** | | | | | |
| SWP Agricultural Uses | Long Term | 0 | 0 | 0 | 0 |
| | Dry | 0 | 0 | 0 | 0 |
| | Critical Dry | 0 | 0 | 0 | 0 |
| SWP M&I (without Article 21) | Long Term | 67 | 83 | -16 | -19 |
| | Dry | 51 | 62 | -11 | -18 |
| | Critical Dry | 42 | 53 | -11 | -21 |
| SWP M&I Article 21 Deliveries | Long Term | 13 | 12 | 1 | 13 |
| | Dry | 14 | 13 | 1 | 11 |
| | Critical Dry | 13 | 12 | 1 | 15 |
| Total SWP Agricultural and M&I (without Article 21) | Long Term | 67 | 83 | -16 | -19 |
| | Dry | 51 | 62 | -11 | -18 |
| | Critical Dry | 42 | 53 | -11 | -21 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 13 | 12 | 1 | 13 |
| | Dry | 14 | 13 | 1 | 11 |
| | Critical Dry | 13 | 12 | 1 | 15 |
| **South of Delta** | | | | | |
| SWP Agricultural Users (without Article 21) | Long Term | 598 | 750 | -152 | -20 |
| | Dry | 449 | 567 | -118 | -21 |
| | Critical Dry | 369 | 484 | -115 | -24 |

| Annual Average Deliveries (TAF) | | | | | |
|---|---|---|---|---|---|
| | | Alternative 5 | Second Basis of Comparison | Alternative 5 as compared to the Second Basis of Comparison | |
| | | | | Difference | Percent Change |
| SWP Agricultural Article 21 Deliveries | Long Term | 24 | 178 | -154 | -86 |
| | Dry | 6 | 143 | -137 | -96 |
| | Critical Dry | 4 | 100 | -96 | -96 |
| SWP M&I Users (without Article 21) | Long Term | 1,784 | 2,183 | -399 | -18 |
| | Dry | 1,397 | 1,732 | -335 | -19 |
| | Critical Dry | 1,157 | 1,494 | -337 | -23 |
| SWP M&I Article 21 Deliveries | Long Term | 19 | 104 | -83 | -82 |
| | Dry | 5 | 86 | -82 | -95 |
| | Critical Dry | 3 | 58 | -55 | -95 |
| Total SWP Agricultural and M&I Users (without Article 21) | Long Term | 2,383 | 2,933 | -550 | -19 |
| | Dry | 1,845 | 2,299 | -454 | -20 |
| | Critical Dry | 1,526 | 1,978 | -452 | -23 |
| Total SWP Agricultural and M&I Article 21 Deliveries | Long Term | 43 | 282 | -239 | -85 |
| | Dry | 11 | 229 | -218 | -95 |
| | Critical Dry | 7 | 158 | -151 | -95 |

The following changes in SWP water deliveries would occur under Alternative 5 as compared to the Second Basis of Comparison.

- Deliveries without Article 21 water to SWP North of Delta water contractors would be reduced by 19 percent over the long-term conditions, 18 percent in dry years, and 21 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be reduced by 19 percent over the long-term conditions, 20 percent in dry years, and 23 percent in critical dry years.

- Deliveries of Article 21 water to SWP North of Delta water contractors would be increased by 13 percent over the long-term conditions, 11 percent in dry years, and 15 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 85 percent over the long-term conditions, 95 percent in dry years, and 95 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014i). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns, the analysis indicated that water transfers would not result in substantial changes in storage or river flows. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 5 and the Second Basis of Comparison.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September in accordance with the 2008 USFWS BO and 2009 NMFS BO. The maximum amount of water to be transferred would be 600,000 acre-feet per year in critical dry years or in dry years following a dry or critical dry year. In all other water year types, the maximum amount of water would be 360,000 acre-feet per year. The maximum amount of water that can be exported in the CVP and SWP facilities is approximately 770,000 acre-feet per month. As indicated in Table 5.110, capacity would be available under Alternative 5 between July and September for water transfers in all water year types.

Under the Second Basis of Comparison, water could be transferred throughout the year. As indicated in Table 5.110, capacity would be available under the Second Basis of Comparison in all months of all water year types without a maximum volume of transferred water.

Overall, the potential for water transfer conveyance would be less under Alternative 5 than under the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Surface Water Resources at Reservoirs that Store CVP and SWP Water*

The San Francisco Bay Area, Central Coast, and Southern California regions include numerous reservoirs that store CVP and SWP water supplies, including CVP and SWP reservoirs, that primarily provide water supplies for M&I water users. Changes in the availability CVP and SWP water supplies for storage in these reservoirs under Alternative 5 as compared to the Second Basis of Comparison would be consistent with the following changes in water deliveries to M&I water users, as summarized in Tables 5.111 and 5.112.

- Deliveries to CVP South of Delta M&I contractors would be reduced by 10 percent in long-term conditions, 9 percent in dry years, and 8 percent in critical dry years.
- Deliveries without Article 21 water to SWP South of Delta water contractors would be reduced by 19 percent over the long-term conditions, 20 percent in dry years, and 23 percent in critical dry years.
- Deliveries of Article 21 water to SWP South of Delta water contractors would be reduced by 85 percent over the long-term conditions, 95 percent in dry years, and 95 percent in critical dry years.

*Changes in CVP and SWP Exports and Deliveries*

Deliveries to CVP and SWP water users are described above in the Central Valley Region.

#### *5.4.3.7 Summary of Impact Analysis*

The results of the impact analysis on surface water conditions and water supplies due to implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 5.113 through 5.116.

**Table 5.113 Comparison of Surface Water Conditions under Alternatives 1 through 5 to the No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | **Trinity Lake**<br>In wet years and dry years, storage would be similar in all months.<br>In above-normal years, storage would be similar in January through October and increased in November and December (up to 6 percent).<br>In below-normal years, storage would be similar in January through October and increased in November and December (up to 5 percent).<br>In critical dry years, storage would be increased in all months (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Trinity River downstream of Lewiston Dam**<br>Over long-term conditions, flows would be similar in March through November; and increased in December through February (up to 11 percent).<br>In wet years, flows would be similar in April through November and increased in December through March (up to 13 percent).<br>In dry years, flows would be similar all months.<br>**Shasta Lake**<br>In wet years, storage would be similar in December through August and October and increased in September and November (up to 9 percent). | Environmental effects associated with changes in the following physical conditions are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources, and Chapter 10, Terrestrial Biological Resources), and recreation resources (as described in Chapter 15, Recreation Resources).<br>Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 9, 10, and 15. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In above-normal years, storage would be similar in January through September and increased in October through December (up to 8 percent).<br>In below-normal years, storage would be similar in March through September and increased in October through February (up to 12 percent).<br>In dry years, storage would be similar in February through October and increased in November through January (up to 7 percent).<br>In critical dry years, storage would be increased under all months (up to 17 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Sacramento River at Keswick**<br>Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 27 percent); and increased flows in December, January, and June (up to 8 percent).<br>In wet years, similar flows would occur in January through July; reduced flows in September through November (up to 44 percent); and increased flows in December and August (up to 17 percent).<br>In dry years, similar flows would occur in July through October, December through March, and May; reduced flows in November (25 percent); and increased flows in April and June (up to 8 percent).<br>**Sacramento River at Freeport**<br>Over long-term conditions, similar flows would occur in October, December through May, and August; reduced flows in September, November, and July (up to 30 percent); and increased flows in June (13 percent).<br>In wet years, similar flows would occur in January through June and October; reduced flows in July through September and November (up to 47 percent); and increased flows in December (7 percent).<br>In dry years, similar flows would occur in August through October and December through April; reduced flows in November and July (up to 14 percent); and increased flows in May and June (up to 14 percent).<br>**Lake Oroville**<br>In wet years, storage would be similar in January through August and reduced in September through December (up to 22 percent).<br>In above-normal years, storage would be similar in February through August and reduced in September through January (up to 15 percent).<br>In below-normal years, storage would be similar in May through July and reduced in August through April (up to 22 percent).<br>In dry years, storage would be similar in June and reduced in all other months (up to 14 percent).<br>In critical dry years, storage would be similar under all months.<br>In all months, in all water year types, surface water elevations would be similar.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in November and April; reduced flows in July through September (up to 43 percent); and increased flows in October, December through March, May, and June (up to 37 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In wet years, similar flows would occur in October, November, and March through May; reduced flows in July through September (up to 65 percent); and increased flows in December through February and June (up to 35 percent).<br>In dry years, similar flows would occur in December through April; reduced flows in July (34 percent); and increased flows in August through October, May, and June (up to 38 percent).<br>**Folsom Lake**<br>In wet years, storage would be similar in December through August; and increased in September through December (up to 12 percent).<br>In above-normal years, storage would be similar in January through July and September through October; increased in November and December (up to 9 percent); and reduced in August (5 percent).<br>In below-normal years, storage would be similar in February through May; reduced in June through September (up to 15 percent); and increased in October through January (up to 14 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in October through June and increased in July through September (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**American River downstream of Nimbus Dam**<br>Over long-term conditions, similar flows would occur in November through May and July; reduced flows in September and October (up to 31 percent); and increased flows in June (5 percent).<br>In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (48 percent); and increased flows in August (12 percent).<br>In dry years, similar flows would occur in November through January, March through June, August, and September; reduced flows in October (14 percent); and increased flows in February and July (up to 8 percent).<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows identical June through April and reduced in May (41 percent).<br>**New Melones Reservoir**<br>In wet years, storage would be similar in all months.<br>In above normal years, storage would be similar in December through September and increased in October and November (up to 6 percent).<br>In below normal years, storage would be similar in November through September and increased in October (5 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in July through September and increased in October through June (up to 8 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, similar flows would occur in July through September; reduced flows in October, March, and April (up to 60 percent); and increased flows in November through February and June (up to 51 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In wet years, similar flows would occur in February and April; reduced flows in October, March, May, July, and August (up to 54 percent); and increased flows in September, November through January, and June (up to 103 percent).<br>In dry years, similar flows would occur in July through September; reduced flows in October and April (up to 61 percent); and increased flows in November through March, May, and June (up to 56 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in July through September and November through May; reduced flows in October (16 percent); and increased flows in June (8 percent).<br>In wet years, similar flows would occur in July through September and November through May; reduced flows in October (14 percent); and increased flows in June (10 percent).<br>In dry years, similar flows would occur in November through March and May through September and reduced flows in October and April (up to 15 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be increased in all months (up to 109 percent). Water storage elevations would be increased in all months (up to 12 percent).<br>In above-normal years, storage would be increased in all months (up to 151 percent). Water storage elevations would be increased in all months (up to 15 percent).<br>In below-normal years, storage would be increased in all months (up to 203 percent). Water storage elevations would be increased in all months (up to 19 percent).<br>In dry years, storage would be increased in all months (up to 70 percent). Water storage elevations would be increased in all months (up to 12 percent).<br>In critical dry years, storage would be increased in all months (up to 57 percent). Water storage elevations would be increased in all months (up to 11 percent).<br>**Yolo Bypass**<br>In wet years, flows into Yolo Bypass would be similar in January through September; reduced in October (20 percent); and increased in November and December (up to 17 percent).<br>In above-normal years, flows into Yolo Bypass would be similar in April through December and increased in January through March (up to 16 percent).<br>In below-normal years, flows into Yolo Bypass would be similar in April through November and increased in December through March (up to 34 percent).<br>In dry years, flows into Yolo Bypass would be similar in January through November and increased in December (6 percent).<br>In critical dry years, flows into Yolo Bypass would be similar in all months.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow would increase in December, February, March, and June (up to 1,492 cfs) and decrease in July through November, January, April, and May (up to 13,683 cfs).<br>In dry years, average monthly Delta outflow would be similar in September; decrease in July, August, and October through May (up to 3,114 cfs); and increase in June (385 cfs). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Reverse Flows in Old and Middle Rivers**<br>In wet years, average monthly OMR flows, would be more positive in June through August and March (up to 923 cfs) and more negative in April through June and September through February (up to 10,005 cfs).<br>In dry years, average monthly OMR flows would be positive in July (up to 2,073 cfs) and more negative in August through June (up to 3,489 cfs). | |
| Alternative 2 | Surface water conditions identical under Alternative 2 as under No Action Alternative. | None needed. |
| Alternative 3 | **Trinity Lake**<br>In wet, above-normal years, below normal, and dry years, storage would be similar in all months.<br>In critical dry years, storage would be increased in all months (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Trinity River downstream of Lewiston Dam**<br>Over long-term conditions, flows would be similar in March through November; and increased in December through February (up to 12 percent).<br>In wet years, flows would be similar in April through October; reduced in November (7 percent); and increased in December through March (up to 15 percent).<br>In dry years, flows would be similar in all months.<br>**Shasta Lake**<br>In wet years, storage would be similar in December through August and increased in September and November (up to 9 percent).<br>In above-normal years, storage would be similar in January through October and increased in November and December (up to 7 percent).<br>In below-normal years, storage would be similar in March through September; and increased in October through February (up to 12 percent).<br>In dry years, storage would be similar in March through October and increased in November through January (up to 7 percent).<br>In critical dry years, storage would increase in all months (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Sacramento River at Keswick**<br>Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 20 percent); and increased flows in December, January, and June (up to 9 percent).<br>In wet years, similar flows would occur in February through August; reduced flows in September through November (up to 42 percent); and increased flows in December and January (up to 17 percent).<br>In dry years, similar flows would occur in July through September and December through May; reduced flows in November (25 percent) and increased flows in January and June (up to 7 percent).<br>**Sacramento River at Freeport**<br>Over long-term conditions, similar flows would occur in October, December through May, July, and August; reduced flows in September and November (up to 30 percent); and increased flows in June (12 percent). | Environmental effects associated with changes in the following physical conditions are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources, and Chapter 10, Terrestrial Biological Resources), and recreation resources (as described in Chapter 15, Recreation Resources).<br>Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 9, 10, and 15. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In wet years, similar flows would occur in January through May, July, and October; reduced flows in August, September, and November (up to 48.1 percent); and increased flows in December and June (up to 7 percent).<br>In dry years, similar flows would occur in July through October and December through April; reduced flows in November (14 percent); and increased flows in May and June (up to 16 percent).<br>**Lake Oroville**<br>In wet years, storage would be similar in January through August and increased in September through December (up to 19 percent).<br>In above-normal years, storage would be similar in February through August; and increased in September through January (up to 19 percent).<br>In below-normal years, storage would be similar in June through September; and increased in October through May (up to 23 percent).<br>In dry years, storage would be similar in May through September and increased in October through April (up to 12 percent).<br>In critical dry years, storage would be similar under all months.<br>In all months, in all water year types, surface water elevations would be similar.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in October, November, March, April, and July; reduced flows in August and September (up to 49 percent); and increased flows in December through February, May, and June (up to 34 percent).<br>In wet years, similar flows would occur in October, November, February through May, and July; reduced flows in August and September (up to 70 percent) and increased flows in December, January, and June (up to 28 percent).<br>In dry years, similar flows would occur in September and January through April; reduced flows in October through December and July (up to 14 percent); and increased flows in May, June, and August (37 percent).<br>**Folsom Lake**<br>In wet years, storage would be similar in December through August and increased in September through December (up to 12 percent).<br>In above-normal years, storage would be similar in January through June, September, and October; increased in November and December (up to 6 percent); and reduced in July and August (up to 7 percent).<br>In below-normal years, storage would be similar in February through July; reduced in August and September (up to 10 percent); and increased in October through January (up to 15 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in October through July and increased in August and September (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**American River downstream of Nimbus Dam**<br>Over long-term conditions, similar flows would occur in November, January through May, July, and August; reduced flows in September and October (up to 29 percent); and increased flows in June (6 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (46 percent); and increased flows in August and December (up to 9 percent).<br>In dry years, similar flows would occur in November through January and March through September; reduced flows in October (11 percent); and increased flows in February (6 percent).<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows would be identical June through April and reduced in May (29 percent).<br>**New Melones Reservoir**<br>In wet years, storage would be increased in all months (up to 13 percent).<br>In above-normal years, storage would be increased in all months (up to 23 percent).<br>In below-normal years, storage would be increased in all months (up to 20 percent).<br>In dry years, storage would be increased in all months (up to 25 percent).<br>In critical dry years, storage would be increased in all months (up to 38 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, reduced flows would occur in October and March through June (up to 58 percent) and increased flows in November through February and July through September (up to 37 percent).<br>In wet years, similar flows would occur in April; reduced flows in October, March, and May (up to 53 percent) and increased flows in June through September and November through February (up to 68 percent).<br>In dry years, similar flows would occur in March and July through September; reduced flows in October and April through June (up to 60 percent); and increased flows in November through February (up to 37 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in November through September and reduced flows in October (16 percent).<br>In wet years, similar flows would occur in November through August; reduced flows in October (14 percent); and increased flows in September (6 percent).<br>In dry years, similar flows would occur in November through March and July through September and reduced flows in October and April through June (up to 15 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be increased in all months (up to 96 percent). Water storage elevations would be increased in all months (up to 13 percent).<br>In above-normal years, storage would be increased in all months (up to 111 percent). Water storage elevations would be similar in October through March and increased in April through September (up to 11 percent).<br>In below-normal years, storage would be increased in all months (up to 107 percent). Water storage elevations would be similar in September and increased in October through August (up to 11 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In dry years, storage would be similar in September; and increased in October through August (up to 52 percent). Water storage elevations would be similar December through May and July through October and increased in November and June (up to 7 percent).<br>In critical dry years, storage would be similar in February through May and increased in June through January (up to 29 percent). Water storage elevations would be similar in all months.<br>**Yolo Bypass**<br>In wet years, flows into Yolo Bypass would be similar in January through September; reduced in October (25 percent); and increased in November and December (up to 15 percent).<br>In above-normal years, storage would be similar in April through January and increased in February and March (up to 17 percent).<br>In below-normal years, flows into Yolo Bypass would be similar in April through November and increased in December through March (up to 32 percent).<br>In dry years, flows into Yolo Bypass would be similar in January through November and increased in December (6 percent).<br>In critical dry years, flows into Yolo Bypass would be similar in all months.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow would increase in December through March (up to 3,307 cfs) and decrease in April through November (up to 13,678 cfs).<br>In dry years, average monthly Delta outflow would increase in January, February, June, and July (up to 277 cfs) and decrease in August through December and March through May (up to 2,902 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, average monthly OMR flows would be more positive in July and August (up to 800 cfs) and more negative in September through June (up to 4,477 cfs).<br>In dry years, average monthly OMR flows would be more positive in July and January (up to 728 cfs) and more negative in August through December and February through June (up to 1,847 cfs). | |
| Alternative 4 | **Trinity Lake**<br>In wet years and dry years, storage would be similar in all months.<br>In above-normal years, storage would be similar in January through October and increased in November and December (up to 6 percent).<br>In below-normal years, storage would be similar in January through October and increased in November and December (up to 5 percent).<br>In critical dry years, storage would be increased in all months (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Trinity River downstream of Lewiston Dam**<br>Over long-term conditions, flows would be similar in March through November; and increased in December through February (up to 11 percent).<br>In wet years, flows would be similar in April through November and increased in December through March (up to 13 percent).<br>In dry years, flows would be similar all months. | Environmental effects associated with changes in the following physical conditions are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources, and Chapter 10, Terrestrial Biological Resources), and recreation resources (as described in Chapter 15, Recreation Resources).<br>Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 9, 10, and 15. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Shasta Lake**<br>In wet years, storage would be similar in December through August and October and increased in September and November (up to 9 percent).<br>In above-normal years, storage would be similar in January through September and increased in October through December (up to 8 percent).<br>In below-normal years, storage would be similar in March through September and increased in October through February (up to 12 percent).<br>In dry years, storage would be similar in February through October and increased in November through January (up to 7 percent).<br>In critical dry years, storage would be increased under all months (up to 17 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Sacramento River at Keswick**<br>Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 27 percent); and increased flows in December, January, and June (up to 8 percent).<br>In wet years, similar flows would occur in January through July; reduced flows in September through November (up to 44 percent); and increased flows in December and August (up to 17 percent).<br>In dry years, similar flows would occur in July through October, December through March, and May; reduced flows in November (25 percent); and increased flows in April and June (up to 8 percent).<br>**Sacramento River at Freeport**<br>Over long-term conditions, similar flows would occur in October, December through May, and August; reduced flows in September, November, and July (up to 30 percent); and increased flows in June (13 percent).<br>In wet years, similar flows would occur in January through June and October; reduced flows in July through September and November (up to 47 percent); and increased flows in December (7 percent).<br>In dry years, similar flows would occur in August through October and December through April; reduced flows in November and July (up to 14 percent); and increased flows in May and June (up to 14 percent).<br>**Lake Oroville**<br>In wet years, storage would be similar in January through August and reduced in September through December (up to 22 percent).<br>In above-normal years, storage would be similar in February through August and reduced in September through January (up to 15 percent).<br>In below-normal years, storage would be similar in May through July and reduced in August through April (up to 22 percent).<br>In dry years, storage would be similar in June and reduced in all other months (up to 14 percent).<br>In critical dry years, storage would be similar under all months.<br>In all months, in all water year types, surface water elevations would be similar. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in November and April; reduced flows in July through September (up to 43 percent); and increased flows in October, December through March, May, and June (up to 37 percent).<br>In wet years, similar flows would occur in October, November, and March through May; reduced flows in July through September (up to 65 percent); and increased flows in December through February and June (up to 35 percent).<br>In dry years, similar flows would occur in December through April; reduced flows in July (34 percent); and increased flows in August through October, May, and June (up to 38 percent).<br>**Folsom Lake**<br>In wet years, storage would be similar in December through August; and increased in September through December (up to 12 percent).<br>In above-normal years, storage would be similar in January through July and September through October; increased in November and December (up to 9 percent); and reduced in August (5 percent).<br>In below-normal years, storage would be similar in February through May; reduced in June through September (up to 15 percent); and increased in October through January (up to 14 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in October through June and increased in July through September (up to 12 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**American River downstream of Nimbus Dam**<br>Over long-term conditions, similar flows would occur in November through May and July; reduced flows in September and October (up to 31 percent); and increased flows in June (5 percent).<br>In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (48 percent); and increased flows in August (12 percent).<br>In dry years, similar flows would occur in November through January, March through June, August, and September; reduced flows in October (14 percent); and increased flows in February and July (up to 8 percent).<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows identical June through April and reduced in May (41 percent).<br>**New Melones Reservoir**<br>In wet years, storage would be similar in all months.<br>In above normal years, storage would be similar in December through September and increased in October and November (up to 6 percent).<br>In below normal years, storage would be similar in November through September and increased in October (5 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in July through September and increased in October through June (up to 8 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, similar flows would occur in July through September; reduced flows in October, March, and April (up to 60 percent); and increased flows in November through February and June (up to 51 percent).<br>In wet years, similar flows would occur in February and April; reduced flows in October, March, May, July, and August (up to 54 percent); and increased flows in September, November through January, and June (up to 103 percent).<br>In dry years, similar flows would occur in July through September; reduced flows in October and April (up to 61 percent); and increased flows in November through March, May, and June (up to 56 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in July through September and November through May; reduced flows in October (16 percent); and increased flows in June (8 percent).<br>In wet years, similar flows would occur in July through September and November through May; reduced flows in October (14 percent); and increased flows in June (10 percent).<br>In dry years, similar flows would occur in November through March and May through September and reduced flows in October and April (up to 15 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be increased in all months (up to 109 percent). Water storage elevations would be increased in all months (up to 12 percent).<br>In above-normal years, storage would be increased in all months (up to 151 percent). Water storage elevations would be increased in all months (up to 15 percent).<br>In below-normal years, storage would be increased in all months (up to 203 percent). Water storage elevations would be increased in all months (up to 19 percent).<br>In dry years, storage would be increased in all months (up to 70 percent). Water storage elevations would be increased in all months (up to 12 percent).<br>In critical dry years, storage would be increased in all months (up to 57 percent). Water storage elevations would be increased in all months (up to 11 percent).<br>**Yolo Bypass**<br>In wet years, flows into Yolo Bypass would be similar in January through September; reduced in October (20 percent); and increased in November and December (up to 17 percent).<br>In above-normal years, flows into Yolo Bypass would be similar in April through December and increased in January through March (up to 16 percent).<br>In below-normal years, flows into Yolo Bypass would be similar in April through November and increased in December through March (up to 34 percent).<br>In dry years, flows into Yolo Bypass would be similar in January through November and increased in December (6 percent).<br>In critical dry years, flows into Yolo Bypass would be similar in all months. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Delta Outflow**<br>In wet years, average monthly Delta outflow would increase in December, February, March, and June (up to 1,492 cfs) and decrease in July through November, January, April, and May (up to 13,683 cfs).<br>In dry years, average monthly Delta outflow would be similar in September; decrease in July, August, and October through May (up to 3,114 cfs); and increase in June (385 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, average monthly OMR flows, would be more positive in June through August and March (up to 923 cfs) and more negative in April through June and September through February (up to 10,005 cfs).<br>In dry years, average monthly OMR flows would be positive in July (up to 2,073 cfs) and more negative in August through June (up to 3,489 cfs). | |
| Alternative 5 | **Trinity Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Trinity River downstream of Lewiston Dam**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Shasta Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Sacramento River at Keswick**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Sacramento River at Freeport**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Lake Oroville**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in June through April and reduced flows in May (7 percent).<br>In wet years, similar flows would occur in all months.<br>In dry years, similar flows would occur in September through April and June; reduced flows in May (27 percent); and increased flows in July and August (up to 9 percent).<br>**Folsom Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**American River downstream of Nimbus Dam**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows would be identical in all months.<br>**New Melones Reservoir**<br>In wet years, storage would be similar in all months.<br>In above normal years, storage would be similar in October through June and reduced in July through September (up to 6 percent).<br>In below normal years, storage would be reduced in all months (up to 9 percent).<br>In dry years, storage would be reduced in all months (up to 10 percent). | Environmental effects associated with changes in stream flows and reservoir storage related to fish and aquatic resources, terrestrial resources, and recreation are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources, and Chapter 10, Terrestrial Biological Resources), and recreation resources (as described in Chapter 15, Recreation Resources).<br>Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 9, 10, and 15. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In critical dry years, storage would be reduced in all months (up to 19 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, flows would be similar in September through February and June; reduced flows would occur in March, July, and August (up to 8 percent); and increased flows in April and May (up to 22 percent).<br>In wet years, similar flows would occur in October, November, January, February, and April through June and reduced flows in December, March, and July through September (up to 18 percent).<br>In dry years, similar flows would occur in June through March and increased flows in April and May (up to 47 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions and wet years, similar flows would occur in all months.<br>In dry years, similar flows would occur in June through March and increased flows in April and May (up to 16 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be similar in January through May and increased in June through December (up to 10 percent).<br>In above-normal years, storage would be similar in all months.<br>In below-normal years, storage would be similar in November, February through April, August, and September; reduced in June and July (up to 9 percent); and increased in October, December, January, and May (up to 8 percent).<br>In dry years, storage would be similar in October through March; and reduced in April through September (up to 17 percent).<br>In critical dry years, storage would be similar in February and March and reduced in April through January (up to 18 percent).<br>Surface water elevations would be similar in all months, in all water years.<br>**Yolo Bypass**<br>Similar flows into the Yolo Bypass in all months and all water year types.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow would be similar.<br>In dry years, average monthly Delta outflow would be similar in July through April and increased in May and June (up to 1,377 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, OMR flows would be more positive or no change in September, October, January, and April through June (up to 171 cfs) and more negative in November, December, March, and August (up to 124 cfs).<br>In dry years, OMR flows would be more positive or no change in October through March (up to 1,359 cfs) and more negative in June through September (up to 568 cfs). | |

**Table 5.114 Comparison of CVP and SWP Water Supply Deliveries under Alternatives 1 through 5 to the No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Long-term average annual exports would be 1,051 TAF (22 percent) more under Alternative 1 as compared to the No Action Alternative.<br>Deliveries to CVP North of Delta agricultural water service contractors would be increased by 18 percent over the long-term conditions, 43 percent in dry years, and 50 percent in critical dry years.<br>Deliveries to CVP North of Delta M&I contractors would be similar in total; however, deliveries to the American River CVP contractors would be increased by 6 percent over the long-term conditions, 8 percent in dry years, and 7 percent in critical dry years.<br>Deliveries to CVP South of Delta agricultural water service contractors would be increased by 30 percent over the long-term conditions, 46 percent in dry years, and 49 percent in critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be increased by 12 percent over the long-term conditions, 10 percent in dry years, and 5 percent in critical dry years.<br>Deliveries to the Eastside contractors would be similar under long-term conditions and in dry years, but increased by 14 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be increased by 22 percent over the long-term conditions, 22 percent in dry years, and 25 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be increased by 22 percent over the long-term conditions, 24 percent in dry years, and 28 percent in critical dry years. | None needed. |
| Alternative 2 | Water supply conditions identical under Alternative 2 as under No Action Alternative. | None needed. |
| Alternative 3 | Long-term average annual exports would be 726 TAF (15 percent) more under Alternative 3 as compared to the No Action Alternative.<br>Deliveries to CVP North of Delta agricultural water service contractors would be increased by 13 percent over the long-term conditions and 29 percent in dry and critical dry years.<br>Deliveries to CVP North of Delta M&I contractors would be similar in total; however, deliveries to the American River CVP contractors would increase by 5 percent over the long-term conditions and 7 percent in dry years, but remain similar in critical dry years.<br>Deliveries to CVP South of Delta agricultural water service contractors would be increased by 28 percent over the long-term conditions, 34 percent in dry years, and 27 percent in critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be similar in critical dry years and increased by 10 percent over the long-term conditions and 8 percent in dry years.<br>Deliveries to the Eastside contractors would be similar under long-term conditions and dry years and increased by 14 percent in critical dry years. | None needed. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be increased by 17 percent over the long-term conditions and in dry years and 13 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be increased by 17 percent over the long-term conditions and in dry years and 14 percent in critical dry years. | |
| Alternative 4 | Same water supply conditions as described for Alternative 1 compared to the No Action Alternative. | None needed. |
| Alternative 5 | Long-term average annual exports would be 45 TAF (1 percent) less under Alternative 5 as compared to the No Action Alternative.<br>Deliveries to CVP North of Delta agricultural water service contractors would be similar over the long-term conditions and in dry and critical dry years.<br>Deliveries to CVP North of Delta M&I contractors would be similar over the long-term conditions and in dry and critical dry years in total and for the American River CVP contractors.<br>Deliveries to CVP South of Delta agricultural water service contractors would be similar over the long-term conditions and in dry and critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be similar over the long-term conditions and in dry and critical dry years.<br>Deliveries to the Eastside contractors would be similar under long-term conditions and dry years; and reduced by 8 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry and critical dry years. | To mitigate reductions of up to 7 percent in critical dry years to the Eastside Contractors, Reclamation would support water transfers from other basin water rights holders to the Eastside Contractors. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

**Table 5.115 Comparison of Surface Water Conditions under the No Action Alternative and Alternatives 1 through 5 to the Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | **Trinity Lake**<br>In wet years, below normal, and dry years, storage would be similar in all months.<br>In above-normal years, storage would be similar in January through October; and less in November and December (up to 6 percent).<br>In critical dry years, storage would be less in all months (up to 10 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Trinity River downstream of Lewiston Dam**<br>Over long-term conditions (over the 82-year analysis period), flows would be similar in March through November and reduced in December through February (up to 10 percent).<br>In wet years, flows would be similar in April through November and reduced in December through March (up to 11 percent).<br>In dry years, flows would be similar all months.<br>**Shasta Lake**<br>In wet years, storage would be similar in October and December through August and reduced in September and November (up to 8 percent).<br>In above-normal years, storage would be similar in January through September and reduced in October through December (up to 8 percent).<br>In below-normal years, storage would be similar in March through September and reduced in October through February (up to 11 percent).<br>In dry years, storage would be similar in January through October and reduced in November and December (up to 6 percent).<br>In critical dry years, storage would be reduced under all months (up to 14 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Sacramento River at Keswick**<br>Over long-term conditions, similar flows would occur in October, February through May, July, and August; increased flows in September and November (up to 38 percent); and reduced flows in December, January, and June (up to 8 percent).<br>In wet years, similar flows would occur in January through July; increased flows in September through November (up to 78 percent); and reduced flows in December and August (up to 15 percent).<br>In dry years, similar flows would occur in July through October, December through March, and May; increased flows in November (33 percent); and reduced flows in April and June (up to 7 percent).<br>**Sacramento River at Freeport**<br>Over long-term conditions, similar flows would occur in October, December through May, and August; increased flows in September, November, and July (up to 43 percent); and reduced flows in June (11 percent).<br>In wet years, similar flows would occur in January through June and October; increased flows in July through September and November (up to 90 percent); and reduced flows in December (11 percent). | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In dry years, similar flows would occur in August through October and December through April; increased flows in November and July (up to 16 percent); and reduced flows in May and June (up to 12 percent).<br>**Lake Oroville**<br>In wet years, storage would be similar in January through August; and reduced in September through December (up to 18 percent).<br>In above normal years, storage would be similar in February through August and reduced in September through January (up to 13 percent).<br>In below normal years, storage would be similar in May through July and reduced in August through April (up to 18 percent).<br>In dry years, storage would be similar in June and reduced in all other months (up to 13 percent).<br>In critical dry years, storage would be similar under all months.<br>In all months, in all water year types, surface water elevations would be similar.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in November and April; increased flows in July through September (up to 76 percent); and reduced flows in October, December through March, May, and June (up to 27 percent).<br>In wet years, similar flows would occur in October through November and March through May; increased flows in July through September (up to 184 percent); and reduced flows in December through February (up to 26 percent).<br>In dry years, similar flows would occur in November through March; increased flows in April and July (up to 52 percent); and reduced flows in August through October and May and June (up to 28 percent).<br>**Folsom Lake**<br>In wet years, storage would be similar in December through August and reduced in September through November (up to 11 percent).<br>In above-normal years, storage would be similar in January through June, September, and October; reduced in November and December (up to 8 percent); and increased in July and August (up to 6 percent).<br>In below-normal years, storage would be similar in February through May; reduced in October through January (up to 12 percent); and increased in July through September (up to 17 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in October through June and reduced in July through September (up to 11 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**American River downstream of Nimbus Dam**<br>Over long-term conditions, similar flows would occur in November through May and July; increased flows in September and October (up to 45 percent); and reduced flows in June and August (up to 6 percent).<br>In wet years, similar flows would occur in October through November and January through July; increased flows in September (91 percent); and reduced flows in December and August (up to 11 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In dry years, similar flows would occur in all months except October, February and July; increased flows in October (17 percent); and reduced flows in February and July (up to 7 percent).<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows identical June through April and increased in May (41 percent).<br>**New Melones Reservoir**<br>In wet, below-normal, and dry years, storage would be similar in all months.<br>In above-normal years, storage would be similar in all months except October when storage would be reduced by 6 percent.<br>In critical dry years, storage would be similar in February, March, and July through September and reduced in October through January and April through June (up to 7 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, similar flows would occur in May and July through September; increased flows in October, March, and April (up to 149 percent); and reduced flows in November through February and June (up to 34 percent).<br>In wet years, similar flows would occur in February and April; increased flows in October, March, May, July, and August (up to 117 percent); and reduced flows in September, November through January, and June (up to 51 percent).<br>In dry years, similar flows would occur in July through September; increased flows in October and April (up to 154 percent); and reduced flows in November through March, May, and June (up to 36 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in July through September and November through May; increased flows in October (19 percent); and reduced flows in June (8 percent).<br>In wet years, similar flows would occur in July through September and November through May; increased flows in October (17 percent); and reduced flows in June (9 percent).<br>In dry years, similar flows would occur in November through March and May through September and increased flows in October and April (up to 18 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be similar in June and September; increased in March, July, and August (up to 10 percent); and reduced in October through February, April, and May (up to 57 percent). Surface water elevations would be less in all months (up to 11 percent).<br>In above-normal years, storage would be similar in July and September; increased in August (10 percent); and reduced in October through June (up to 71 percent). Surface water elevations would be less in all months (up to 13 percent).<br>In below-normal years, storage would be similar in July and September; increased in August (20 percent); and reduced in October through June (up to 67 percent). Surface water elevations would be less in all months (up to 16 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In dry years, storage would be similar in September; increased in July (34 percent); and reduced in October through June and August (up to 44 percent). Surface water elevations would be similar in September through January and less in February through August (up to 10 percent).<br>In critical dry years, storage would be similar in September; increased in July (60 percent); and reduced in August and October through June (up to 51 percent). Surface water elevations would be similar in October through January and reduced in February through September (up to 10 percent).<br>**Yolo Bypass**<br>In wet years, flows into Yolo Bypass would be similar in January through September; increased in October (25 percent); and reduced in November and December (up to 15 percent).<br>In above-normal years, flows into Yolo Bypass would be similar in April through December and reduced in January through March (up to 14 percent).<br>In below-normal years, flows into Yolo Bypass would be similar in April through November and reduced in December through March (up to 25 percent).<br>In dry years, flows into Yolo Bypass would be similar in January through November and reduced in December (6 percent).<br>In critical dry years, flows into Yolo Bypass would be similar in all months.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow in July through November, January, April, and May (up to 13,683 cfs) and decrease in December, February, March, and June (up to 1,590 cfs).<br>In dry years, average monthly Delta outflow would be similar or increase in all months (up to 3,114 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, average monthly OMR flows would be more positive in September through February, April, and May (up to 10,005 cfs) and more negative in March and June through August (up to 923 cfs).<br>In dry years, average monthly OMR flows would be more positive in August through June (up to 3,489 cfs) and more negative in June (2,073 cfs). | |
| Alternative 1 | Surface water conditions identical under Alternative 1 as under Second Basis of Comparison. | None needed. |
| Alternative 2 | Same surface water conditions as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | **Trinity Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Trinity River downstream of Lewiston Dam**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Shasta Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Sacramento River at Keswick**<br>Similar flows in all months for long-term conditions and wet and dry years. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Sacramento River at Freeport**<br>Similar flows in all months for long-term conditions and wet years.<br>In dry years, similar flows would occur in July through May and increased flows in June (11 percent).<br>**Lake Oroville**<br>Similar storage and surface water elevations in all months and all water year types.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in November and January through June; reduced flows in October, December, and September (up to 13 percent); and increased flows in July and August (up to 17 percent).<br>In wet years, similar flows would occur in November and January through May; reduced flows in October, December, and September (up to 15 percent); and increased flows in June through August (up to 11 percent).<br>In dry years, similar flows would occur in November and January through June; reduced flows in August through October (up to 21 percent); and increased flows in July (37 percent).<br>**Folsom Lake**<br>Similar storage and surface water elevations in all months and all water year types.<br>**American River downstream of Nimbus Dam**<br>Similar flows in all months for long-term conditions and wet and dry years.<br>**Clear Creek downstream of Whiskeytown Dam**<br>Flows would be identical in all months.<br>**New Melones Reservoir**<br>In wet years, storage would be similar in March through May and increased in June through February (up to 8 percent).<br>In above-normal years, storage would be increased in all months (up to 16 percent).<br>In below-normal years, storage would be increased in all months (up to 15 percent).<br>In dry years, storage would be increased in all months (up to 20 percent).<br>In critical dry years, storage would be increased in all months (up to 32 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, similar flows would occur in October, December, January, and March; reduced flows would occur in November, May, and June (up to 52 percent); and increased flows in February, April, July, and August through September (up to 27 percent).<br>In wet years, similar flows would occur in October, November, January, and April; reduced flows in May and June (up to 45 percent); and increased flows in December, February, March, and July through September (up to 69 percent).<br>In dry years, similar flows would occur in July through October; reduced flows in November through March and May through June (up to 36 percent); and increased flows in April (40 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in July through May and reduced flows in June (12 percent).<br>In wet years, similar flows would occur in September through January, March through May, and July; reduced flows in June (8 percent); and increased flows in August and February (6 percent).<br>In dry years, similar flows would occur in July through March; reduced flows in May and June (up to 12 percent); and increased flows in April (7 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be similar in July through November and March through May and reduced in December through February and June (up to 16 percent). Surface water elevations would be similar in all months.<br>In above-normal years, storage would be similar in November; increased in August and September (up to 12 percent); and reduced in October and December through July (up to 22 percent). Surface water elevations would be similar in March through December and reduced in January and February (up to 6 percent).<br>In below-normal years, storage would be similar in August and September and reduced in October through July (up to 40 percent). Surface water elevations would be similar in all months.<br>In dry years, storage would be reduced in January through September (up to 19 percent) and increased in October through December (up to 13 percent). Surface water elevations would be similar in all months.<br>In critical dry years, storage would be reduced in October through August (up to 29 percent) and increased in September (8 percent). Surface water elevations would be similar September through January and reduced in February through August (up to 7 percent).<br>**Yolo Bypass**<br>In wet years, flows into the Yolo Bypass would be similar in November through September and reduced in October (6 percent).<br>In above-normal, below-normal, dry, and critical dry years, flows into the Yolo Bypass would be similar in all months.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow would increase in November through February and July through September (up to 2,546 cfs) and decrease in October and March through June (up to 1,127 cfs).<br>In dry years, average monthly Delta outflow would increase in November through April, July and August (up to 3,391 cfs) and decrease October, May, and June (up to 373 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, flows would be more positive in September through February, April, and May (up to 5,528 cfs) and more negative in March and June through August (up to 1,453 cfs).<br>In dry years, flows would be more positive in August through May (up to 3,249 cfs) and more negative flows in June and July (up to 1,345 cfs). | |
| Alternative 4 | Surface water conditions identical under Alternative 4 as under Second Basis of Comparison. | None needed. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 5 | **Trinity Lake**<br>In wet, below-normal, and dry years, storage would be similar.<br>In above-normal years, storage would be similar in January through October and reduced in November and December (up to 5 percent).<br>In critical dry years, storage would be reduced in all months (up to 10 percent).<br>In all months, in all water year types, surface water elevations would be similar.<br>**Trinity River downstream of Lewiston Dam**<br>Over long-term conditions, flows would be similar in March through November and January and reduced in December and February (up to 10 percent).<br>In wet years, flows would be similar in January and April through November and reduced in December, February, and March (up to 14 percent).<br>In dry years, flows would be similar in all months.<br>**Shasta Lake**<br>In wet years, storage would be similar in October and December through August and reduced in November and September (up to 8 percent).<br>In above-normal years, storage would be similar in February through September and reduced in October through December (up to 8 percent).<br>In below-normal years, storage would be similar in March through September and reduced in October through February (up to 10 percent).<br>In dry years, storage would be similar in January through October and reduced in November through December (up to 6 percent).<br>In critical dry years, storage would be reduced in all months (up to 17 percent).<br>In all months, in all water year types, surface water elevations are similar.<br>**Sacramento River at Keswick**<br>Over long-term conditions, flows would be similar in July, August, October, and February through April; reduced in December, January, May and June (up to 8 percent); and increased in September and November (up to 39 percent).<br>In wet years, flows would be similar in January through July; reduced in December and August (up to 15 percent); and increased in September through November (up to 77 percent).<br>In dry years, similar flows would occur in July through October and December through March; reduced in April through June (up to 10 percent); and increased flows in November (32 percent).<br>**Sacramento River at Freeport**<br>Over long-term conditions, flows would be similar in October and December through April; reduced in May and June (up to 12 percent); and increased in July through September and November (43 percent).<br>In wet years, flows would be similar in October and January through June; reduced in December (6 percent); and increased in July through September and November (up to 89 percent).<br>In dry years, similar flows would occur in August through October and December through April; reduced in May and June (up to 14 percent); and increased flows in July and November (up to 19 percent). | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Lake Oroville**<br>In wet years, storage would be similar in January through August; and reduced in September through December (up to 18 percent).<br>In above-normal years, storage would be similar in March through August and reduced in September through February (up to 14 percent).<br>In below-normal years, storage would be similar in May through July and reduced in August through April (up to 17 percent).<br>In dry years, storage would be similar in May and June and reduced in July through April (up to 11 percent).<br>In critical dry years, storage would be similar in all months.<br>Surface water elevations would be similar in all months, in all years.<br>**Feather River downstream of Thermalito Complex**<br>Over long-term conditions, similar flows would occur in November and April; reduced flows in October, December through March, May, and June (up to 28 percent); and increased flows in July through September (up to 76 percent).<br>In wet years, similar flows would occur in October, November, March through May; reduced flows in December through February and June (up to 26 percent); and increased flows in July through September (up to 182 percent).<br>In dry years, similar flows would occur in November through April; reduced flows in October, May, June, August, and September (up to 45 percent); and increased flows in July (60 percent).<br>**Folsom Lake**<br>In wet years, storage would be similar in December through July and reduced in August through November (up to 7 percent).<br>In above-normal years, storage would be similar in January through June, August, and October; reduced in September, November, and December (up to 8 percent); and increased in July (5 percent).<br>In below-normal years, storage would be similar in February through May; reduced in August through January (up to 13 percent); and increased in June and July (up to 10 percent).<br>In dry years, storage would be similar in all months.<br>In critical dry years, storage would be similar in August and June and reduced in July (8 percent).<br>Surface water elevations would be similar in all months, in all years.<br>**American River downstream of Nimbus Dam**<br>Over long-term conditions, similar flows would occur in November through July; reduced flows in August (6 percent); and increased in September and October (42 percent).<br>In wet years, similar flows would occur in October, November, and January through July; reduced flows in December and August (up to 14 percent); and increased flows in September (88 percent).<br>In dry years, similar flows would occur in November through September; and increased flows in October (17 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Clear Creek downstream of Whiskeytown Dam**<br>Flows identical June through April and increased in May (41 percent).<br>**New Melones Reservoir**<br>In wet years, storage would be reduced in all months (up to 9 percent).<br>In above-normal years, storage would be reduced in all months (up to 10 percent).<br>In below-normal years, storage would be reduced in all months (up to 13 percent).<br>In dry years, storage would be reduced in all months (up to 14 percent).<br>In critical dry years, storage would be reduced in all months (up to 23 percent).<br>Surface water elevations would be similar in all months, in all water year types.<br>**Stanislaus River downstream of Goodwin Dam**<br>Over long-term conditions, similar flows would occur in August; reduced flows would occur in November through February, June, July, August, and September (up to 36 percent); and increased flows in October and March through May (up to 149 percent).<br>In wet years, similar flows would occur in February and April; reduced flows in November through January and June through September (up to 53 percent); and increased flows in October and March (up to 113 percent).<br>In dry years, similar flows would occur in July through September; reduced flows in November through March and June (up to 36 percent); and increased flows in October, April, and May (150 percent).<br>**San Joaquin River at Vernalis**<br>Over long-term conditions, similar flows would occur in November through March, May, and July through September; reduced flows in June (8 percent); increased flows in October and April (19 percent).<br>In wet years, similar flows would occur in November through May and July through September; reduced flows in June (10 percent); and increased flows in October (16 percent).<br>In dry years, similar flows would occur in November through March and June through September; and increased flows in October, April, and May (up to 25 percent).<br>**San Luis Reservoir**<br>In wet years, storage would be reduced in all months (up to 49 percent). Surface water elevations would be similar in September and March; and reduced in October through February and April through August (up to 10 percent).<br>In above-normal years, storage would be reduced in all months (up to 59 percent). Surface water elevations would be similar in September; and reduced in October through August (up to 13 percent).<br>In below-normal years, storage would be reduced in all months (up to 70 percent). Surface water elevations would be similar in September; and reduced in October through August (up to 17 percent).<br>In dry years, storage would be reduced in all months (up to 51 percent). Surface water elevations would be similar in October through December; and reduced in January through September (up to 14 percent). | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | In critical dry years, storage would be reduced in all months (46 percent). Surface water elevations would be reduced in all months (up to 14 percent).<br>**Yolo Bypass**<br>In wet years, flows would be similar in February through September; reduced flows in November through January (up to 15 percent); and increased in October (16 percent).<br>In above-normal years, flows would be similar in April through December and reduced flows in January through March (up to 15 percent).<br>In below-normal years, flows would be similar in April through November and reduced flows in December through March (up to 24 percent).<br>In dry years, flows would be similar in January through November and reduced flows in December (up to 7 percent).<br>In critical dry years, flows would be similar in all months.<br>**Delta Outflow**<br>In wet years, average monthly Delta outflow would be increased in July through November, January, and April and May (up to 13,666 cfs) and reduced in December, February, March, and June (up to 1,713 cfs).<br>In dry years, average monthly Delta outflow would be increased in July through May (up to 3,384 cfs) and reduced in June (526 cfs).<br>**Reverse Flows in Old and Middle Rivers**<br>In wet years, OMR flows would be more positive in September through February, April and May (up to 10,017 cfs) and more negative in March and June through August (up to 964 cfs).<br>In dry years, OMR flows would be more positive in September through June (up to 4,724 cfs) and more negative in July and August (up to 2,620 cfs). | |

**Table 5.116 Comparison of CVP and SWP Water Supply Deliveries under the No Action Alternative and Alternatives 1 through 5 to the Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Long-term average annual exports would be 1,051 TAF (18 percent) less under the No Action Alternative as compared to the Second Basis of Comparison.<br>Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 16 percent over the long-term conditions, 30 percent in dry years, and 34 percent in critical dry years.<br>Deliveries to CVP North of Delta M&I contractors would be similar in total; however, deliveries to the American River CVP contractors would be reduced by 6 percent over the long-term conditions, 8 percent in dry years, and 6 percent in critical dry years.<br>Deliveries to CVP South of Delta agricultural water service contractors would be reduced by 23 percent over the long-term conditions, 32 percent in dry years, and 33 percent in critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be reduced by 10 percent over the long-term conditions, 9 percent in dry years, and 5 percent in critical dry years.<br>Deliveries to the Eastside contractors would be similar under the long-term conditions and in dry years but were reduced by 12 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be reduced by 18 percent over the long-term conditions, 18 percent in dry years, and 20 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be reduced by 18 percent over the long-term conditions, 19 percent in dry years, and 22 percent in critical dry years. | Not considered for this comparison. |
| Alternative 1 | Water supply conditions identical under Alternative 1 as under Second Basis of Comparison. | None needed. |
| Alternative 2 | Same water supply effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Long-term average annual exports would be 326 TAF (6 percent) less under Alternative 3 as compared to the Second Basis of Comparison.<br>Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 5 percent over the long-term conditions, 9 percent in dry years, and 11 percent in critical dry years.<br>Deliveries to CVP North of Delta M&I contractors (including American River CVP contractors) would be similar in long-term conditions and dry and critical dry years.<br>Deliveries to CVP South of Delta agricultural water service contractors would be similar over the long-term conditions and reduced by 8 percent in dry years and 14 percent in critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be similar in long-term conditions and dry and critical dry years.<br>Deliveries to the Eastside contractors would be similar under long-term conditions and dry and critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be similar over the long-term conditions and in dry years and reduced by 10 percent in critical dry years. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be similar over the long-term conditions and in dry years and reduced by 11 percent in critical dry years. | |
| Alternative 4 | Water supply conditions identical under Alternative 4 as under Second Basis of Comparison. | None needed. |
| Alternative 5 | Long-term average annual exports would be 1,096 TAF (19 percent) less under Alternative 5 as compared to the Second Basis of Comparison.<br>Deliveries to CVP North of Delta agricultural water service contractors would be reduced by 16 percent over the long-term conditions, 30 percent in dry years, and 31 percent in critical dry years.<br>Deliveries to CVP North of Delta M&I contractors would be similar in long-term conditions and dry and critical dry years; however, American River Contractors would be reduced by 6 percent over the long-term conditions, 9 percent in dry years, and 8 percent in critical dry years.<br>Deliveries to CVP South of Delta agricultural water service contractors would be reduced by 24 percent over the long-term conditions, 33 percent in dry years, and 33 percent in critical dry years.<br>Deliveries to CVP South of Delta M&I contractors would be reduced by 10 percent in long-term conditions, 8 percent in dry years, and 6 percent in critical dry years.<br>Deliveries to the Eastside contractors would be reduced by 5 percent under long-term conditions and dry years and reduced by 19 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP North of Delta water contractors would be reduced by 19 percent over the long-term conditions, 18 percent in dry years, and 21 percent in critical dry years.<br>Deliveries under Table A contracts without Article 21 water to SWP South of Delta water contractors would be reduced by 19 percent over the long-term conditions, 20 percent in dry years, and 23 percent in critical dry years. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

#### *5.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

##### 5.4.3.8.1 Surface Water Conditions

As described above and summarized in Table 5.113, implementation of Alternatives 1 through 5 as compared to the No Action Alternative would result in reductions in river flows downstream of CVP and SWP reservoirs and Delta outflow, and increased negative OMR flows. Environmental effects associated with changes in these physical conditions are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources, and Chapter 10, Terrestrial Biological Resources), and recreation resources (as described in Chapter 15, Recreation Resources). Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 9, 10, and 15.

#### 5.4.3.8.2 CVP and SWP Water Supply Deliveries

Implementation of Alternatives 1 through 4 would not result in adverse impacts to CVP and SWP water deliveries as compared to the No Action Alternative, as summarized in Table 5.114. Therefore, no mitigation measures are required.

Implementation of Alternative 5 would result in up to 8 percent reductions of CVP water deliveries to the Eastside Contractors (Stockton East Water District and Central San Joaquin Water Conservation District) in critical dry years. A potential mitigation measure for this reduction in critical dry years would be:

- Reclamation would support water transfers from other basin water rights holders to the Eastside Contractors. .

### *5.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Water Supplies are summarized in Table 5.117.

**Table 5.117 Summary of Cumulative Effects on Water Supply Deliveries under Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions Included in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>• Implementation of Federal and state policies and programs, including Clean Water Act (e.g.,Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>• General plans for 2030.<br>• Trinity River Restoration Program.<br>• Central Valley Project Improvement Act programs<br>• Iron Mountain Mine Superfund Site<br>• Nimbus Fish Hatchery Fish Passage Project<br>• Folsom Dam Water Control Manual Update<br>• FERC Relicensing for the Middle Fork of the American River Project<br>• Lower Mokelumne River Spawning Habitat Improvement Project<br>• Dutch Slough Tidal Marsh Restoration<br>• Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>• Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>• San Joaquin River Restoration Program<br>• Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>• Grasslands Bypass Project<br>• Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities | These effects would be the same under all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce carryover storage in reservoirs, stream flows and Delta outflow, and the availability of CVP and SWP water supplies as compared to past conditions.<br>Some future water quality and habitat projects could modify surface water conditions; however, water supplies are not anticipated to be affected.<br>Future water supply projects are anticipated to both improve water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Future Actions Considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>• Bay-Delta Water Quality Control Plan Update<br>• FERC Relicensing Projects<br>• Bay Delta Conservation Plan (including the California WaterFix alternative)<br>• Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>• El Dorado Water and Power Authority Supplemental Water Rights Project<br>• Sacramento River Water Reliability Project<br>• Semitropic Water Storage District Delta Wetlands<br>• North Bay Aqueduct Alternative Intake<br>• Irrigated Lands Regulatory Program<br>• San Luis Reservoir Low Point Improvement Project<br>• *Westlands Water District v. United States Settlement*<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same under all alternatives.</u><br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative would result in changes stream flows, increased Delta outflow, and reduced CVP and SWP water supplies as compared to historical conditions prior to the BOs.<br>The availability of future water supply projects (discussed above) could reduce the effects of reduced CVP and SWP water supplies. However, these actions also could result in less water for future growth as compared to future conditions without the No Action Alternative. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternatives 1 and 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>The future water supply projects (discussed above) would be more available to provide water for future growth as compared to future conditions with the No Action Alternative. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions for water supplies would be the same as for the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>The future water supply projects (discussed above) would be more available to provide water for future growth as compared to future conditions with the No Action Alternative. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in changes in stream flows, increased Delta outflows, and reduced CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>The availability of future water supply projects (discussed above) could reduce the effects of reduced CVP and SWP water supplies. However, these actions also could result in less water for future growth as compared to future conditions under the No Action Alternative. |

## 5.5 References


Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan*. Final. 2013 Update.

AVEK (Antelope Valley-East Kern Water Agency). 2011. *Water Supply Stabilization Project No. 2 Implementation Grant Proposal*.

AVRWC (Apple Valley Ranchos Water Company). 2011. *2010 Urban Water Management Plan*. Adopted June 23, 2011.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html.

BLM et al. (Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Forest Service). 2012. *River Mileage Classifications for Components of the National Wild and Scenic Rivers System*. September.

BVWSD (Buena Vista Water Storage District). 2015. Buena Vista Water Storage District, James Groundwater Storage and Recovery Project. Site accessed February 15, 2015. http://bvh2o.com/James.html.

CALFED. 2004. *Environmental Water Program Pilot Flow Augmentation Project: Concept Proposal for Flow Acquisition on Lower Clear Creek*. August.

Camp Far West (Camp Far West Events). *Camp Far West Lake*. Site accessed May 19, 2014. http://www.campfarwestlake.net/aboutus.htm

Carlsbad MWD (Carlsbad Metropolitan Water District). 2012. *Approval of a Mitigated Negative Declaration for Carlsbad Municipal Water District Phase III Recycled Water Project, Draft Initial Study/Mitigated Negative Declaration*. November 27.

CBC (Clark Broadcasting Corporation). 2013. Destination Guide – Lake Tulloch. Site accessed February 25, 2013. http://www.mymotherlode.com/community/destination/lake-tulloch.

CBMWD (Central Basin Municipal Water District). 2011. *2010 Urban Water Management Plan*. Draft. March.

CCSD (Cambria Community Services District). 2014. *Cambria Emergency Water Supply Project*. June.

CCSF (City and County of San Francisco). 2009. *Draft Environmental Impact Report, San Francisco Public Utilities Commission, Calaveras Dam Replacement Project*. October 6.

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://www.lbwater.org/overview-long-beach-seawater-desalination-project.

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

____. 2010. *Water System Ten-Year Capital Improvement Program for the Fiscal Years 2010-2019*.

____. 2011. *Urban Water Management Plan, 2010*. May 3.

____. 2013. *Tujunga Spreading Grounds Enhancement Project, Final Environmental Impact Report*. April.

City of Oceanside. 2012. *Oceanside Harbor Desalination Testing Project*.

City of Oxnard. 2013. *GREAT Program Update, City Council Report, December 10, 2013, Draft*. November 22.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2002. *Long-Range Water Resources Plan (2002-2030)*. December 9.

____. 2009a. *Fact Sheet: Mission Valley Basin*. September 11.

____. 2009b. *Fact Sheet: San Pasqual Basin*. September 11.

____. 2014a. Reservoirs: Barrett Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/barrett/index.shtml.

____. 2014b. Reservoirs: Sutherland Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/sutherland.shtml.

____. 2014c. Reservoirs: El Capitan Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/elcapitan.shtml.

____. 2014d. Reservoirs: Morena Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/morena.shtml.

____. 2014e. Reservoirs: Lower Otay Reservoir. Site accessed September 17, 2014. http://www.sandiego.gov/water/recreation/reservoirs/lowerotay.shtml

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp.

CRS (Congressional Research Service). 2015. *California Drought: Hydrological and Regulatory Water Supply Issues*. August 14.

CVPIA (Central Valley Project Improvement Act Program). 2013. *Draft CVPIA Fiscal Year 2014 Annual Work Plan, Clear Creek Restoration, CVPIA Section 3406(b)(12)*.

____. 2014. *Draft CVPIA Fiscal Year 2015 Annual Work Plan, Clear Creek Restoration, CVPIA Section 3406(b)(12)*.

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html.

DOI (U.S. Department of the Interior). 2000. *U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report December 2000*. December.

____. 2014. *Trinity River Division Authorization's 50,000 acre-foot Proviso and the 1959 Contract between the Bureau of Reclamation and Humboldt County, from Solicitor to Secretary of the Department of the Interior*. December 23.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.Drought Monitor. 2015. Site accessed October 29, 2015. http://droughtmonitor.unl.edu/MapsAndData/Data Tables. aspx

DWR (California Department of Water Resources). 1957. *Bulletin Number 3 California Water Plan*.

____. 1984. *The Potential for Rehabilitating Salmonid Habitat in Clear Creek, Shasta County*. June.

____. 1986. *Clear Creek Fishery Study*. March.

____. 1994. *California Water Plan Update Volume 1. Bulletin 160 93*. October.

____. 1997. *Quail Lake*. July.

____. 2005. *The Simulation of Natural Flows in Middle Piru Creek, Final Environmental Impact Report*. January.

____. 2007a. *Draft Environmental Impact Report Oroville Facilities Relicensing*—FERC Project No. 2100. May.

____. 2007b. *Monterey Plus Draft Environmental Impact Report*. October.

____. 2009a. *California Water Plan Update 2009*. Bulletin 160-09.

_____. 2009b. *East Branch Extension Phase I Improvements Project, Draft Supplemental Environmental Impact Report No. 2*. March.

_____. 2010a. *Perris Dam Remediation Program, Draft Environmental Impact Report*. January.

_____. 2010b. *The State Water Project Delivery Reliability Report 2009*. August.

_____. 2011. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

_____. 2012. *The State Water Project, Final Delivery Reliability Report, 2011*. June.

_____. 2013a. *California Water Plan Update 2013 – Public Review Draft*.

_____. 2013b. *Upper Feather River Lakes*. April.

_____. 2013c. Thermalito Facilities. Site accessed March 4, 2013. http://water.ca.gov/swp/facilities/Oroville/thermalito.cfm.

_____. 2013d. Trinity Lake, Reservoir Storage. Site accessed October 17, 2013. http://water.ca.gov/cgi-progs/selectQuery?station_id=CLE&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+15:53[10/17/2013 3:54:17 PM].

_____. 2013e. Trinity Lake, Reservoir Elevation. Site accessed October 16, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=CLE&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/16/2013+11:00[10/16/2013 2:22:10 PM].

_____. 2013f. Trinity Lake, Reservoir Outflow. Site accessed October 16, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=CLE&dur_code=D&sensor_num=23&start_date=10/01/2000+00:00&end_date=10/16/2013+11:00[10/16/2013 11:14:33 AM].

_____. 2013g. Lewiston, Reservoir Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=LEW&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+15:55[10/17/2013 3:55:22 PM].

_____. 2013h. Lewiston, Reservoir Elevation. Site accessed October 16, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=LEW&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/16/2013+14:29[10/16/2013 5:14:34 PM].

____. 2013i. Trinity River at Douglas City. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=DGC&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+16:41[10/15/2013 4:45:05 PM].

____. 2013j. Whiskeytown Dam, Reservoir Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=WHI&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+15:59[10/17/2013 3:58:56 PM].

____. 2013k. Whiskeytown Dam, Reservoir Elevation. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=WHI&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+14:34[10/17/2013 2:41:44 PM].

____. 2013l. Whiskeytown Dam, Reservoir Outflow. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=WHI&dur_code=D&sensor_num=23&start_date=10/01/2000+00:00&end_date=10/17/2013+14:34[10/17/2013 2:37:55 PM].

____. 2013m. Shasta Dam, Reservoir Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SHA&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+15:56[10/17/2013 3:56:38 PM].

____. 2013n. Shasta Dam, Reservoir Elevation. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SHA&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+14:03[10/17/2013 2:15:43 PM].

____. 2013o. Shasta Dam, Reservoir Outflow. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SHA&dur_code=D&sensor_num=23&start_date=10/01/2000+00:00&end_date=10/17/2013+13:50[10/17/2013 1:51:24 PM].

____. 2013p. Keswick Reservoir, Reservoir Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=KES&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+15:57[10/17/2013 3:57:44 PM].

____. 2013q. Keswick Reservoir, Reservoir Elevation. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=KES&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+14:26[10/17/2013 2:30:34 PM].

____. 2013r. Keswick Reservoir, Reservoir Outflow. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=KES&dur_code=D&sensor_num=23&start_date=10/01/2000+00:00&end_date=10/17/2013+14:23[10/17/2013 2:24:39 PM].

____. 2013s. Clear Creek nr Igo. Site accessed December 17, 2013. http://cdec.water.ca.gov/...y?station_id=IGO&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=12/17/2013+11:14[12/17/2013 11:36:28 AM].

____. 2013t. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

____. 2013u. Sacramento River at Bend Bridge. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=BND&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+16:16[10/15/2013 4:18:45 PM].

____. 2013v. Sacramento River at Vina Bridge – Main Ch. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=VIN&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+16:50[10/15/2013 4:50:14 PM].

____. 2013w. Sacramento River at Hamilton City – Main Ch. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=HMC&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:01[10/15/2013 5:01:30 PM].

____. 2013x. Sacramento River Below Wilkins Slough. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=WLK&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:11[10/15/2013 5:11:13 PM].

____. 2013y. Sacramento River at Verona. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=VON&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:16[10/15/2013 5:17:34 PM].

____. 2013z. Sacramento River at Freeport. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=FPT&dur_code=D&sensor_num=20&start_date=10/01/2000+00:00&end_date=10/17/2013+16:36[10/17/2013 4:42:46 PM].

____. 2013aa. Sacramento River at Fremont Weir (Crest 33.5’). Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=FRE&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:09[10/15/2013 5:09:22 PM].

____. 2013ab. Oroville Dam. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=ORO&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:00[10/17/2013 4:02:16 PM].

____. 2013ac. Oroville Dam. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=ORO&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+14:45[10/17/2013 2:49:41 PM].

____. 2013ad. Thermalito Storage. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=TAB&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:04[10/17/2013 4:04:49 PM].

____. 2013af. Feather River. Site accessed October 15, 2013.

____. 2013ag. Folsom Lake. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=FOL&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:07[10/17/2013 4:10:33 PM].

____. 2013ah. Folsom Lake. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=FOL&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+14:51[10/17/2013 2:58:56 PM].

____. 2013ai. Lake Natoma (Nimbus Dam). Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=NAT&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:14[10/17/2013 4:14:24 PM].

____. 2013aj. Lake Natoma (Nimbus Dam). Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=NAT&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+15:01[10/17/2013 3:06:50 PM].

____. 2013ak. American River. Site accessed October 15, 2013.

____. 2013al. San Joaquin River Near Mendota. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=MEN&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:19[10/15/2013 5:19:55 PM].

____. 2013am. San Joaquin River near Vernalis. Site accessed October 15, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=VNS&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=10/15/2013+17:23[10/15/2013 5:23:56 PM].

____. 2013an. New Melones Reservoir. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=NML&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:15[10/17/2013 4:16:44 PM].

____. 2013ao. *New Melones Reservoir*. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=NML&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+15:09[10/17/2013 3:29:57 PM].

____. 2013ap. Goodwin Dam. Site accessed December 18, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=GDW&dur_code=D&sensor_num=15&start_date=10/01/2000+00:00&end_date=12/18/2013+14:20[12/18/2013 2:35:54 PM].

____. 2013aq. Goodwin Dam. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=GDW&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+15:35[10/17/2013 3:37:54 PM].

____. 2013ar. Stanislaus River at Orange Blossom Bridge. Site accessed December 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=OBB&dur_code=D&sensor_num=41&start_date=10/01/2000+00:00&end_date=12/17/2013+17:45[12/17/2013 5:51:03 PM].

____. 2013as. San Luis Reservoir. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SNL&dur_code=M&sensor_num=15&start_date=10/01/2000+00:00&end_date=10/17/2013+16:57[10/17/2013 4:59:39 PM].

____. 2013at. San Luis Reservoir. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SNL&dur_code=D&sensor_num=6&start_date=10/01/2000+00:00&end_date=10/17/2013+16:57[10/17/2013 5:00:20 PM].

____. 2013au. Delta Outflow. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=DTO&dur_code=D&sensor_num=23&start_date=10/01/2000+00:00&end_date=10/17/2013+16:55[10/17/2013 4:56:04 PM].

____. 2013av. Tracy Pumping Plant. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=TRP&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:51[10/17/2013 4:52:19 PM].

____. 2013aw. Harvey O Banks Pumping Plant. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=HRO&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:44[10/17/2013 4:45:06 PM].

____. 2013ax. Barker Slough Pumping Plant. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=BKS&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:53[10/17/2013 4:53:59 PM].

____. 2013ay. CCWD Rock Slough PP Near Brentwood. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=INB&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:48[10/17/2013 4:48:08 PM].

____. 2013az. CCWD Old River PP Near Discovery Bay. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=IDB&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:46[10/17/2013 4:46:59 PM].

____. 2013ba. CCWD Middle River PP on Victoria Canal. Site accessed October 17, 2013. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=CCW&dur_code=D&sensor_num=70&start_date=10/01/2000+00:00&end_date=10/17/2013+16:50[10/17/2013 4:50:14 PM].

____. 2014a. Chronological Reconstructed Sacramento and San Joaquin Valley, Water Year Hydrologic Classification Indices. Site accessed September 24, 2014. http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

____. 2014b. Division of Safety of Dams, Listing of Dams. Site accessed September 3, 2014. http://www.water.ca.gov/damsafety/damlisting/.

____. 2014c. California Data Exchange Center, Reservoir Information, Sorted by Dam Name. Site accessed September 16, 2014. http://cdec.water.ca.gov/misc/resinfo.html.

____. 2014d. Klamath River near Klamath (KNK). Site accessed September 4, 2014. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=KNK&dur_code=D&sensor_num=41&start_date=09/04/2014.

____. 2014e. *Notice to State Water Project Contractors, 2014 State Water Project Allocation Scheduling Revision*. May 30.

____. 2015. *Notice to State Water Project Contractors, 2015 State Water Project Allocation Increase – 20 Percent*. March 2.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper), Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

DWR et al. (California Department of Water Resources, Yuba County Water Agency, Bureau of Reclamation). 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord*. June.

EBMUD (East Bay Municipal Utility District). 2011. *Urban Water Management Plan 2010*. June.

____. 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

EMWD (Eastern Municipal Water District). 2014a. *Administrative Draft, Mitigated Negative Declaration, Temecula Valley Regional Water Reclamation Facility, 23 MGD Expansion*. January.

____. 2014b. *San Jacinto Regional Water Reclamation Facility*. March.

____. 2014c. *Indirect Potable Reuse Program*. January 8.

____. 2014d. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

FERC (Federal Energy Regulatory Commission). 2012. *Draft Environmental Impact Statement for Hydropower License, Middle Fork American River Hydroelectric Project – FERC Project No. 2079-069.* July.

____. 2013. *Draft Environmental Impact Statement for the Drum-Spaulding Project (P-2310-173) and Yuba-Bear Hydroelectric Project (P-2266-096).* May 17.

____. 2015. *FERC: Hydropower- General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp.

FID (Fresno Irrigation District). 2015. FID Pond Measurement – State of California DWR LGA Grant. Site accessed February 13, 2015. http://www.fresnoirrigation.com/index.php?c=36.

Frantzich, J. 2014. *Yolo Bypass as a Source of Delta Phytoplankton: Not Just a Legend of the Fall?* Presented at the Interagency Ecological Program 2014 Annual Workshop, Friday February 28, 2014. Site accessed May 19, 2015. http://www.water.ca.gov/aes/staff/frantzich.cfm.

Hudley, Norris. 2001. *The Great Thirst – Californians and Water: A History*. Revised edition.

IEUA (Inland Empire Utilities Agency). 2015. *Draft Fiscal Year 2015/16 Ten-Year Capital Improvement Plan*. January.

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

KEYT (KEYT News). 2015. *Santa Barbara Desalination Plant Permit Approved*. Site accessed February 19, 2015. http://www.keyt.com/news/santa-barbara-desal-plant-permit-approved/31055434.

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP)*.

LACSD (Los Angeles County Sanitation District). 2005. *Final Palmdale Water Reclamation Plant 2025 Plan and Environmental Impact Report*. September.

Los Angeles County (County of Los Angeles). 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

LYRARMT (Lower Yuba River Accord, River Management Team). 2013. *Interim Monitoring & Evaluation Report*. April 8.

Marshall, Colonel Robert Bradford. 1919. *Irrigation of Twelve Million Acres in the Valley of California*. Distributed by the California State Irrigation Association. March 16.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html.

MWA (Mojave Water Agency). 2014. *Silverwood Lake*. Site accessed September 15, 2014. http://www.mojavewater.org/silverwood-lake.html.

Mulholland, Catherine. 2000. *William Mulholland and the Rise of Los Angeles*.

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome.

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

PFMC (Pacific Fishery Management Council). 2015. *Pacific Fishery Management Council Meeting*. November.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

____. 2012. *Agricultural Water Management Plan*. December 13.

Reclamation (Bureau of Reclamation). 1994. *San Felipe Division, The Central Valley Project.*

____. 1997. *Draft Central Valley Project Improvement Act – Programmatic Environmental Impact Statement/Report.* September.

____. 2005. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

____. 2009a. Whiskeytown Dam Hydraulics and Hydrology. June 4. Site accessed January 26, 2015 http://www.usbr.gov/projects/Facility.jsp?fac_Name=Whiskeytown+Dam&groupName=Hydraulics+26+Hydrology.

____. 2009b. Keswick Dam. Site accessed February 28, 2013. http://www.usbr.gov/projects/Facility.jsp?fac_Name=Keswick+Dam&groupName=Hydraulics+26+Hydrology. June.

____. 2010a. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

____. 2010b. *Draft Environmental Assessment, Antelope Valley Water Bank Initial Recharge and Recovery Facilities Improvement Project*. January.

____. 2010c. *Cachuma Lake, Final Resource Management Plan/Environmental Impact Statement*. May.

____. 2011a. Updated Information Pertaining to the 2008 Biological Opinion for Coordinated Long-Tem Operation of the Central Valley Project (CVP) and State Water Project (SWP). Letter from Susan M. Fry, Reclamation Bay-Delta Office Manager to Michael A. Chotkowski, U.S. Fish and Wildlife Service Field Supervisor. August 26.

____. 2011b. Shasta/Trinity River Division Project, Project Data. April 2011. Site accessed January 26, 2015 http://www.usbr.gov/projects/Project.jsp?proj_Name=Shasta/Trinity River Division Project&pageType=ProjectDataPage.

____. 2011c. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

____. 2012. *Colorado River Basin Water Supply and Demand Study*. December.

____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

____. 2014a. Orland Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Orland+Project.

____. 2014b. San Luis Unit Project. Site accessed September 13, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=San Luis Unit Project.

____. 2014c. Cachuma Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Cachuma+Project.

____. 2014d. Shasta/Trinity River Division Project. Site accessed September 14, 2014. http://www.usbr.gov/projects/Project.jsp?proj_Name=Shasta/Trinity River Division Project.

____. 2014e. Spring Creek Debris Dam and Powerplant. Site accessed September 19, 2014. http://www.usbr.gov/mp/headlines/2014/June/Photo_of_the_Week6-16-14.pdf.

____. 2014f. *Battle Creek Salmon and Steelhead Restoration Project*. Site accessed September 19, 2014. http://www.usbr.gov/mp/battlecreek/about.html

____. 2014g. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

____. 2014h. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

____. 2014i. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

____. 2014j. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

____. 2015. *Central Valley Project Summary of Water Supply Allocations (1977 to 2015). Site accessed October 29, 2015. http://www.usbr.gov/mp/cvo*Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2011. *San Joaquin River Restoration Program Environmental Impact Statement/Report*.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2014a. *CVP and SWP Drought Contingency Plan, October 15, 2014 through January 15, 2015, Balancing Multiple Needs in Fall 2014.* October 15.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2014b. *Interagency 2015 Drought Strategy for the Central Valley Project and State Water Project, Working Draft. December 11.*

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2015a. *Central Valley Project and State Water Project Drought Contingency Plan, January 15, 2015 – September 30, 2015.* January 15.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2010. *Millerton Lake Final Resource Management Plan/General Plan Environmental Impact Statement/Environmental Impact Report*. April.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

SBCWD (San Benito County Water District). 2014. *West Hills Water Treatment Plant Project, Draft Environmental Impact Report*. January.

SCVWD (Santa Clara Valley Water District). 2012a. *2011 Urban Water Management Plan 2010*. May.

____. 2012b. *2012 Water Supply and Infrastructure Master Plan*. October.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

____. 2014. *Fact Sheet, The Carlsbad Desalination Project*.

____. 2015. Seawater Desalination. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination.

SDCWA and USACE (San Diego County Water Authority and U.S. Army Corps of Engineers). 2008. *Final Environmental Impact Report/Environmental Impact Statement for the Carryover Storage and San Vicente Dam Raise Project*. April.

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html.

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011a. *Draft Program Environmental Impact Statement/Environmental Impact Report*. April.

____. 2011b. *Friant-Kern Canal Capacity Restoration, Draft*. June.

____. 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://restoresjr.net/activities/site_specific/madera-canal/index.html

SRWP (Sacramento River Watershed Program). 2014a. *Cow Creek-Bassett Diversion Fish Passage Project*. Site accessed September 19, 2014. http://www.sacriver.org/aboutwatershed/roadmap/projects/cow-creek-bassett-diversion-fish-passage-project.

State Parks and Reclamation (California Department of Parks and Recreation and Bureau of Reclamation). 2003. *Draft Resource Inventory, Folsom Lake State Recreation Area*. April.

____. 2007. *Folsom General Plan/Resource Management Plan Preliminary General Plan & Resource Management Plan, and Draft Environmental Impact Report/Environmental Impact Statement*. November.

SWRCB (State Water Resources Control Board). 1982. *In the Matter of Applications 25988 and 26058 and Application 26434, Decision Approving Applications 25988, 26058, and 26434*. November 18.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

____. 2009a. *In the Matter of Petitions for Reconsideration of Water Quality Certification for the Re-Operation of Pyramid Dam for the California Aqueduct Hydroelectric Project Federal Energy Regulatory Commission Project No. 2426*. August 4.

____. 2009b. *Water Recycling Funding Program (WRFP)*. Site accessed October 29, 2015. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/muirec.shtml

____. 2012. *Public Draft, Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joauqin Delta Estuary: San Joaquin River Flows and Southern Delta Water Quality*. December.

____. 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January.

Tri-Dam Project. 2012. *Tulloch Project, FERC No. 2067, Recreation Plan for Black Creek Arm Day Use Area*. December.

TRRP (Trinity River Restoration Program, including Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service, Hoopa Valley Tribe, Yurok Tribe, California Department of Water Resources, California Department of Fish and Wildlife, and Trinity

County). 2014. Typical Releases. Site accessed September 4, 2014. http://www.trrp.net/restore/flows/typical/.

USACE (U.S.  Army Corps of Engineers). 1991. *Sacramento River, Sloughs, and Tributaries, California 1991 Aerial Atlas Collinsville to Shasta Dam*.

USACE (U.S. Army Corps of Engineers). 2012. *Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir, and Daguerre Point Dam on the Yuba River*. January.

____. 2013. *Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River*. October.

____. 2014. Recreation at Englebright Lake. Site accessed May 19, 2014. http://www.spk.usace.army.mil/Locations/SacramentoDistrictParks/EnglebrightLake.aspx.

USFS (U.S.  Department of Agriculture, Forest Service).  2006a.  *Lake Davis Recreation Area*.  May.

USFS (U.S.  Department of Agriculture, Forest Service).  2006b.  *Frenchman Lake Recreation Area*.  May.

USFS (U.S.  Department of Agriculture, Forest Service).  2011.  *Antelope Lake Recreation Area*.  July.

USFS (U.S.  Department of Agriculture, Forest Service).  2014. *Management Guide Shasta and Trinity Units, Whiskeytown-Shasta-Trinity National Recreation Area*.

USFWS (U.S. Fish and Wildlife Service). 2014a. *Identification of the Instream Flow Requirements for Anadromous Fish in the Streams within the Central Valley of California and Fisheries Investigation, Annual Progress Report, Fiscal Year 2013*. January 2.

USFWS (U.S. Fish and Wildlife Service). 2014b. *Clear Creek Restoration Program. Presentation*.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. *Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report*. October.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

VCWPD and LACDPW (Ventura County Watershed Protection District and Los Angeles County Department of Public Works). 2011. *Geomorphic Assessment of the Santa Clara River Watershed, Synthesis of the Lower and Upper Watershed Studies, Ventura and Los Angeles Counties*. April.

VVWRA (Victor Valley Wastewater Reclamation Authority). 2015. Apple Valley Subregional Water Recycling Plant. Site accessed January 25, 2015. http://vvwra.com/index.aspx?page=122.

WBMWD (Western Basin Municipal Water District). 2011. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

____. 2015a. *Water Recycling Satellite Facilities*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/recycled-water/satellite-facilities.

____. 2015b. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview.

WDCWA (Woodland-Davis Clean Water Agency). 2013. *The Project*. Site accessed February 5, 2013. http://www.wdcwa.com/the_project.

Western Regional Climate Center. 2011. *Climate of California. National Oceanic and Atmospheric Administration Narrative Summaries, Tables, and Maps for Each State with Overview of State Climatologist Programs.* Third edition. Vol. 1. Site accessed July 2011. http://www.wrcc.dri.edu/narratives/CALIFORNIA.htm.

WMWD (Western Municipal Water District). 2015. *Arlington Desalter*. Site accessed January 19, 2015. http://wmwd.com/index.aspx?nid=301&PREVIEW=YES.

WRD (Water Replenishment District). 2012. *Notice of Intent to Adopt a Negative Declaration for Leo J. Vanders Lans Water Treatment Facility Expansion Project, Revised March 9, 2012.* March 9.

____. 2015. *Recirculated Draft Environmental Impact Report, Groundwater Reliability Improvement Program (GRIP), Recycled Water Project*. April.

WSRCD (Western Shasta Resource Conservation District). 1998. *Lower Clear Creek Watershed Management Plan*. September.

____. 2003. *2002 Riparian Revegetation Monitoring Report, Lower Clear Creek Floodway Rehabilitation Project Phases 2A, 2B North & 2B South*. April.

____. 2004. *WY2004 Geomorphic Monitoring Report, Clear Creek Floodplain Rehabilitation Project*. June.

____. 2007a. *Clear Creek Geomorphic Monitoring Project, Shasta County, California, WY 2006 Annual Report*. June.

____. 2007b. *Executive Summary of the 2006 Update to the Clear Creek Gravel Management Plan*. May.

WWD (Westlands Water District). 2013. *Water Management Plan, 2012.* April 19.

YCWA (Yuba County Water Agency). 2012. *Yuba County Water Agency's Yuba River Development Project Relicensing*.

This page left blank intentionally.

# Surface Water Resources and Water Supply Figures

The following figures are included in Chapter 5, Surface Water Resources and Water Supply.

- 5.23 Historical Water Year 2001 – 2012 Sacramento River Mean Daily Flows at Wilkins Slough
- 5.24 Historical Water Year 2001 – 2012 Sacramento River Mean Daily Flows at Verona
- 5.25 Historical Water Year 2001 – 2012 Sacramento River Mean Daily Flows at Freeport
- 5.26 Historical Water Year 2001 – 2012 Flows into Yolo Bypass over Fremont Weir
- 5.27 Historical Water Year 2001 – 2012 Lake Oroville Storage
- 5.28  Historical Water Year 2001 – 2012 Lake Oroville Elevation
- 5.29 Historical Water Year 2001 – 2012 Thermalito Reservoir Storage
- 5.30 Historical Water Year 2008 – 2012 Thermalito Reservoir Elevation
- 5.31 Historical Water Year 2001 – 2012 Feather River Mean Daily Flows near Gridley
- 5.32 Historical Water Year 2001 – 2012 Folsom Lake Storage
- 5.33  Historical Water Year 2001 – 2012 Folsom Lake Elevation
- 5.34 Historical Water Year 2001 – 2012 Lake Natoma Storage
- 5.35  Historical Water Year 2001 – 2012 Lake Natoma Elevation
- 5.36 Historical Water Year 2001 – 2012 American River Mean Daily Flows at Fair Oaks
- 5.37 Historical Water Year 2001 – 2012 San Joaquin River Mean Daily Flows at Mendota
- 5.38 Historical Water Year 2001 – 2012 San Joaquin River Mean Daily Flows at Vernalis
- 5.39 Historical Water Year 2001 – 2012 New Melones Reservoir Storage
- 5.40 Historical Water Year 2001 – 2012 New Melones Reservoir Elevation
- 5.41 Historical Water Year 2001 – 2012 Goodwin Reservoir Storage
- 5.42 Historical Water Year 2001 – 2012 Goodwin Reservoir Elevation
- 5.43 Historical Water Year 2001 – 2012 Stanislaus River Mean Daily Flows at Orange Blossom Bridge
- 5.44 Historical Water Year 2001 – 2012 San Luis Reservoir Storage
- 5.45 Historical Water Year 2001 – 2012 San Luis Reservoir Elevation
- 5.46 Historical Water Year 2001 – 2012 Delta Outflow Mean Daily Flows

- 5.47 Historical Water Year 2001 – 2012 Jones Pumping Plant Mean Daily Flows
- 5.48 Historical Water Year 2001 – 2012 Banks Pumping Plant Mean Daily Flows
- 5.49 Historical Water Year 2008 – 2012 Barker Slough Pumping Plant Mean Daily Flows
- 5.50 Historical Water Year 2008 – 2012 Contra Costa Canal Rock Slough Intake Mean Daily Flows
- 5.51 Historical Water Year 2008 – 2012 Contra Costa Water District Old River Intake Mean Daily Flows
- 5.52 Historical Water Year 2010 – 2012 Contra Costa Water District Middle River Intake Mean Daily Flows
- 5.53 Trinity River below Lewiston Reservoir, Long-Term Average Flow
- 5.54 Trinity River below Lewiston Reservoir, Wet Year, Long-Term Average Flow
- 5.55 Trinity River below Lewiston Reservoir, Dry Year Long-Term Average Flow
- 5.56 Sacramento River downstream of Keswick Reservoir, Long-Term Average Flow
- 5.57 Sacramento River downstream of Keswick Reservoir, Wet Year Long-Term Average Flow
- 5.58 Sacramento River downstream of Keswick Reservoir, Dry Year Long-Term Average Flow
- 5.59 Sacramento River at Freeport, Long-Term Average Flow
- 5.60 Sacramento River at Freeport, Wet Year Long-Term Average Flow
- 5.61 Sacramento River at Freeport, Dry Year Long-Term Average Flow
- 5.62 Feather River downstream of Thermalito, Long-Term Average Flow
- 5.63 Feather River downstream of Thermalito, Wet Year Long-Term Average Flow
- 5.64 Feather River downstream of Thermalito, Dry Year Long-Term Average Flow
- 5.65 American River downstream of Nimbus Dam, Long-Term Average Flow
- 5.66 American River downstream of Nimbus Dam, Wet Year Long-Term Average Flow
- 5.67 American River downstream of Nimbus Dam, Dry Year Long-Term Average Flow

- 5.68 Stanislaus River below Goodwin, Long-Term Average Flow
- 5.69 Stanislaus River below Goodwin, Wet Year Long-Term Average Flow
- 5.70 Stanislaus River below Goodwin, Dry Year Long-Term Average Flow
- 5.71 San Joaquin River at Vernalis, Long-Term Average Flow
- 5.72 San Joaquin River at Vernalis, Wet Year Long-Term Average Flow
- 5.73 San Joaquin River at Vernalis, Dry Year Long-Term Average Flow
- 5.74 Sacramento/San Joaquin River Delta Outflow, Long-Term Average Flow
- 5.75 Sacramento/San Joaquin River Delta Outflow, Wet Year Long-Term Average Flow
- 5.76 Sacramento/San Joaquin River Delta Outflow, Dry Year Long-Term Average Flow
- 5.77 Old and Middle River, Long-Term Average Flow
- 5.78 Old and Middle River, Wet Year Long-Term Average Flow
- 5.79 Old and Middle River, Dry Year Long-Term Average Flow

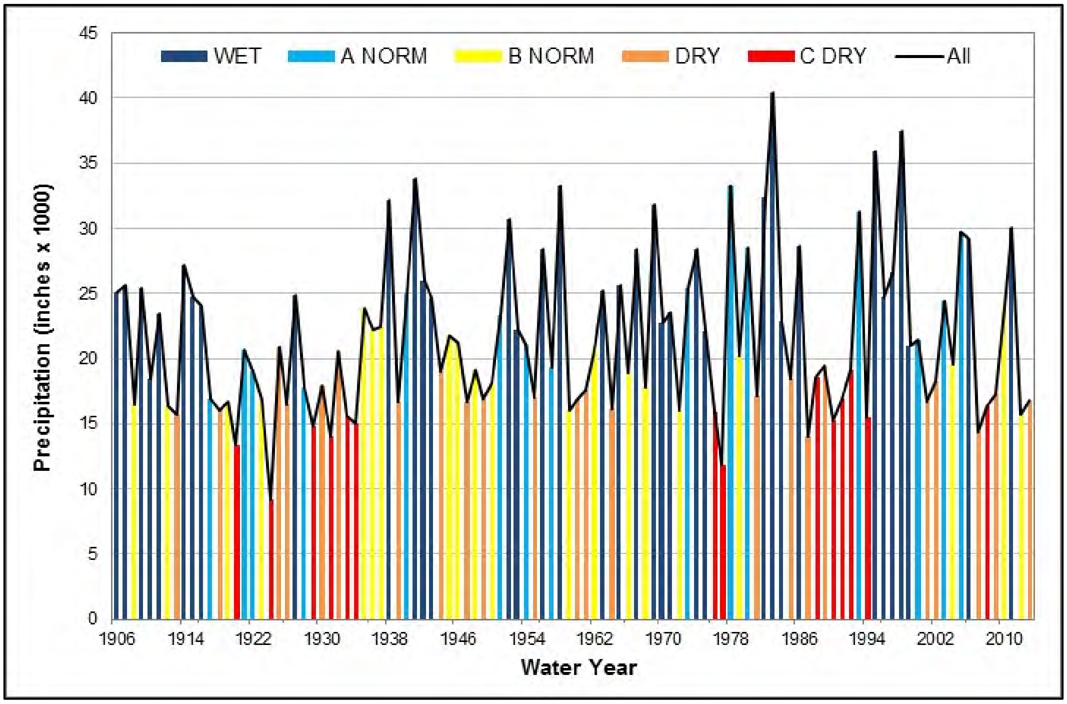
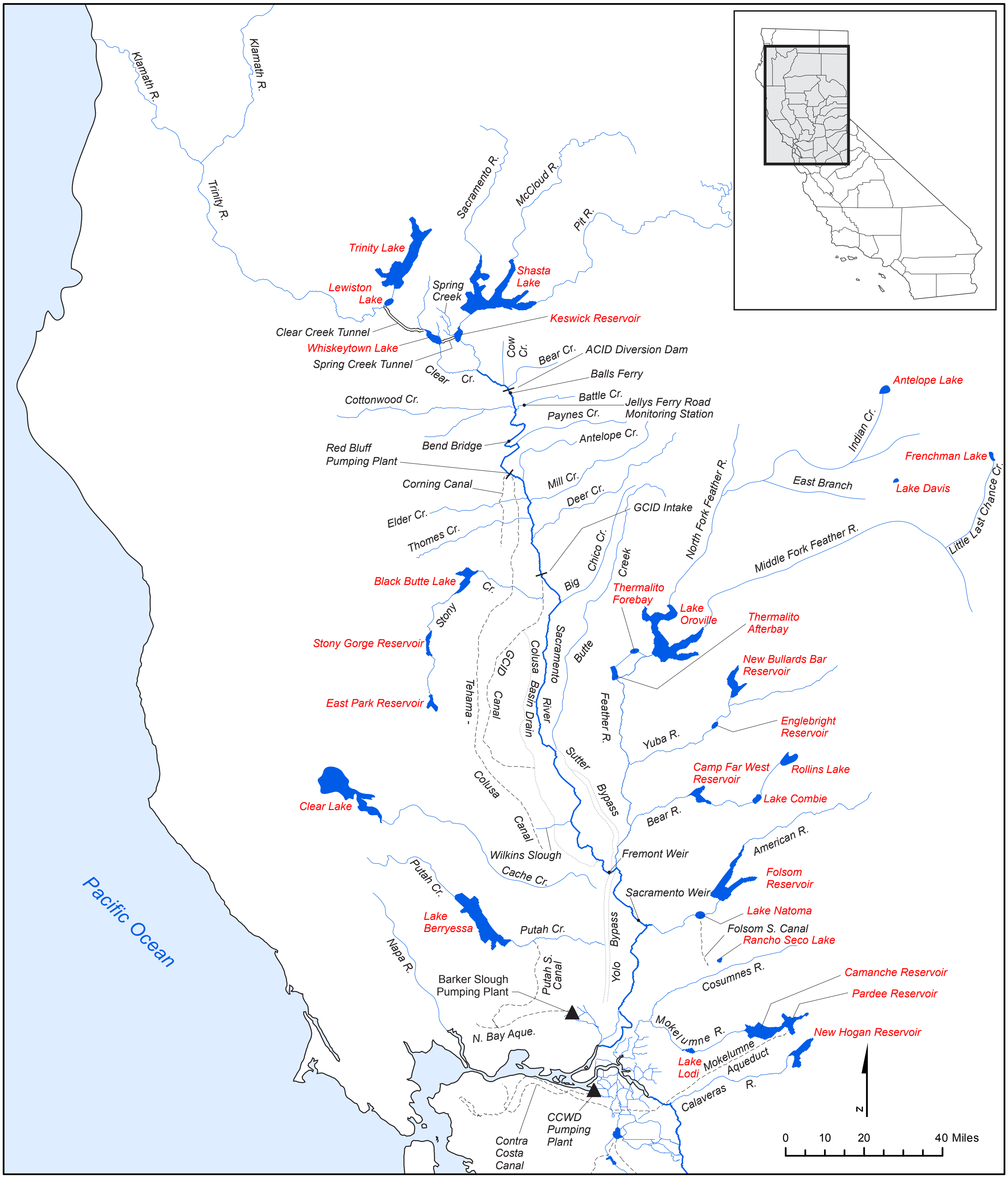
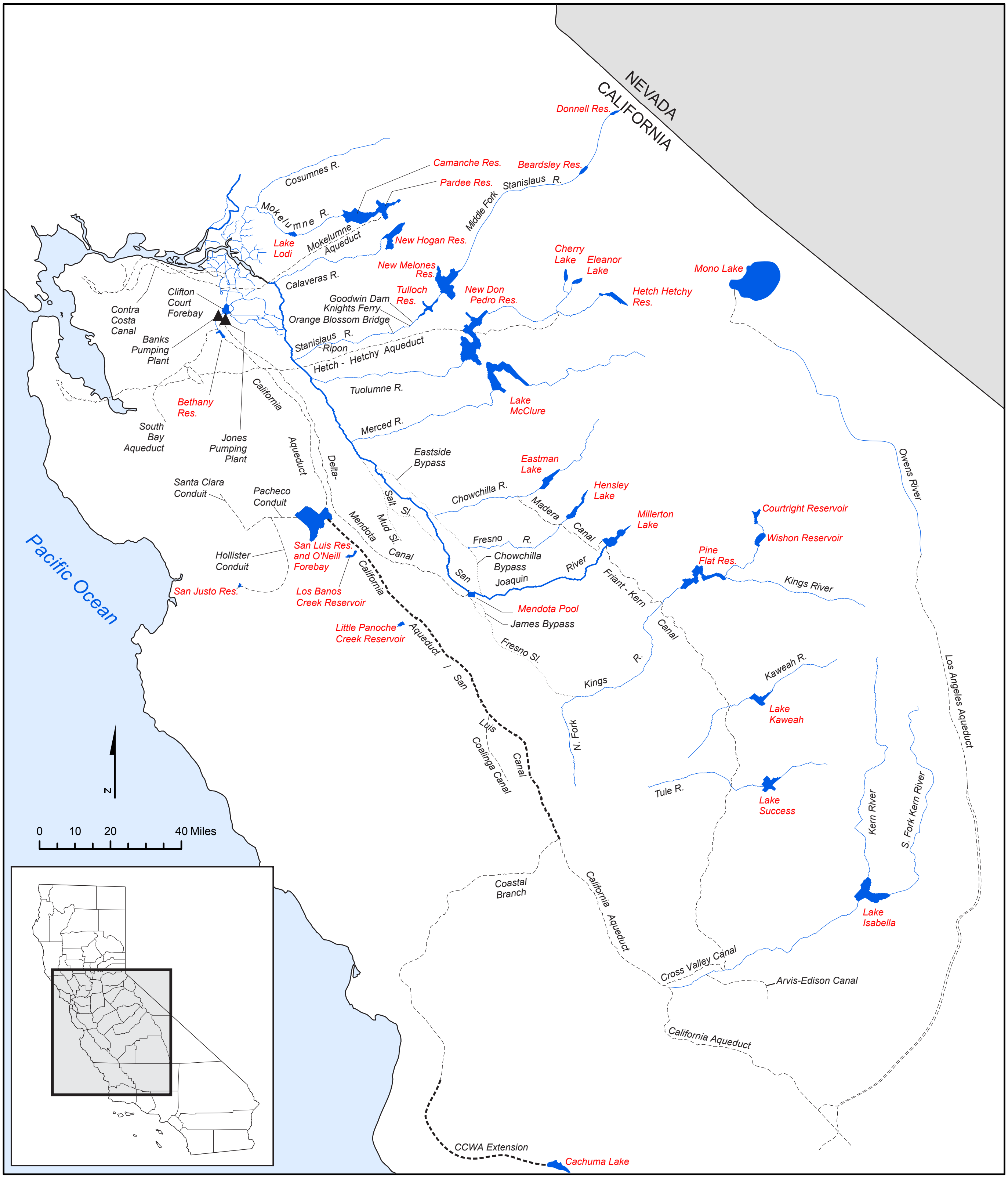



**Figure 5.1 California Precipitation Trends**

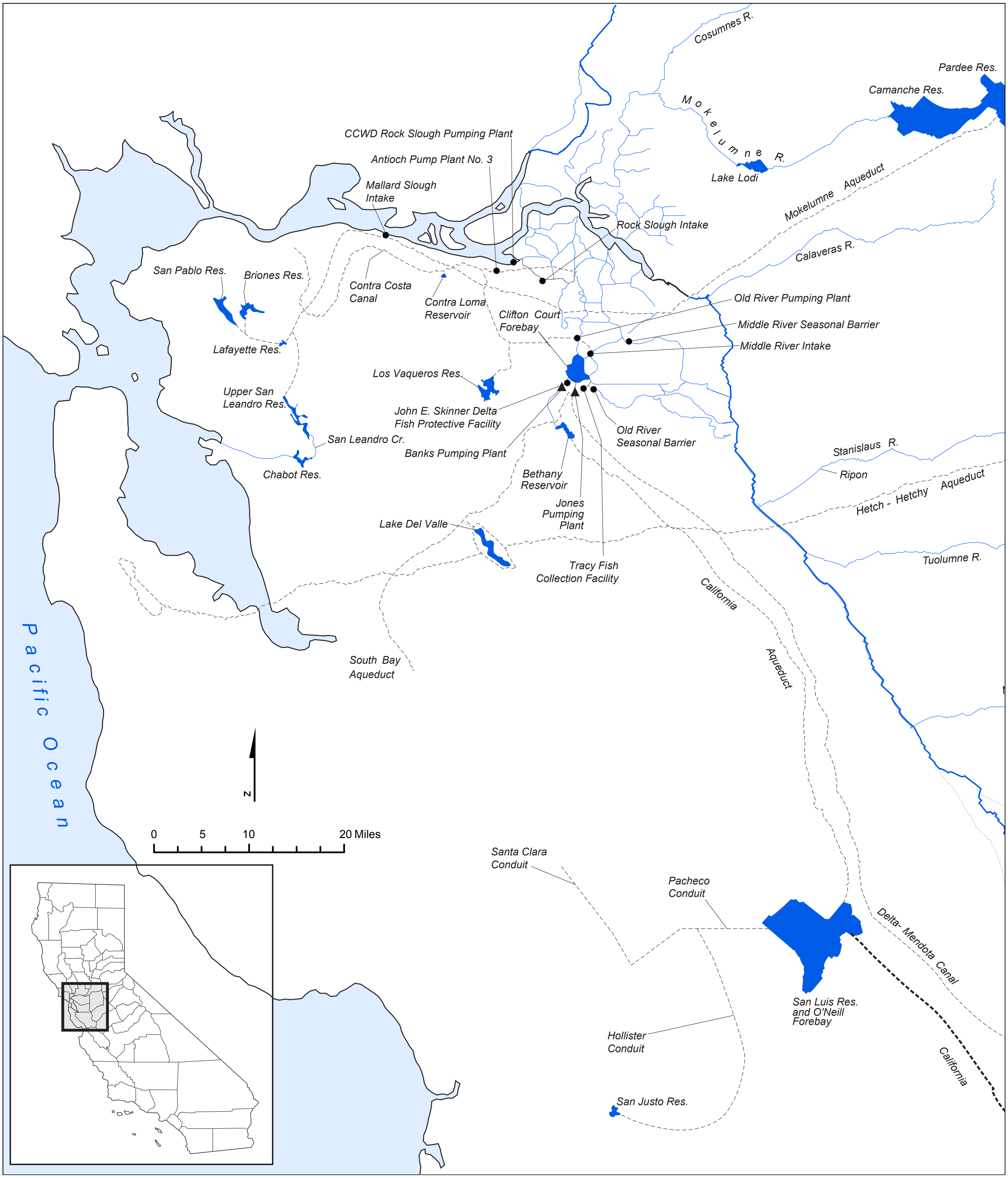

**5.2 California Major Water Supply Facilities**



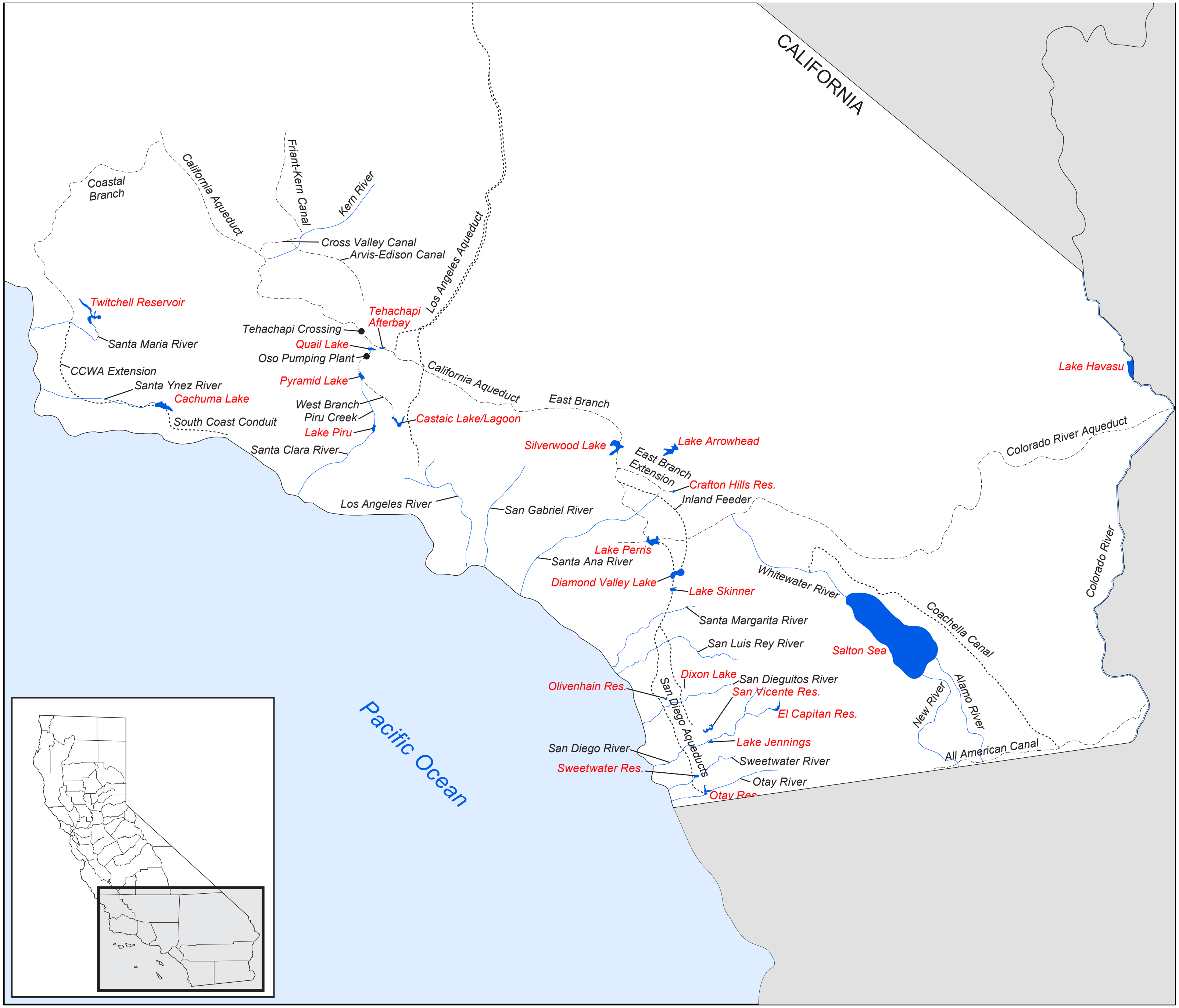

5.3 Northern California Major Water Supply Facilities




**5.4 San Joaquin Valley and Tulare Lake Major Water Supply Facilities**




**5.5 San Francisco Bay Area Major Water Supply Facilities**




**5.6 Central Coast and Southern California Major Water Supply Facilities**

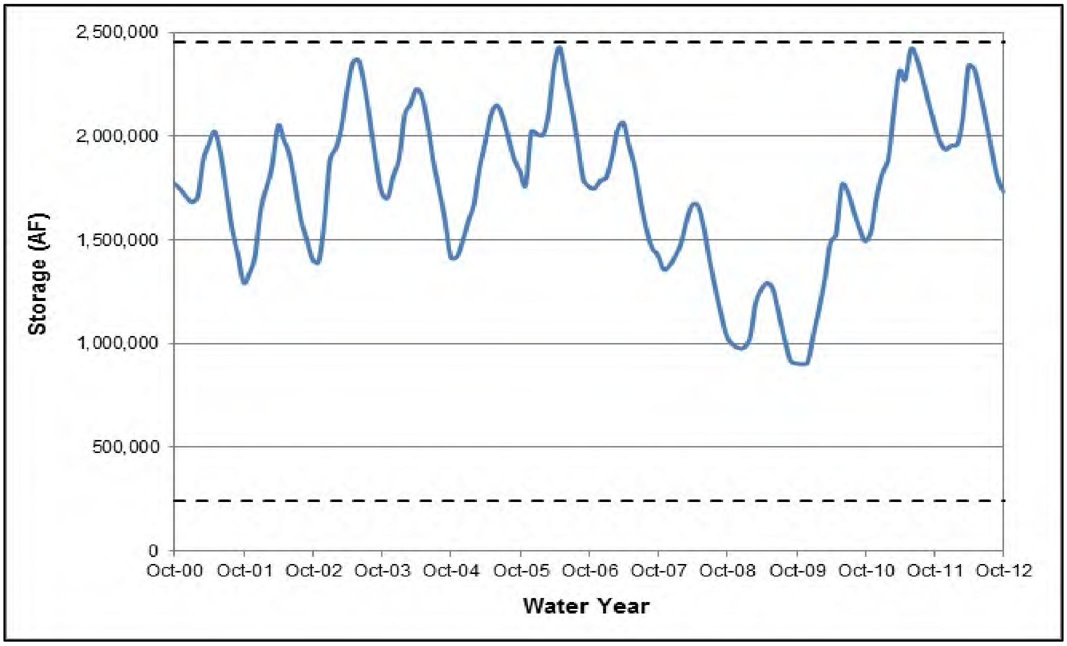



**Figure 5.7 Historical Water Years 2001-2012 Trinity Lake Storage[1]**

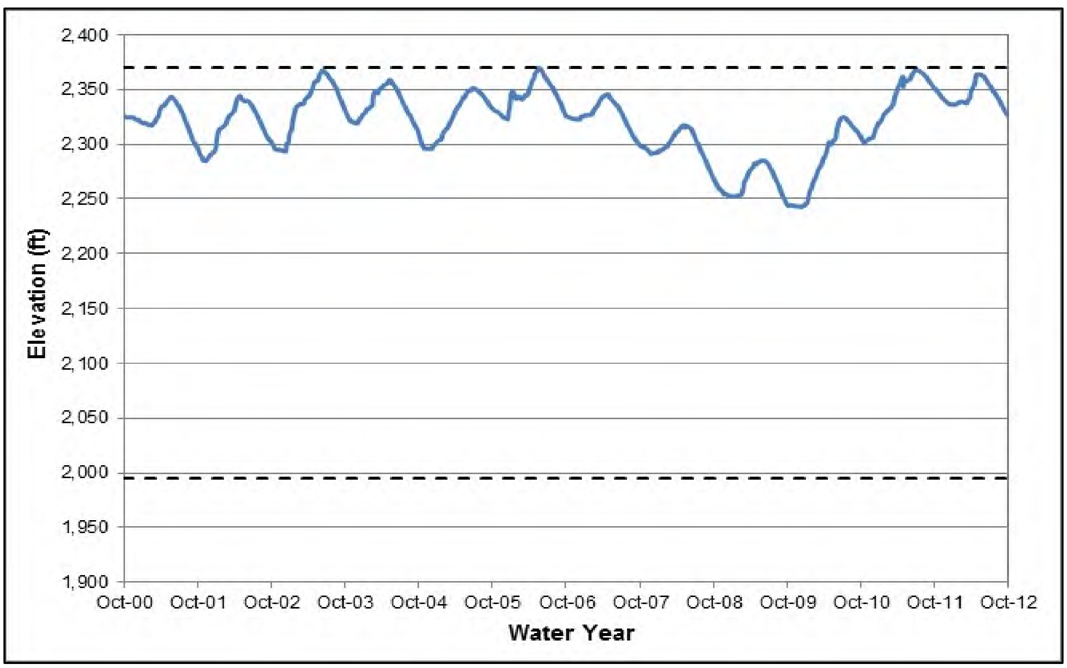



**Figure 5.8 Historical Water Years 2001-2012 Trinity Lake Elevation[2]**

---

[1] The minimum storage line of 240,000 AF was taken from CalSim II. The maximum storage line of 2,448,000 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

[2] The minimum elevation line of 1995 ft was taken from Reclamation's website http://www.usbr.gov/projects/Facility.jsp?fac_Name=Trinity+Dam&groupName=Dimensions. The maximum elevation line of 2,370 ft was provided by Reclamation.

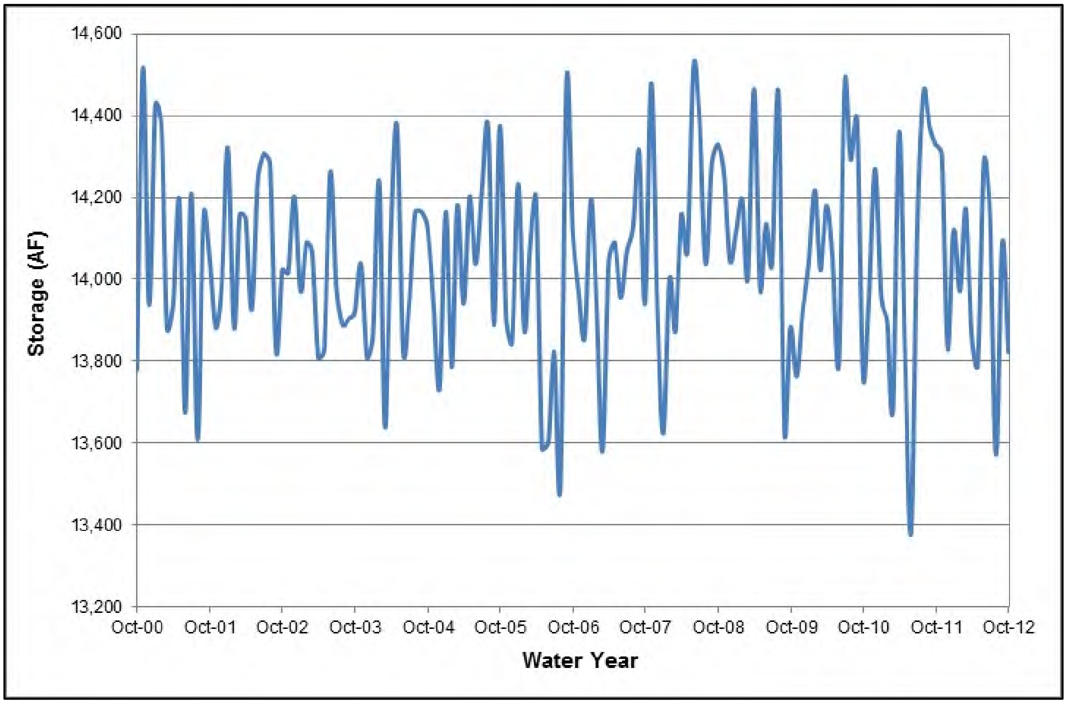



**Figure 5.9 Historical Water Years 2001-2012 Lewiston Reservoir Storage**

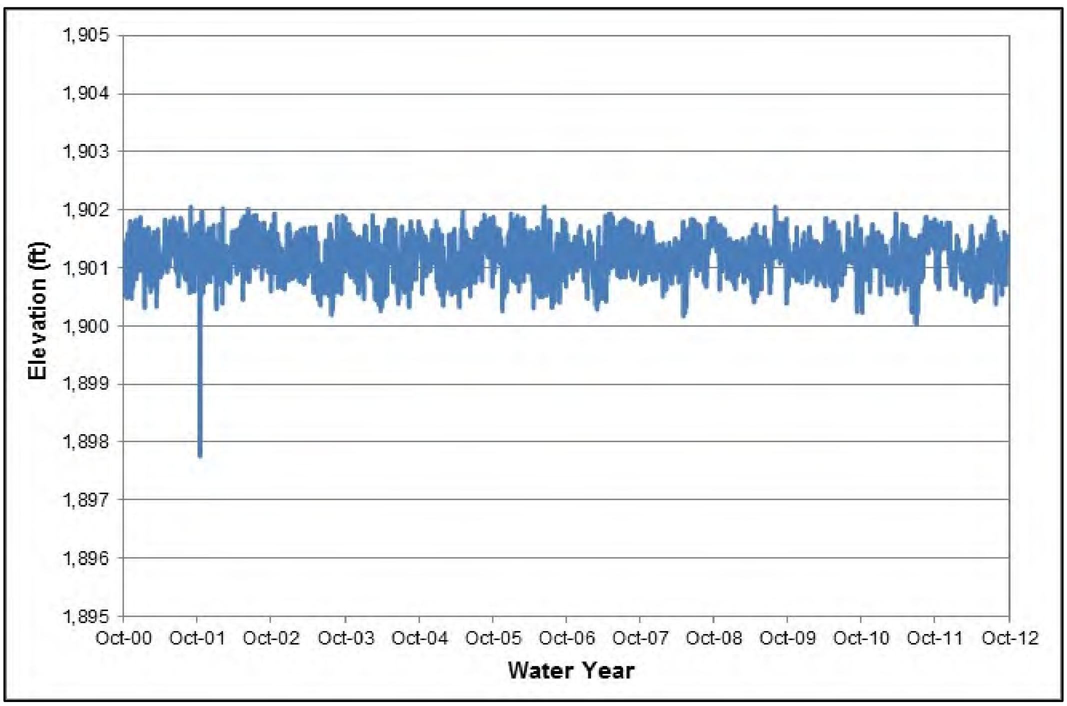



**Figure 5.10 Historical Water Years 2001-2012 Lewiston Reservoir Elevation**

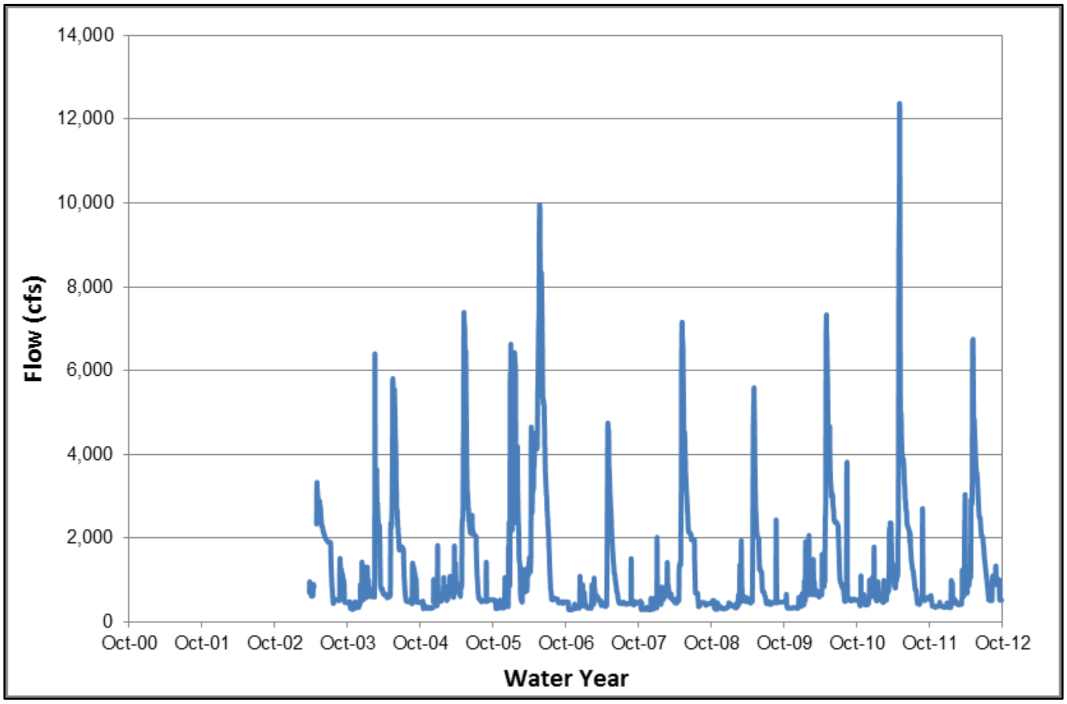



**Figure 5.11 Historical Water Years 2003-2012 Trinity River Mean Daily Flows at Douglas City**

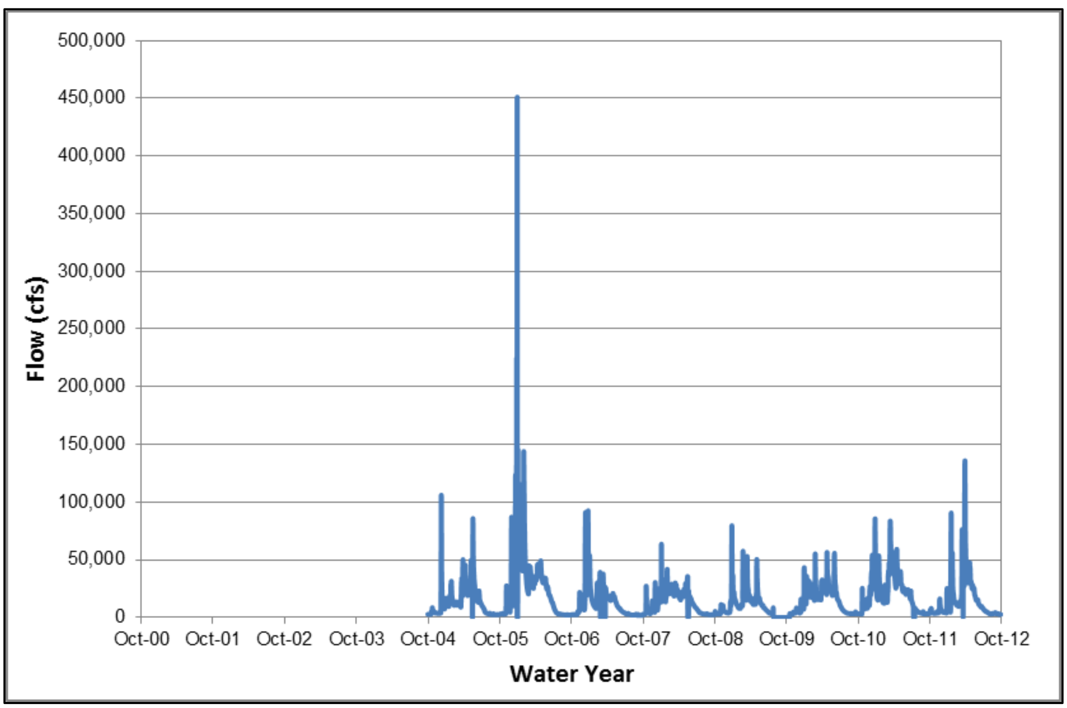



**Figure 5.12 Historical Water Years 2005-2012 Klamath River Mean Daily Flows at Klamath**

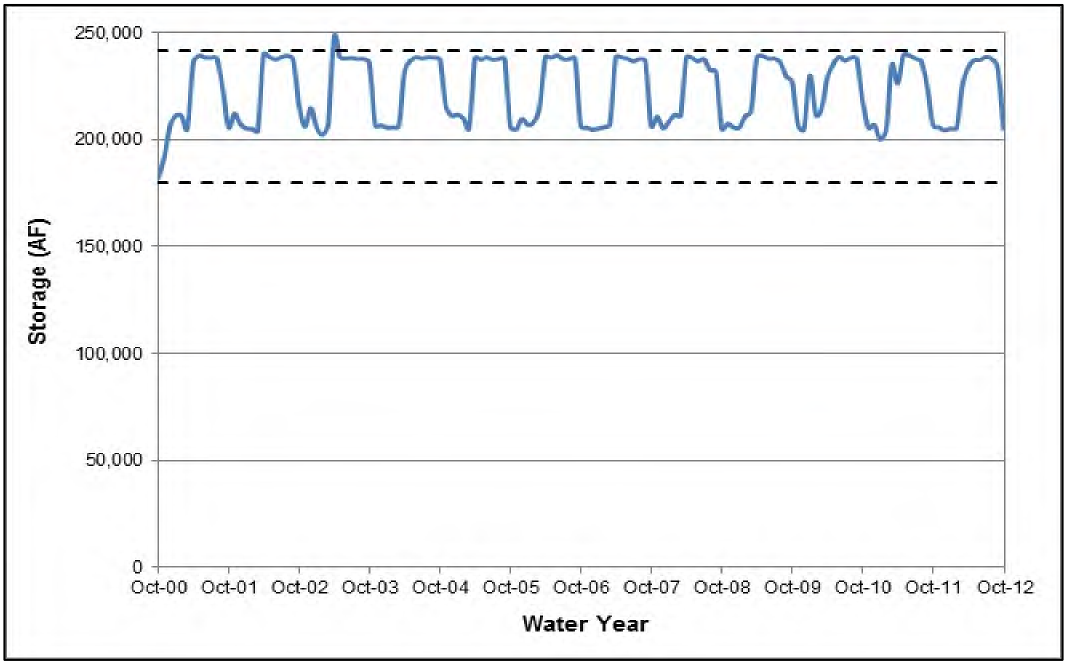



**Figure 5.13 Historical Water Years 2001-2012 Whiskeytown Lake Storage**[3]

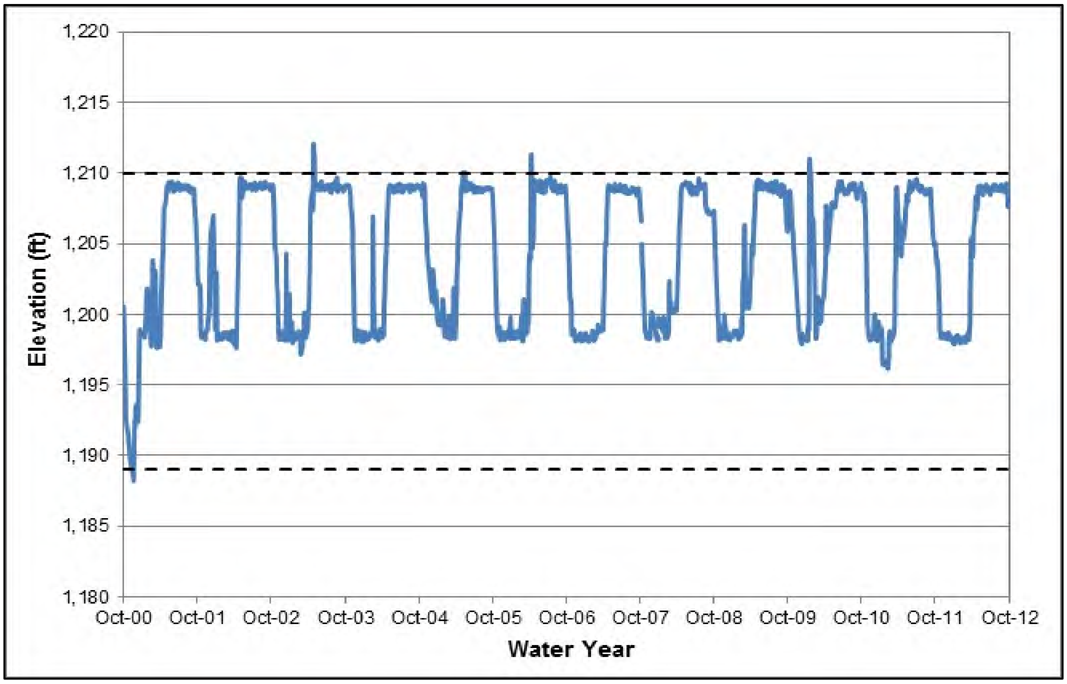



**Figure 5.14 Historical Water Years 2001-2012 Whiskeytown Lake Elevation**[4]

[3] The minimum storage line of 180,000 AF was taken from CalSim II. The maximum storage line of 241,000 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

[4] The minimum elevation line of 1190 ft was taken from CalSim II. The maximum elevation line of 1,210 ft was provided by Reclamation.

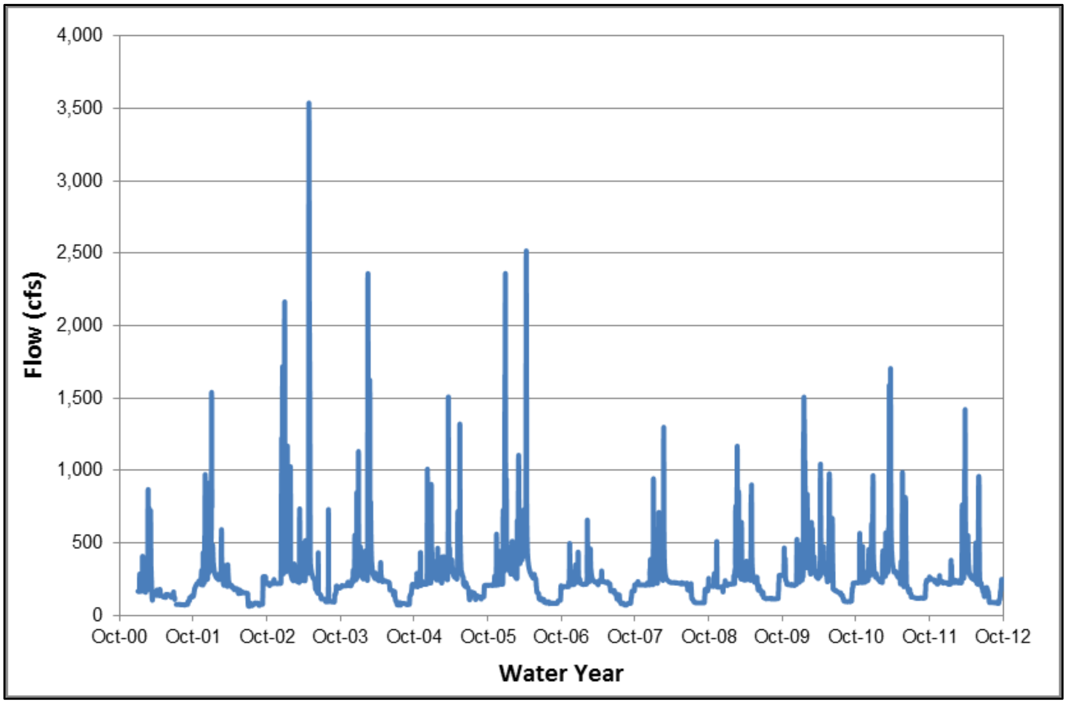



**Figure 5.15 Historical Water Years 2001-2012 Clear Creek Mean Daily Flows at Igo**

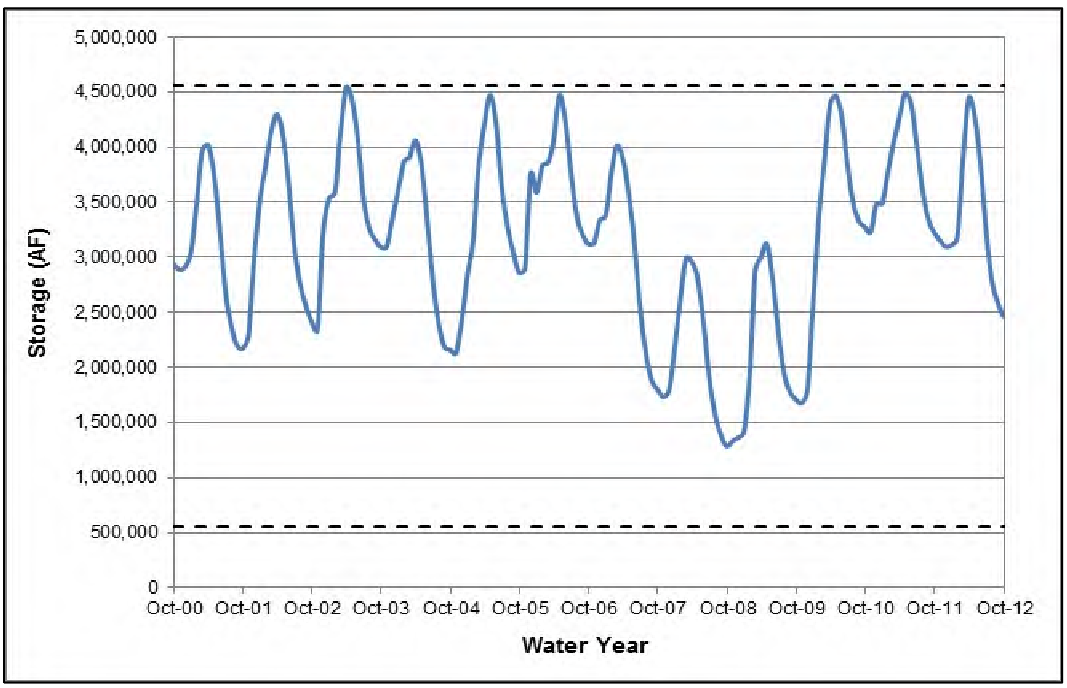



**Figure 5.16 Historical Water Years 2001-2012 Shasta Lake Storage**[5]

[5] The minimum storage line of 550,000 AF was taken from CalSim II. The maximum storage line of 4,552,000 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

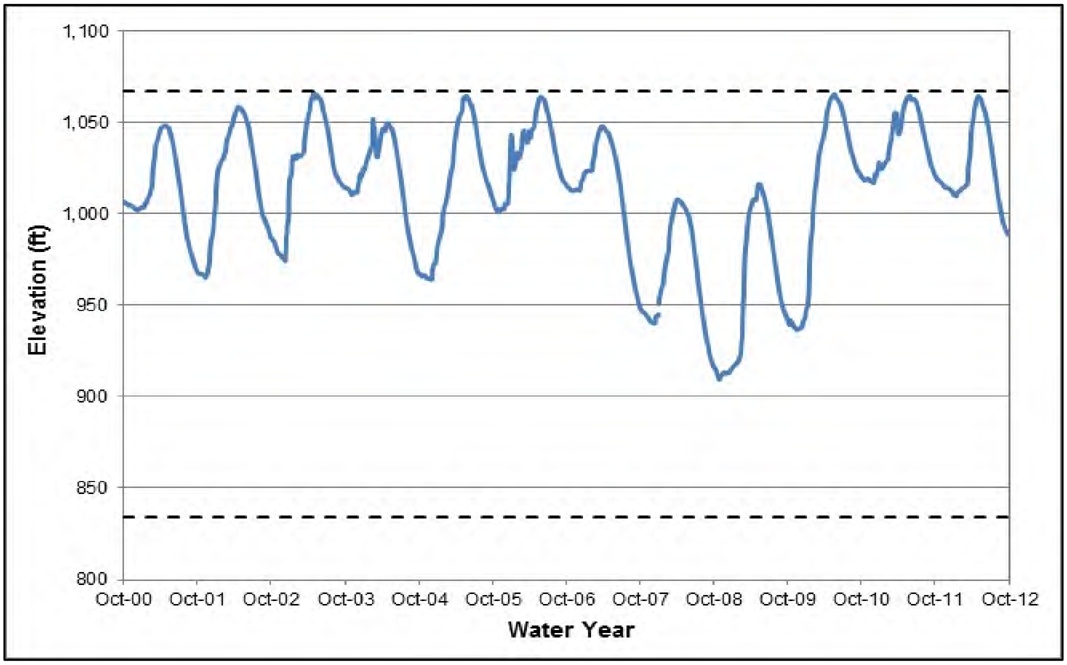



**Figure 5.17 Historical Water Years 2001-2012 Shasta Lake Elevation[6]**

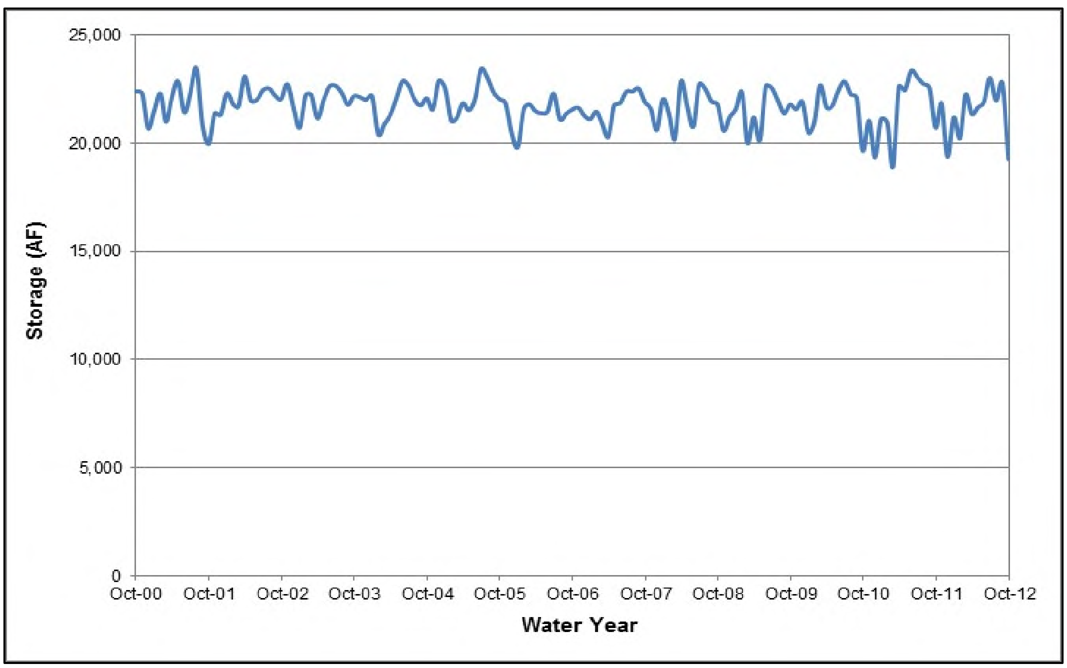



**Figure 5.18 Historical Water Year 2001 - 2012 Keswick Reservoir Storage**

[6] The minimum elevation line of 834 ft was taken from CalSim II. The maximum elevation line of 1,067 ft was provided by Reclamation.

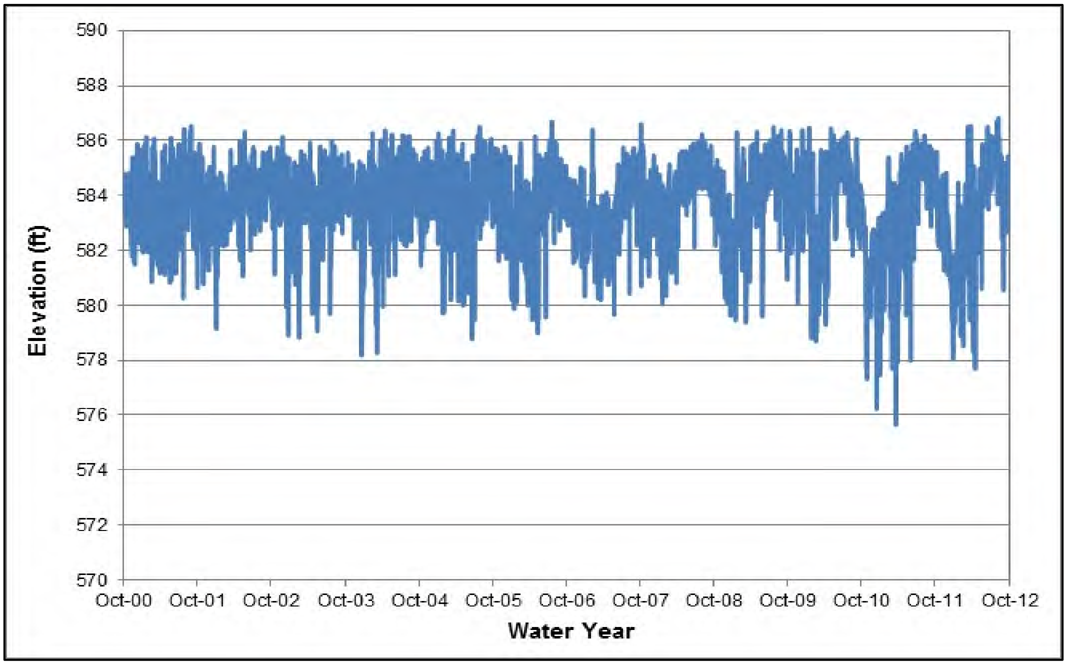



**Figure 5.19 Historical Water Year 2001 - 2012 Keswick Reservoir Elevation**

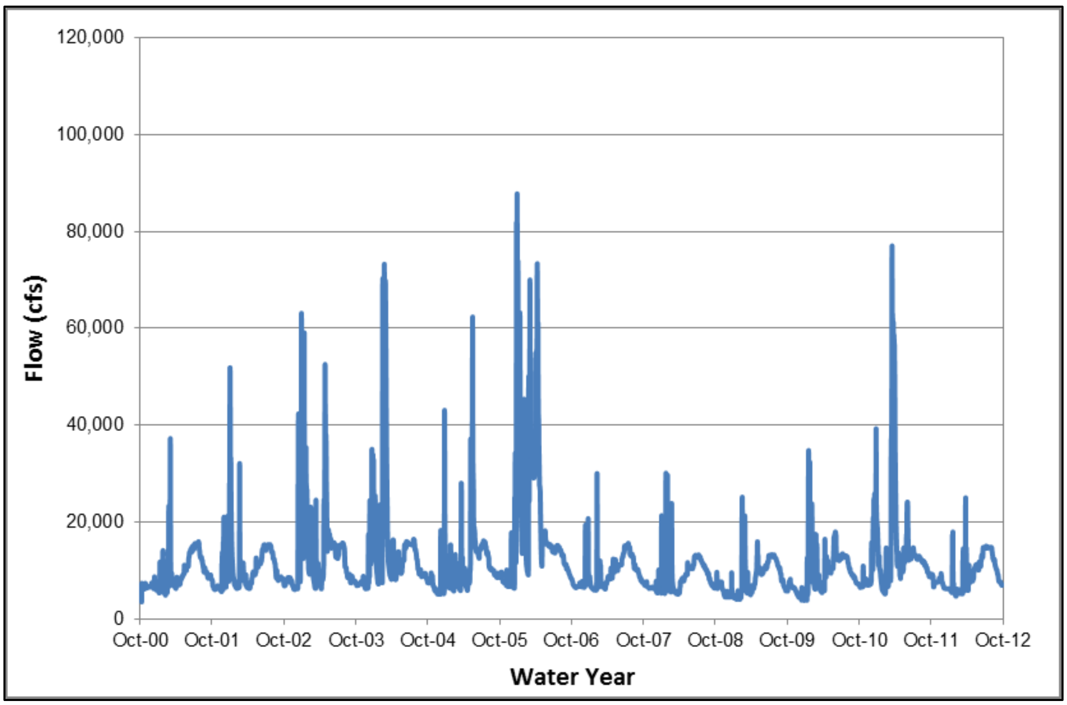



**Figure 5.20 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Bend Bridge**

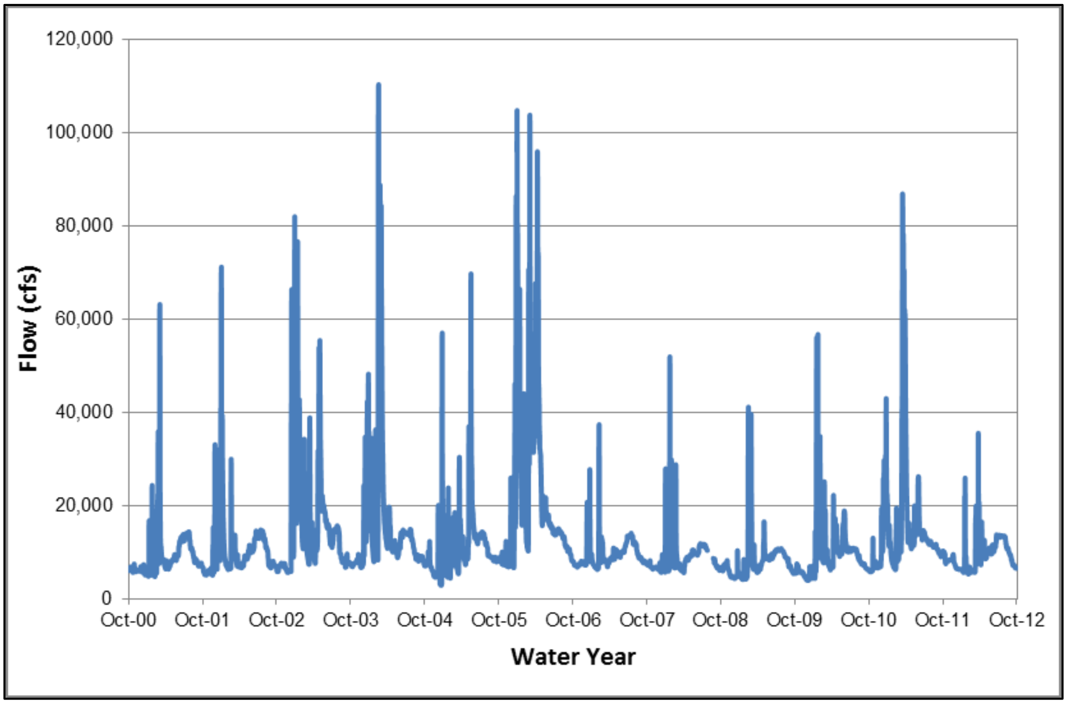



**Figure 5.21 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Vina Bridge**

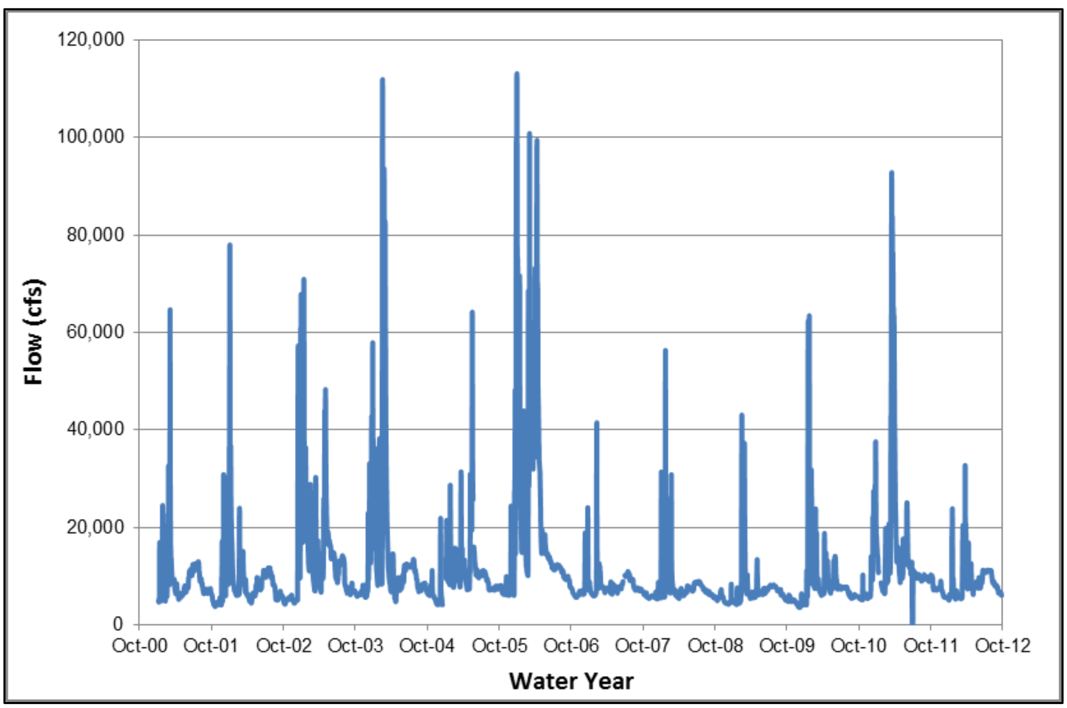



**Figure 5.22 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Hamilton City**

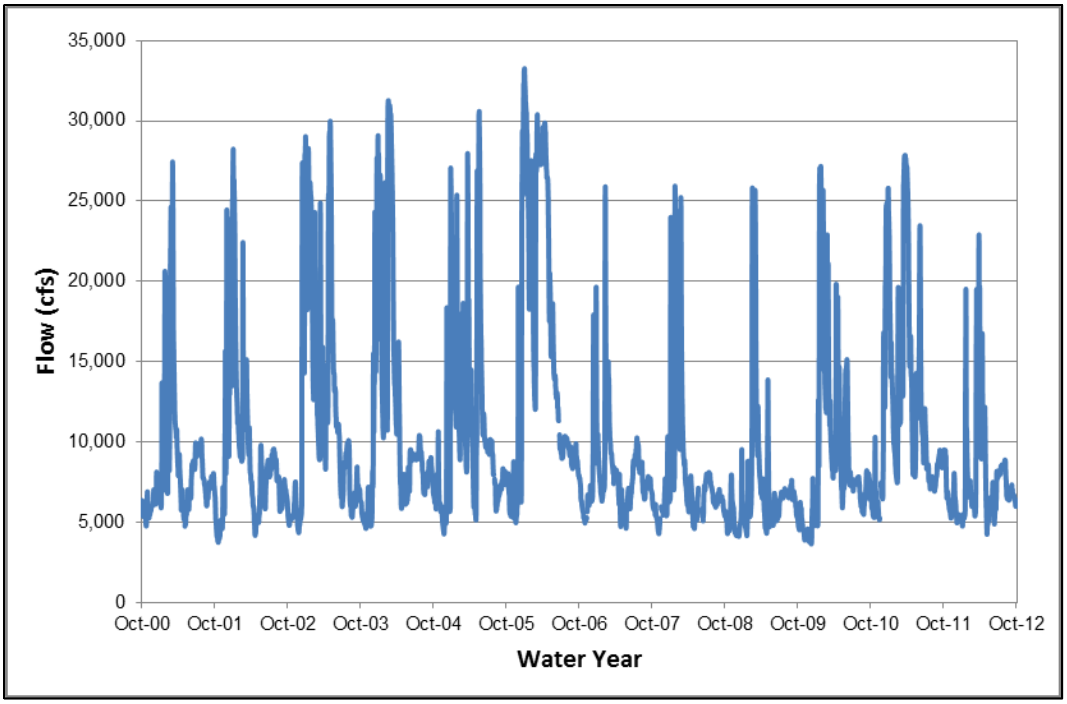



**Figure 5.23 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Wilkins Slough**

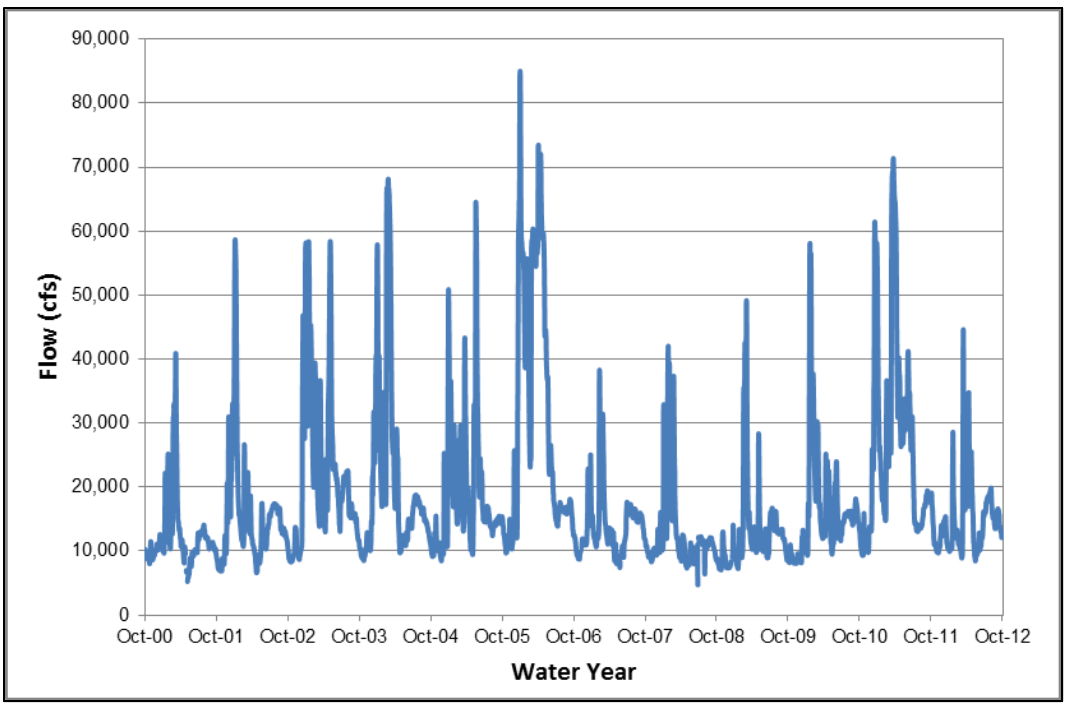



**Figure 5.24 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Verona**

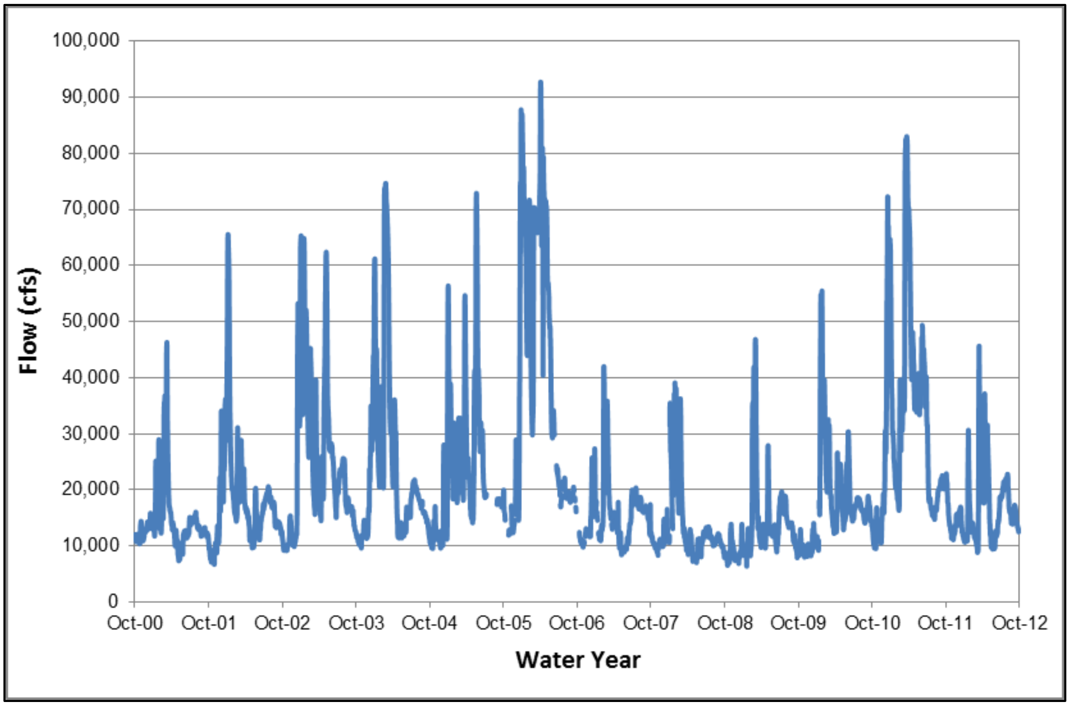



**Figure 5.25 Historical Water Year 2001 - 2012 Sacramento River Mean Daily Flows at Freeport**

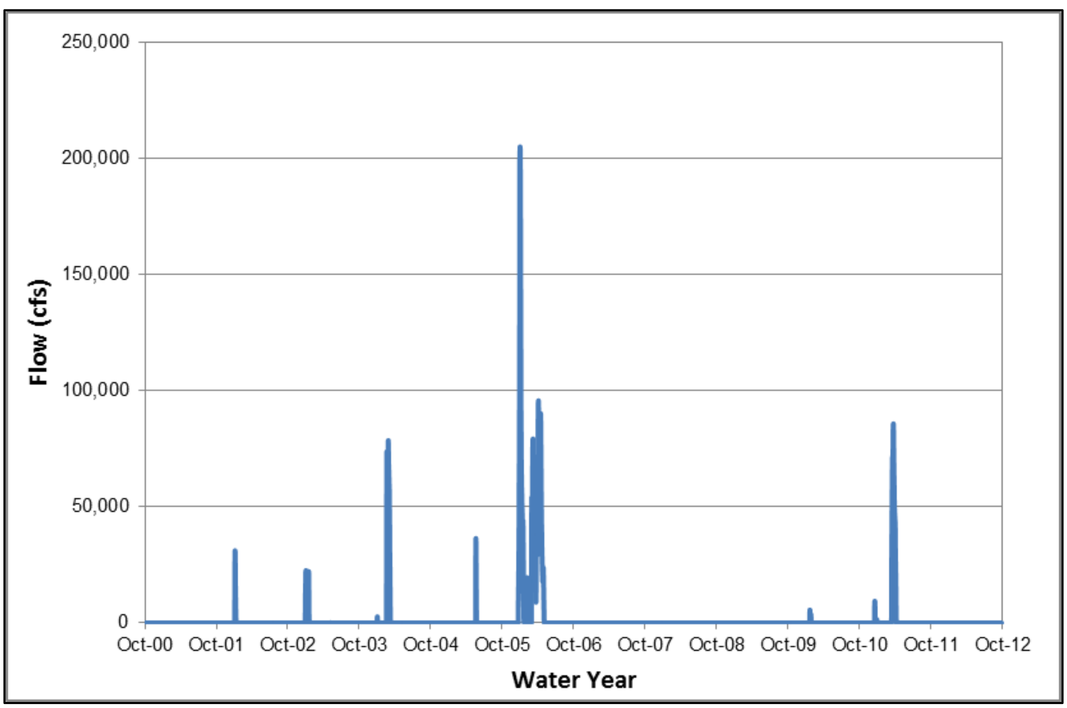



**Figure 5.26 Historical Water Year 2001 - 2012 Flows into Yolo Bypass over Fremont Weir**

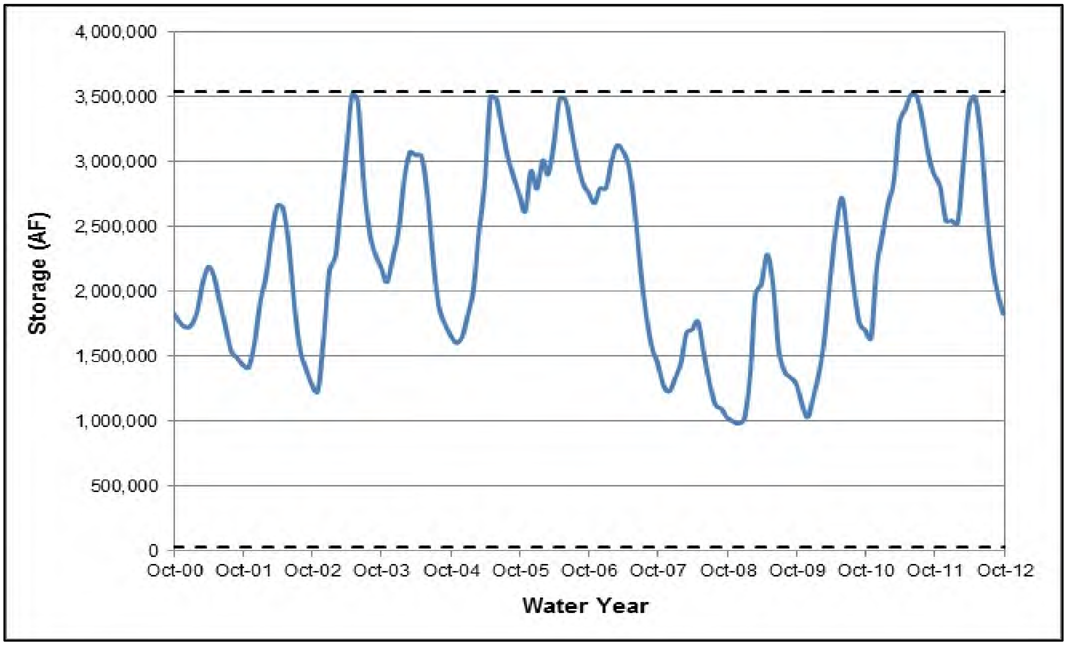



**Figure 5.27 Historical Water Year 2001 - 2012 Lake Oroville Storage**[7]

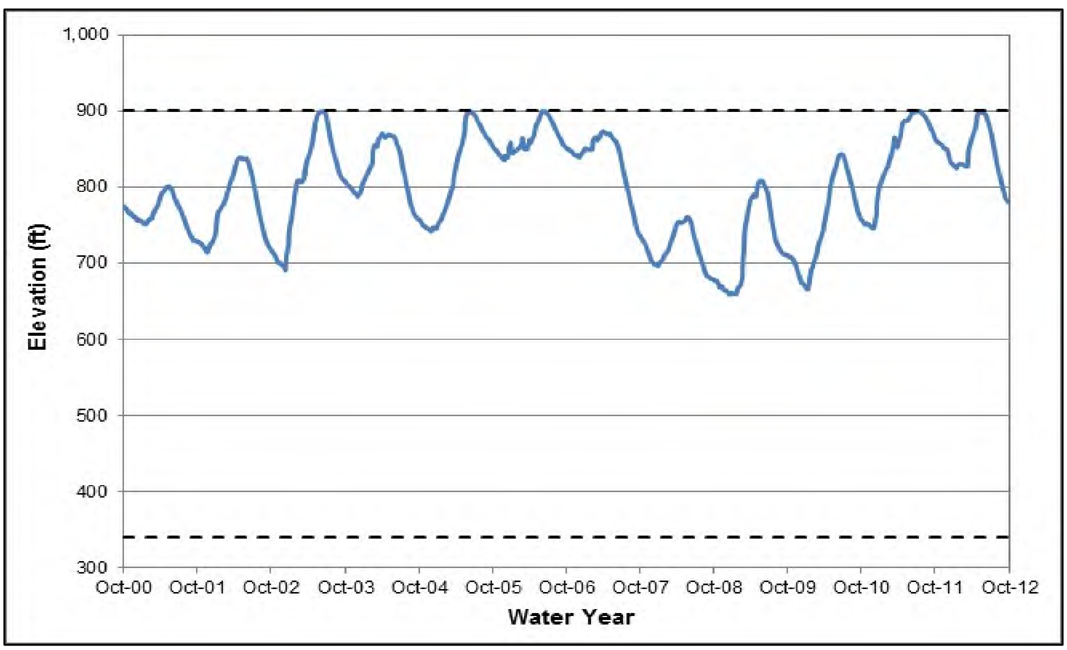



**Figure 5.28 Historical Water Year 2001 - 2012 Lake Oroville Elevation**[8]

---

[7] The minimum storage line of 30,000 AF was taken from CalSim II. The maximum storage line of 3,537,577 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

[8] The minimum elevation line of 340 ft was taken from CalSim II. The maximum elevation line of 900 ft was provided by Reclamation. Erroneous data on 7/9/2005 was deleted.

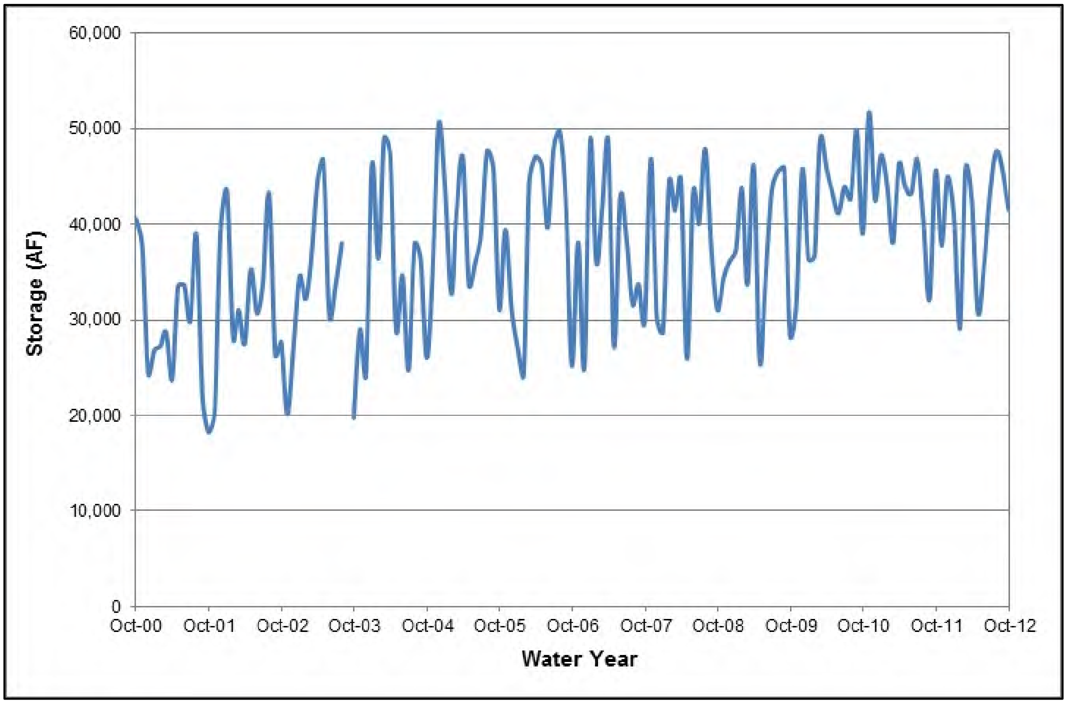



**Figure 5.29 Historical Water Year 2001 - 2012 Thermalito Reservoir Storage**

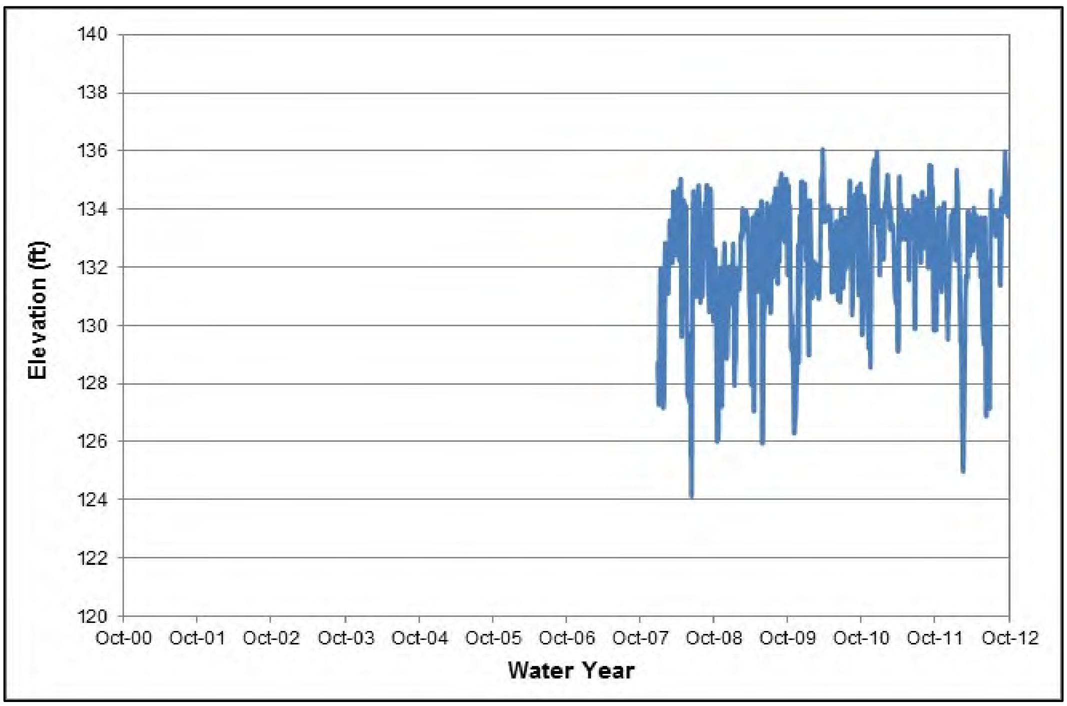



**Figure 5.30 Historical Water Year 2008 - 2012 Thermalito Reservoir Elevation**

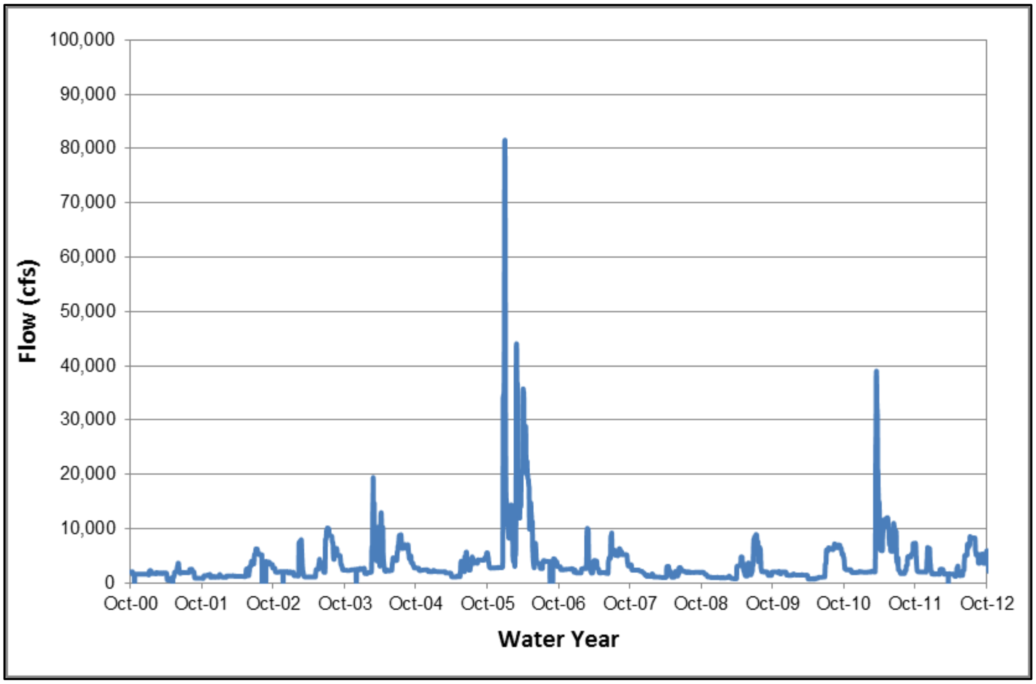



**Figure 5.31 Historical Water Year 2001 - 2012 Feather River Mean Daily Flows near Gridley**

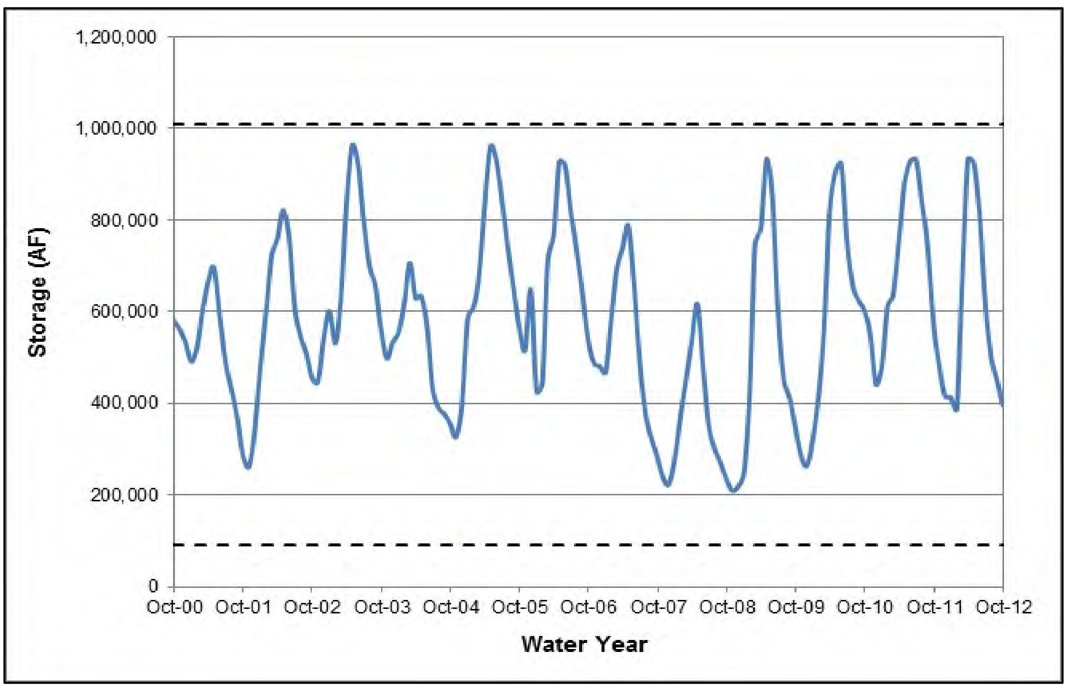



**Figure 5.32 Historical Water Year 2001 - 2012 Folsom Lake Storage**[9]

---

[9] The minimum storage line of 90,000 AF was taken from CalSim II. The maximum storage line of 977,000 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

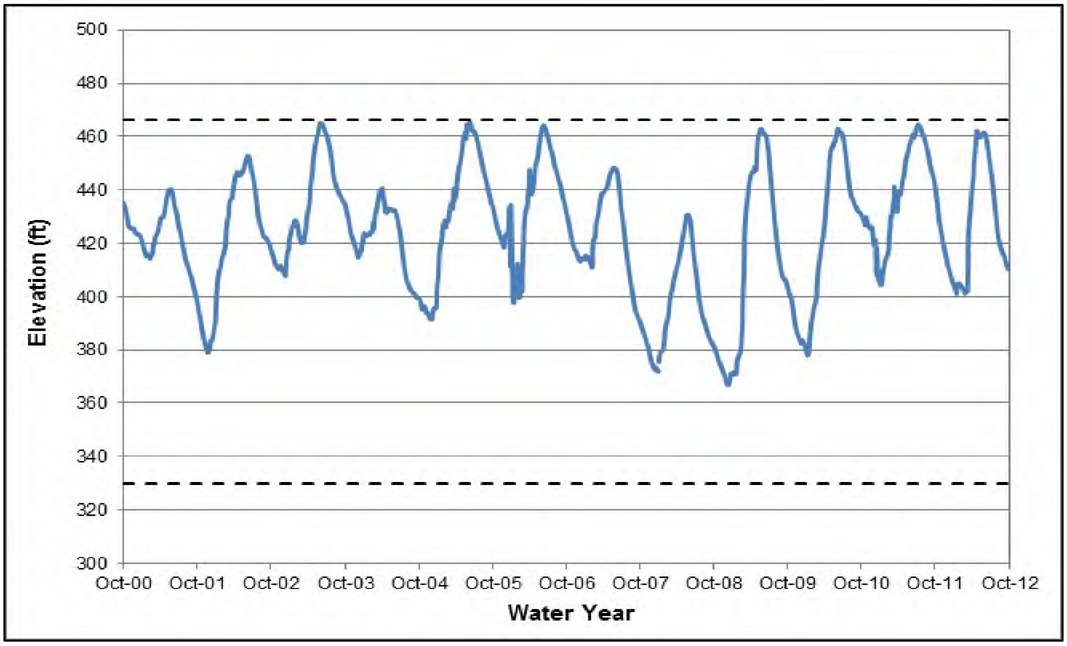



**Figure 5.33 Historical Water Year 2001 - 2012 Folsom Lake Elevation[10]**

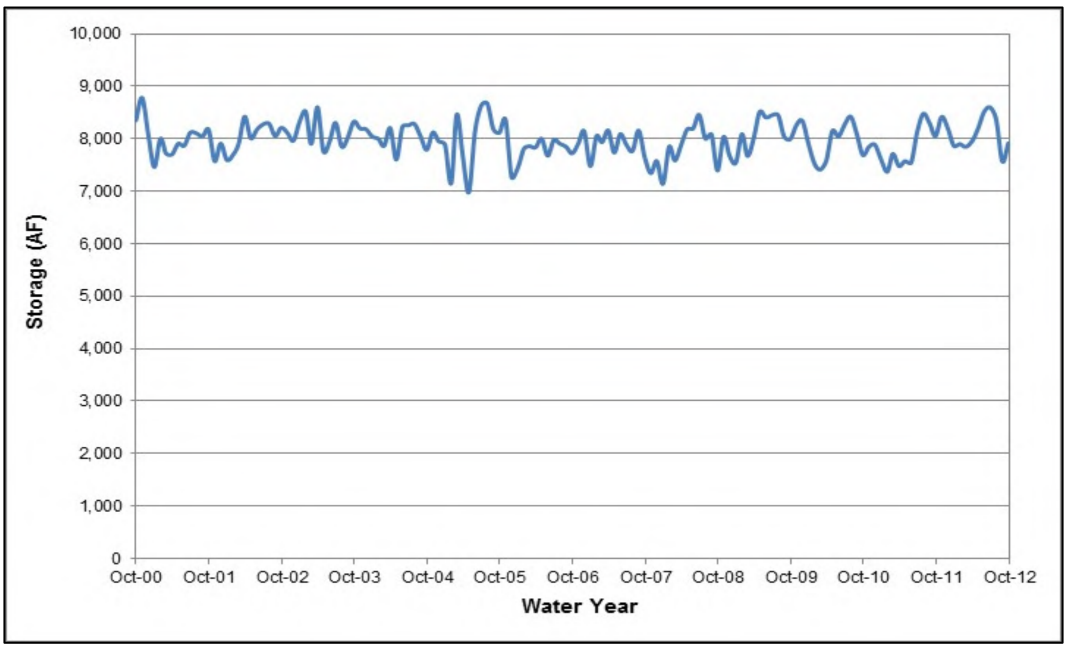



**Figure 5.34 Historical Water Year 2001 - 2012 Lake Natoma Storage**

[10] The minimum elevation line of 330 ft was taken from CalSim II. The maximum elevation line of 466 ft was provided by Reclamation.

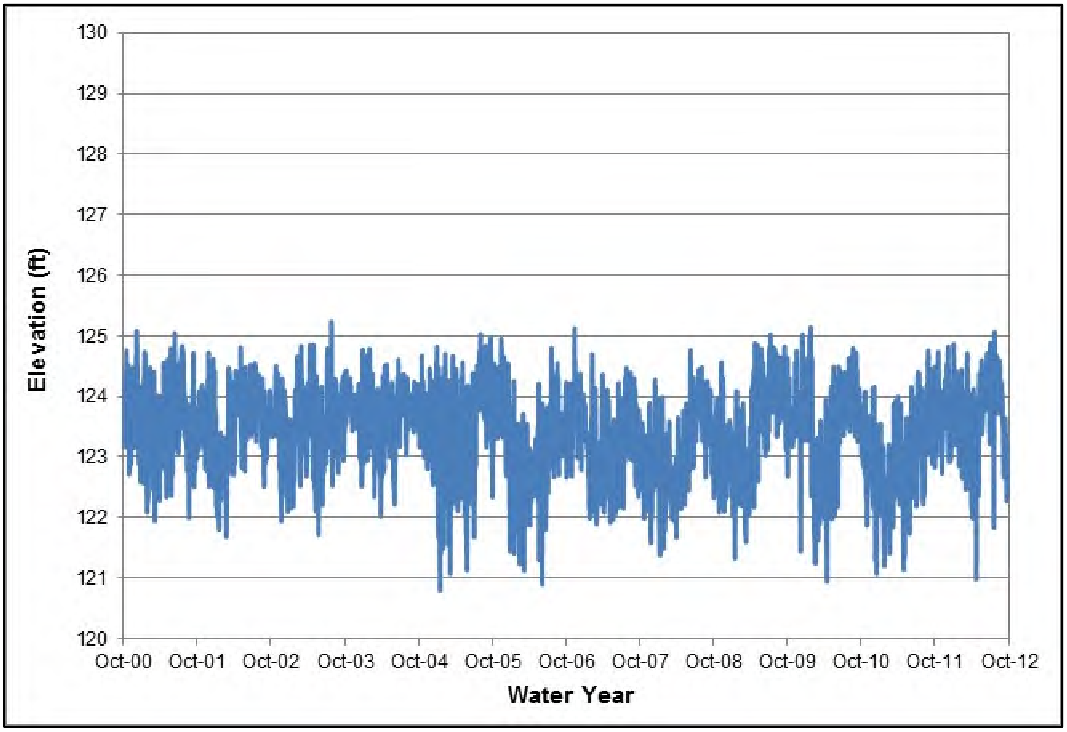



**Figure 5.35 Historical Water Year 2001 - 2012 Lake Natoma Elevation**

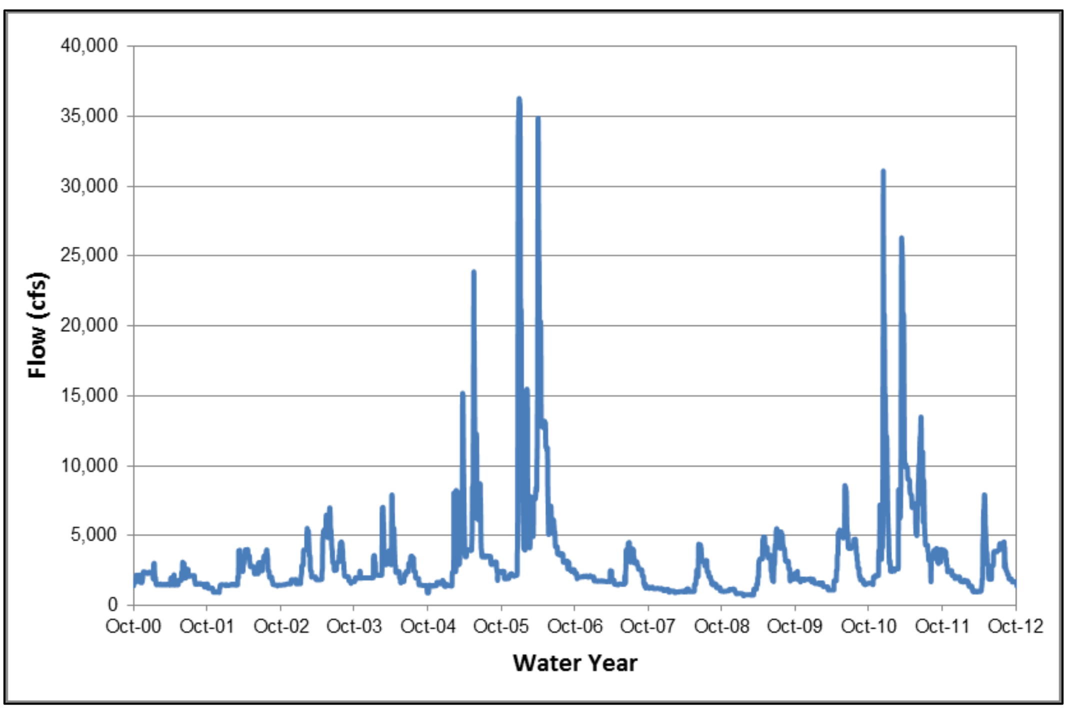



**Figure 5.36 Historical Water Year 2001 - 2012 American River Mean Daily Flows at Fair Oaks**

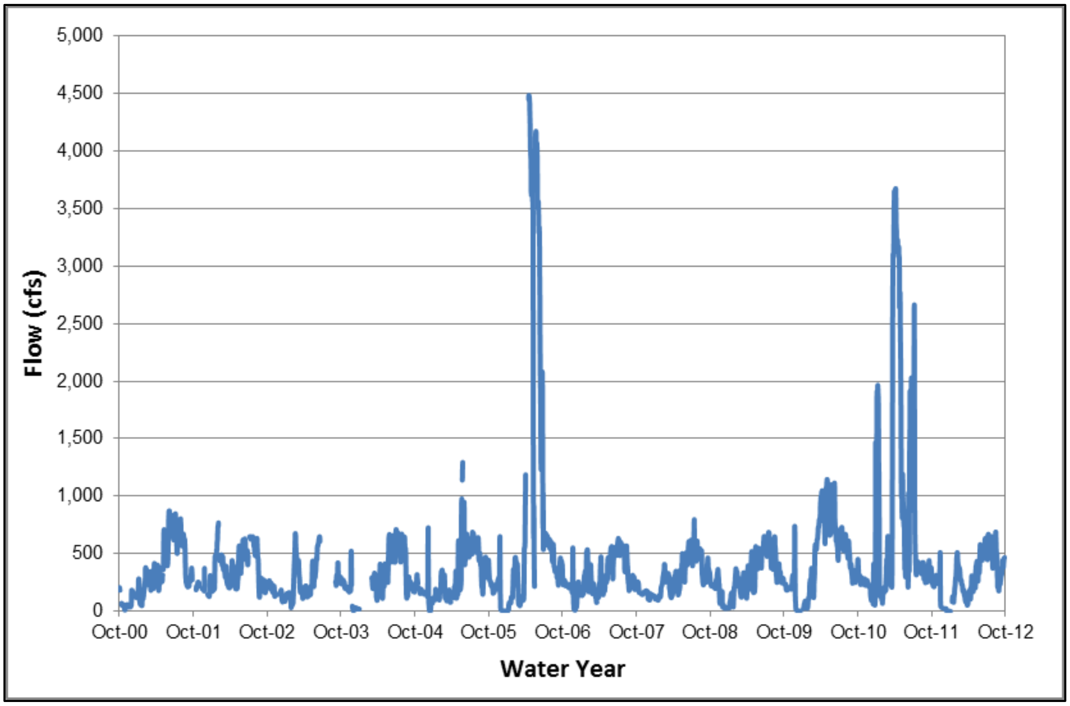



**Figure 5.37 Historical Water Year 2001 - 2012 San Joaquin River Mean Daily Flows at Mendota**

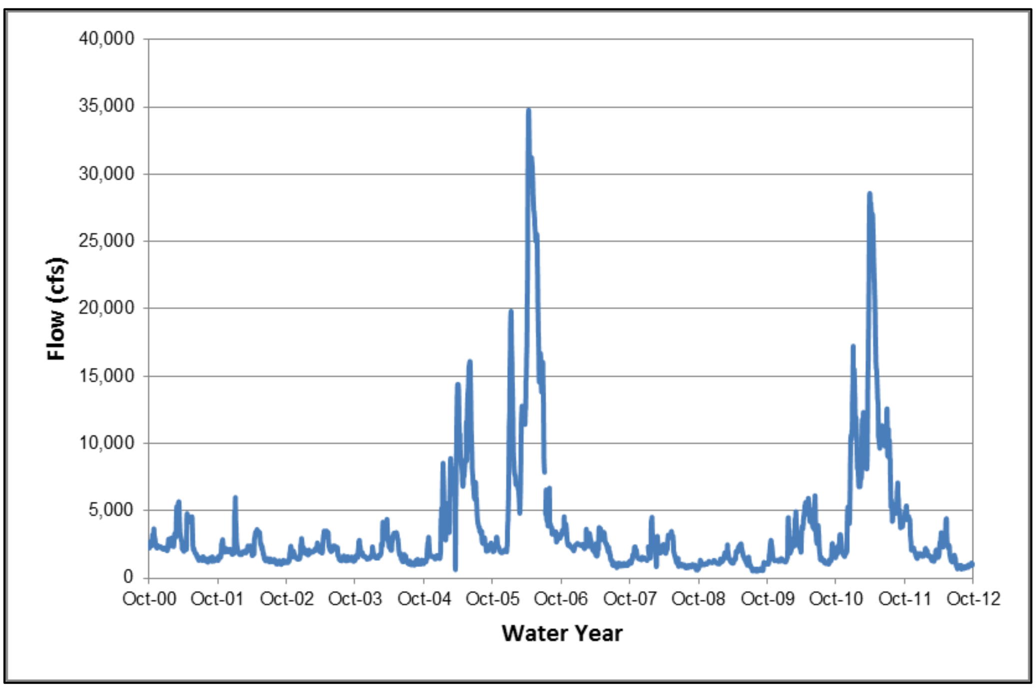



**Figure 5.38 Historical Water Year 2001 - 2012 San Joaquin River Mean Daily Flows at Vernalis**

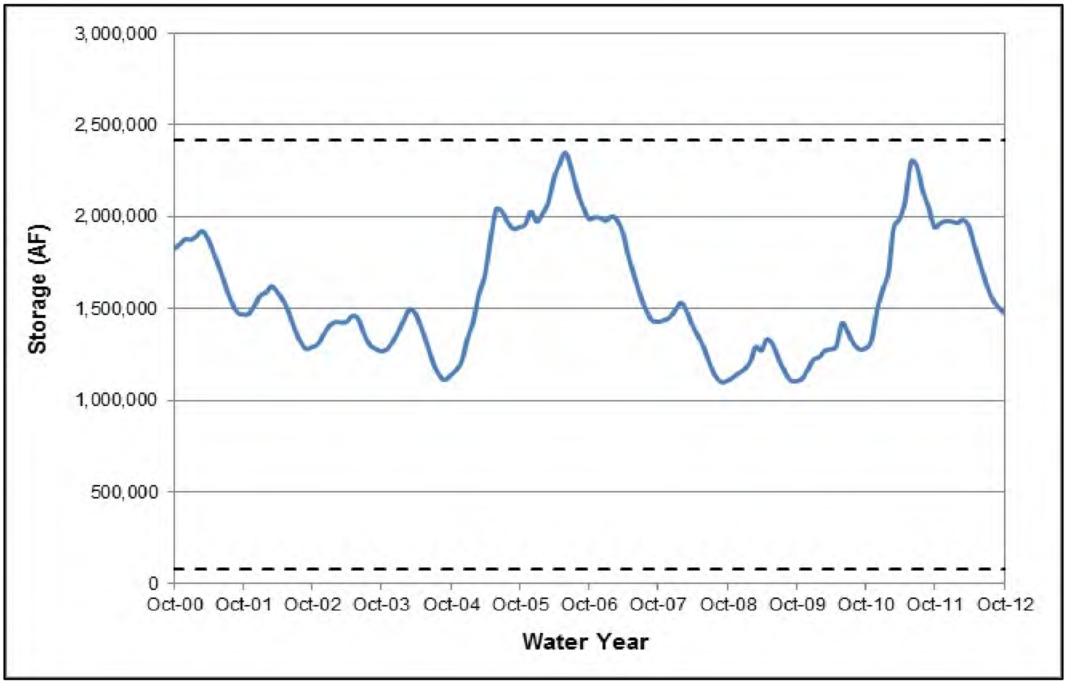



**Figure 5.39 Historical Water Year 2001 - 2012 New Melones Reservoir Storage**[11]

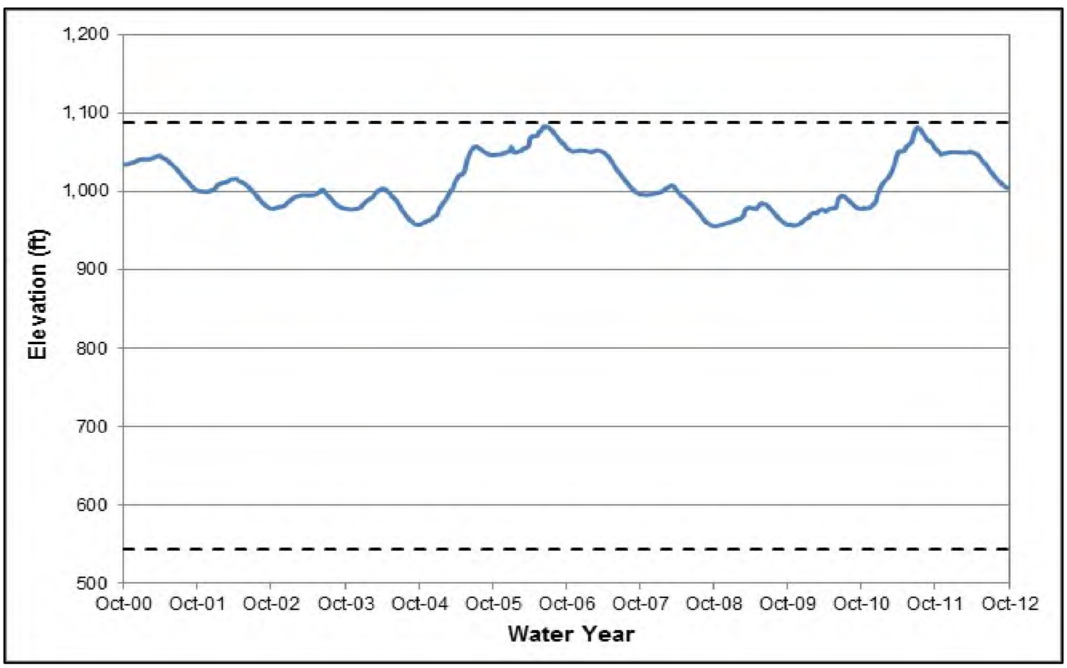



**Figure 5.40 Historical Water Year 2001 - 2012 New Melones Reservoir Elevation**[12]

---

[11] The minimum storage line of 80,000 AF was taken from CalSim II. The maximum storage line of 2,400,000 AF was taken from the California Data Exchange Center website http://cdec.water.ca.gov/misc/resinfo.html.

[12] The dead pool elevation of 543 feet and normal pool elevation of 1,088 feet was taken from CalSim II.

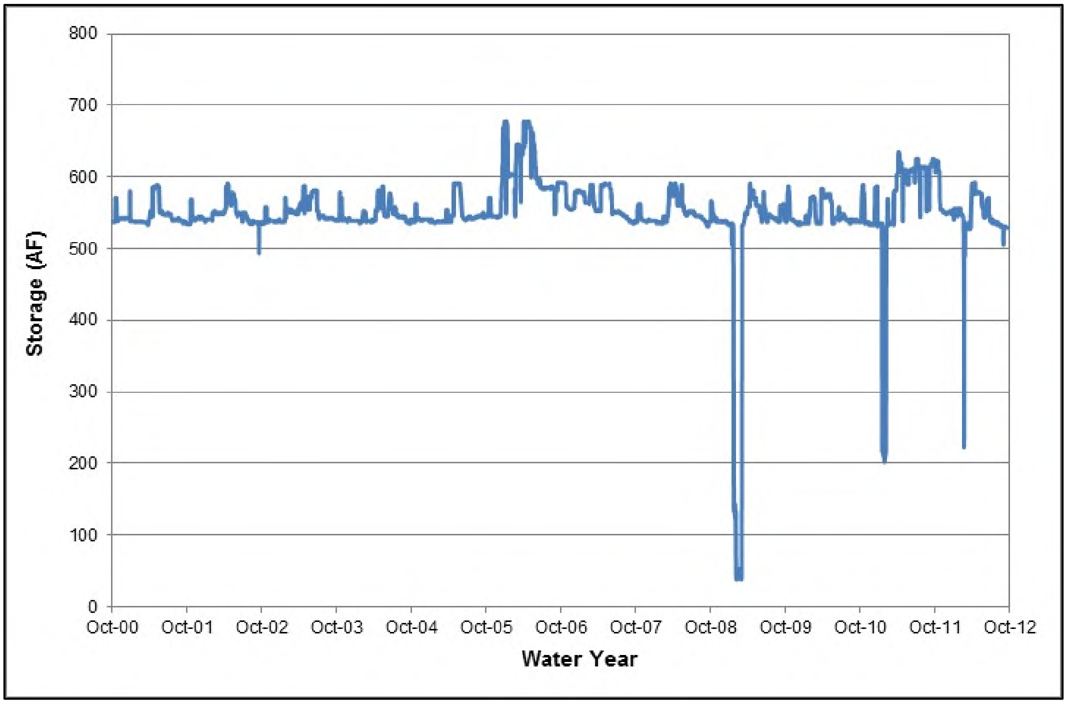



**Figure 5.41 Historical Water Year 2001 - 2012 Goodwin Reservoir Storage**

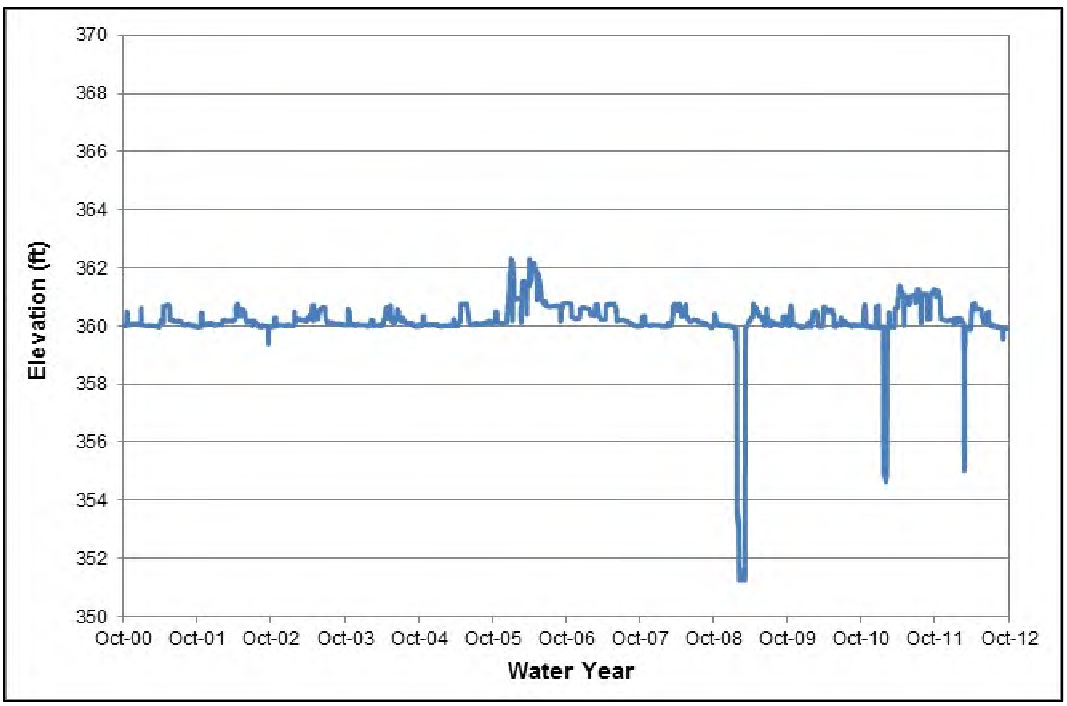



**Figure 5.42 Historical Water Year 2001 - 2012 Goodwin Reservoir Elevation**[13]

[13] Erroneous data on 10/30/2002 was removed.

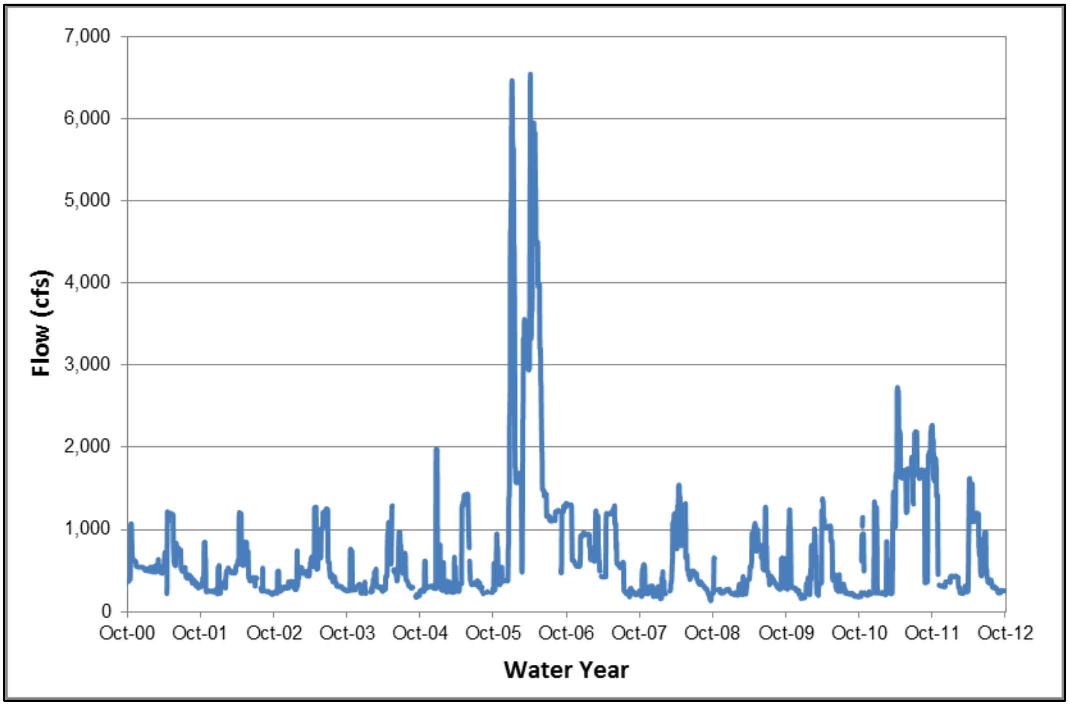



**Figure 5.43 Historical Water Year 2001 - 2012 Stanislaus River Mean Daily Flows at Orange Blossom Bridge**

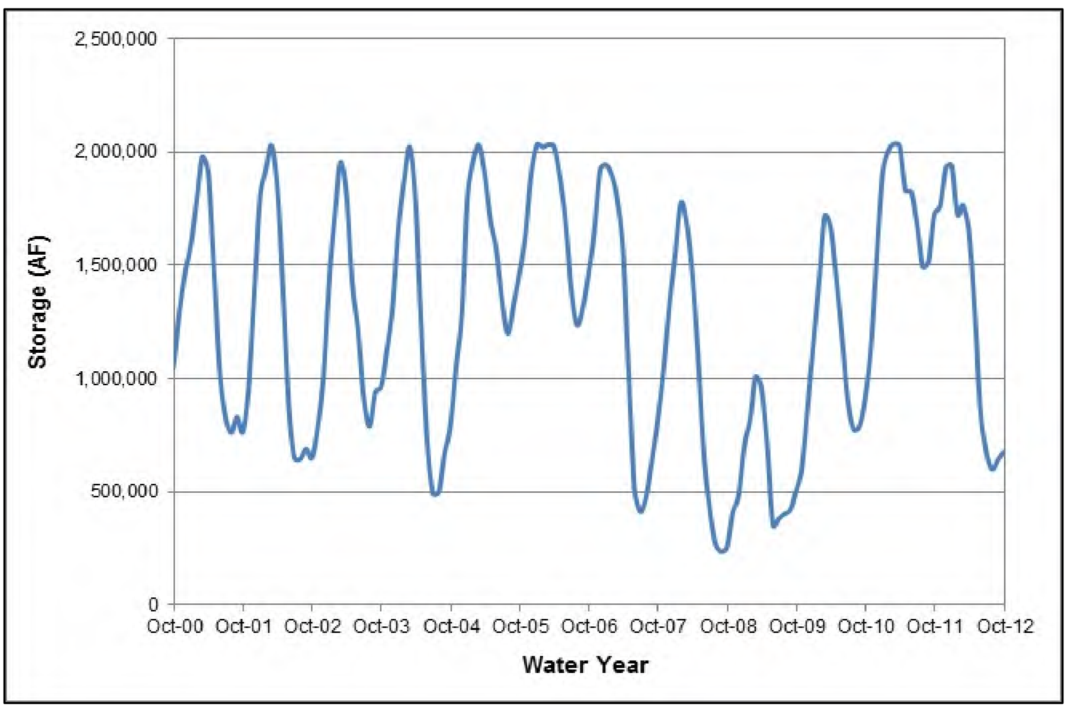



**Figure 5.44 Historical Water Year 2001 - 2012 San Luis Reservoir Storage**

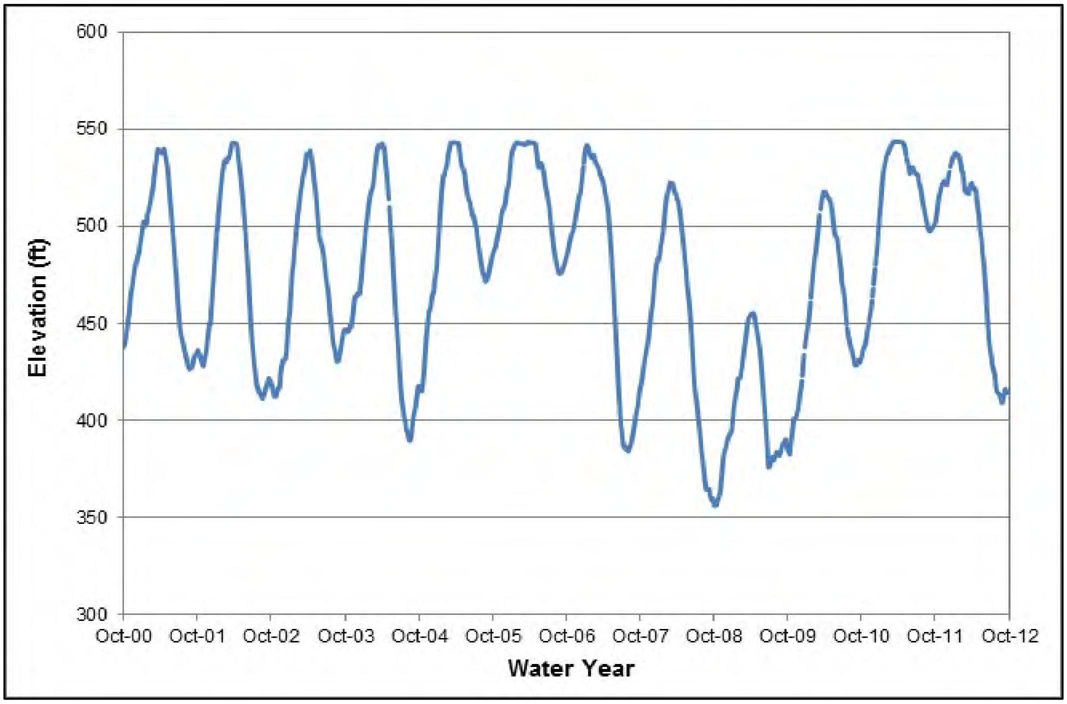



**Figure 5.45 Historical Water Year 2001 - 2012 San Luis Reservoir Elevation**[14]

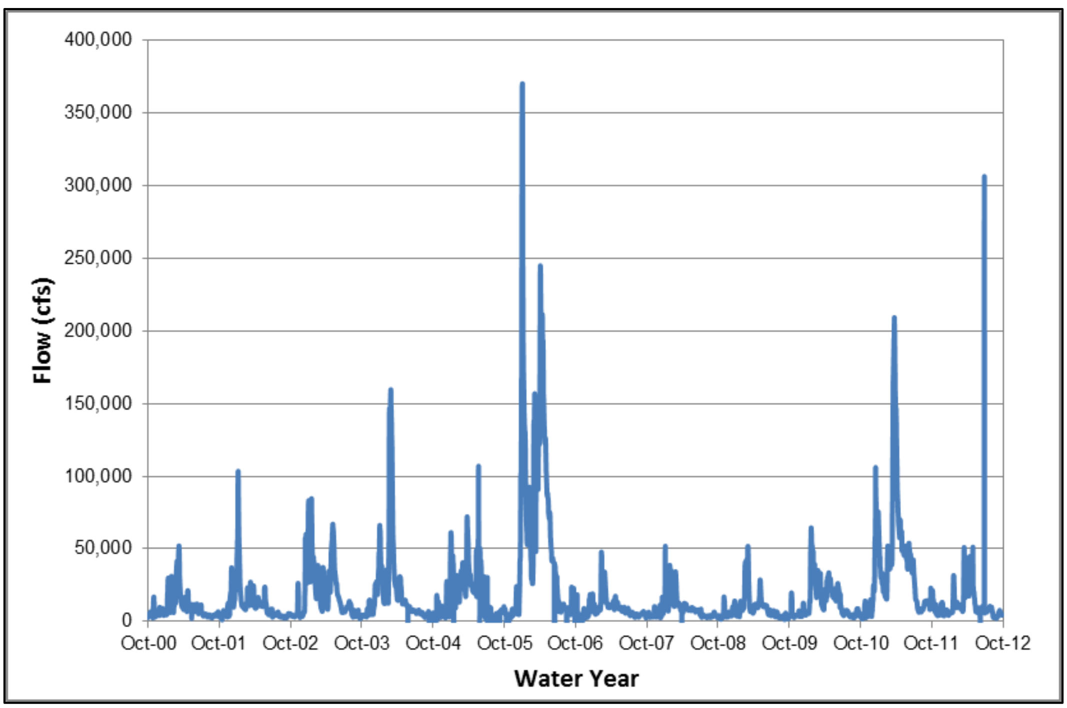



**Figure 5.46 Historical Water Year 2001 - 2012 Delta Outflow Mean Daily Flows**

[14] Erroneous data on 10/13/2003, 9/18/2007, and 7/19/2010 was removed.

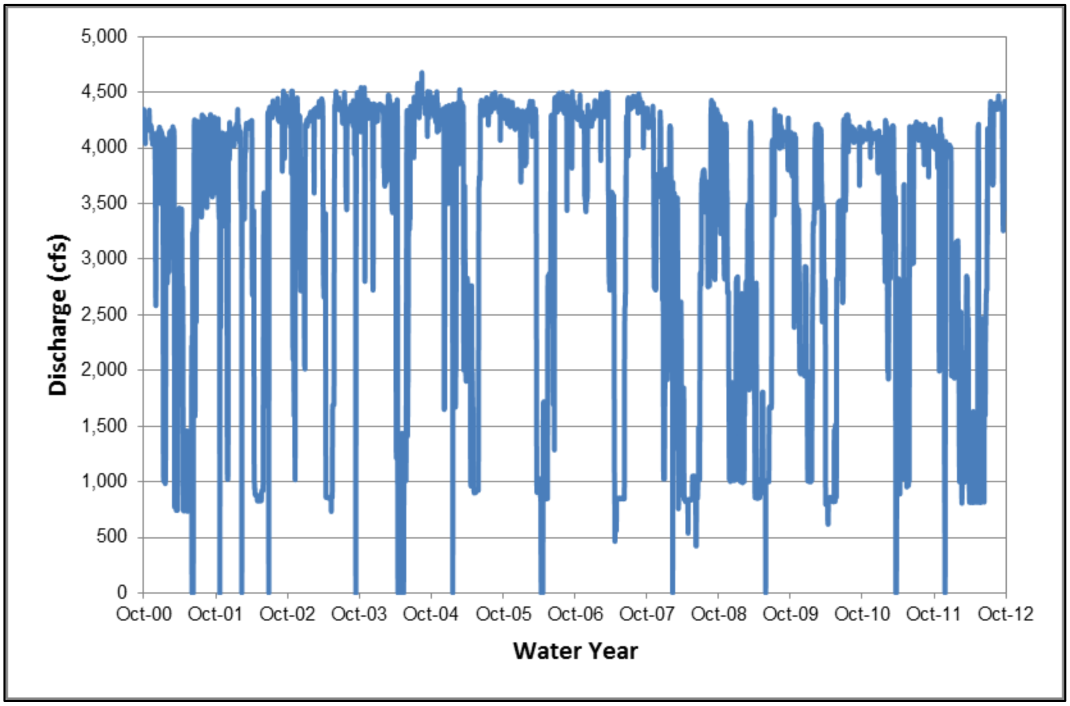



**Figure 5.47 Historical Water Year 2001 - 2012 Jones Pumping Plant Mean Daily Flows**

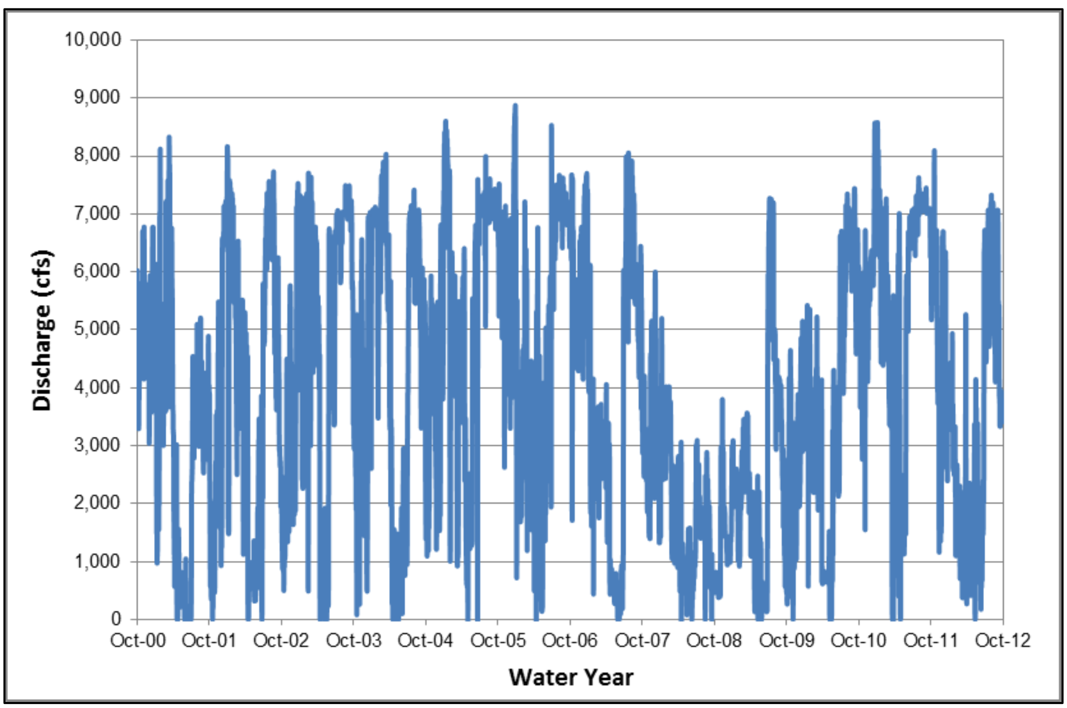



**Figure 5.48 Historical Water Year 2001 - 2012 Banks Pumping Plant Mean Daily Flows**

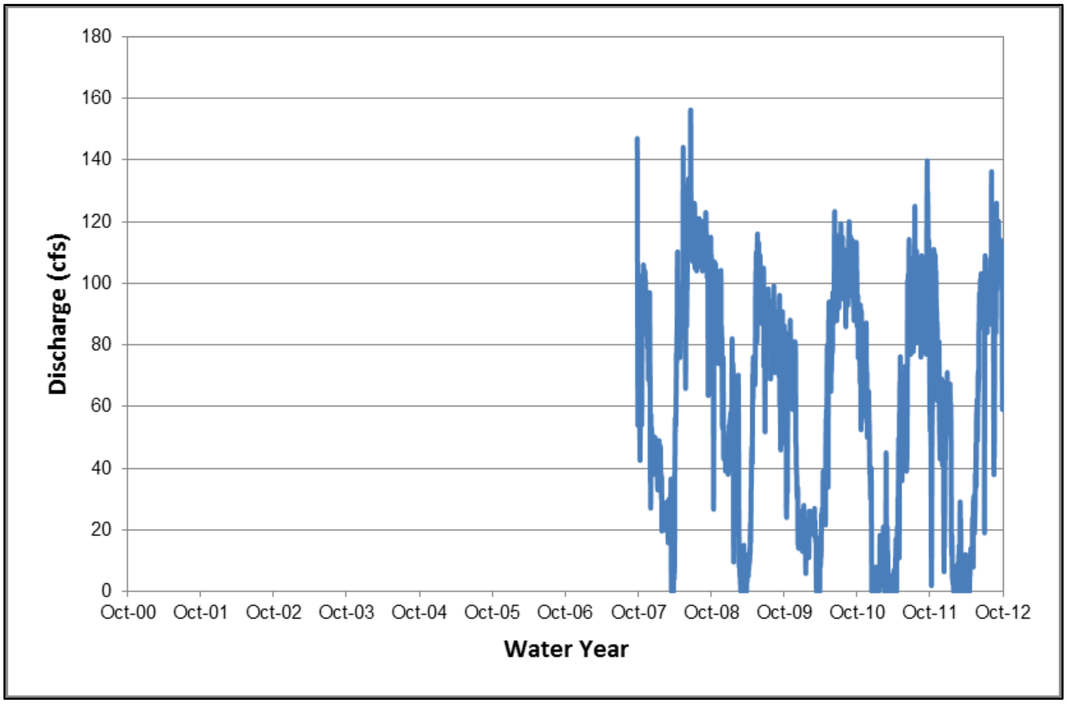



**Figure 5.49 Historical Water Year 2008 - 2012 Barker Slough Pumping Plant Mean Daily Flows**

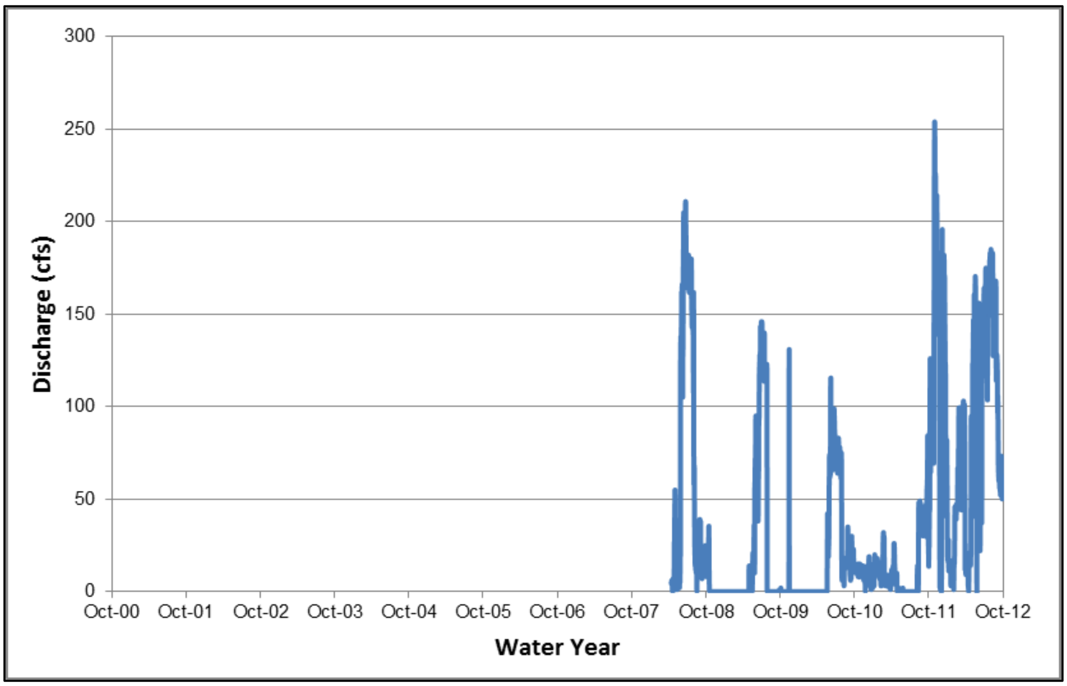



**Figure 5.50 Water Year 2008 – 2012 Contra Costa Canal Rock Slough Intake Mean Daily Flows**

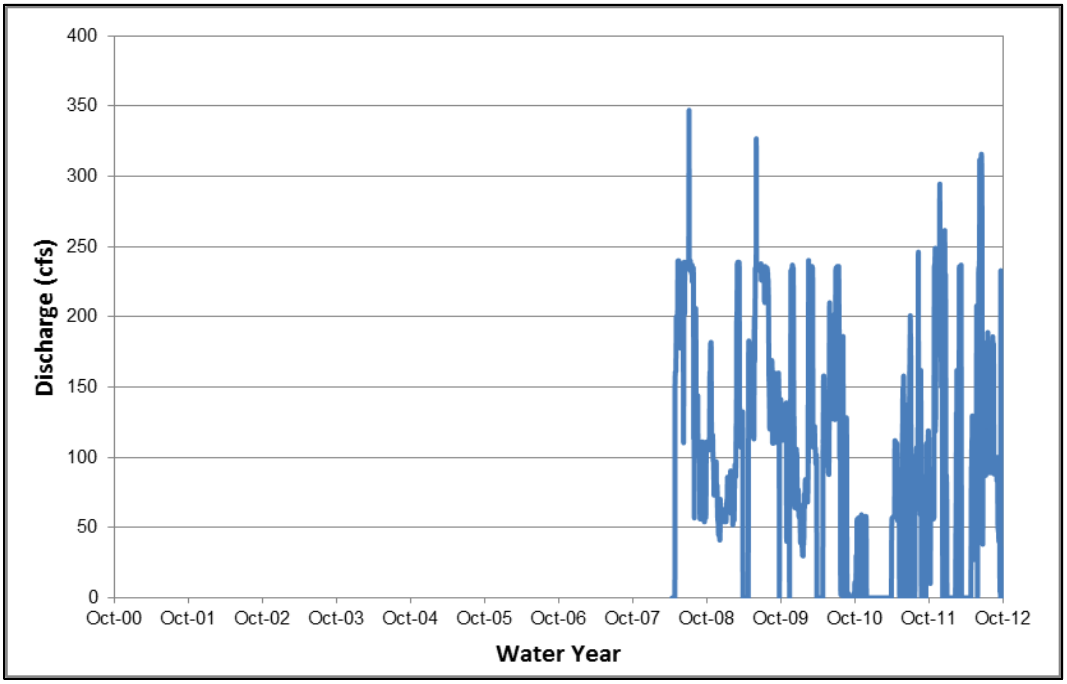



**Figure 5.51 Historical Water Year 2008 - 2012 Contra Costa Water District Old River Intake Mean Daily Flows**

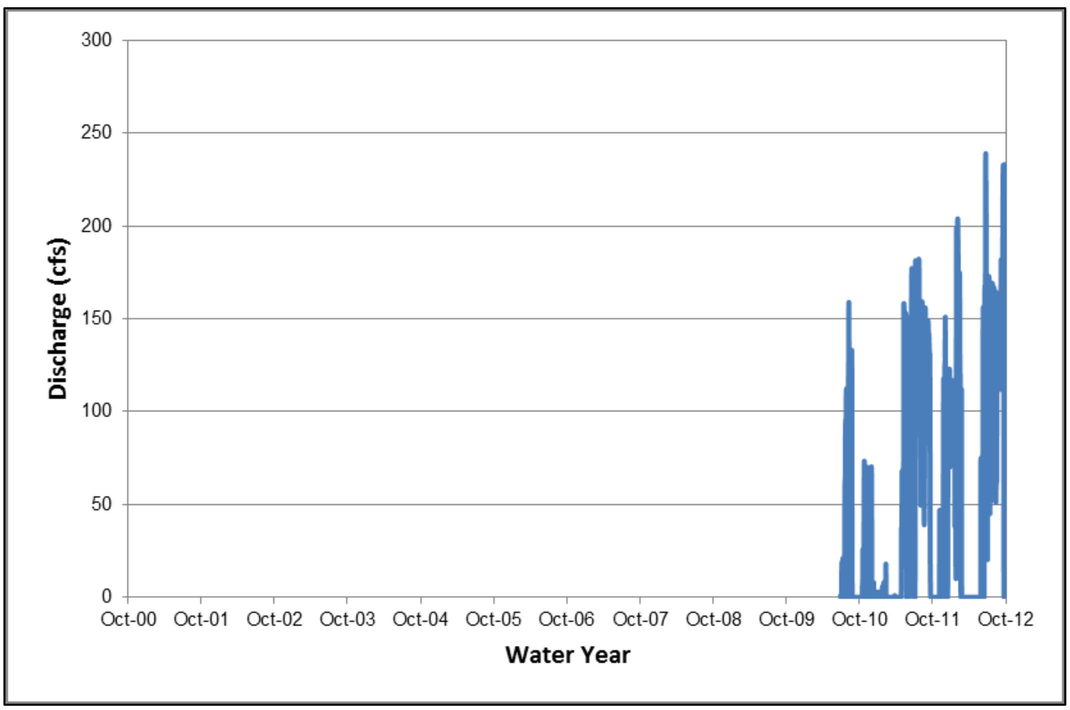



**Figure 5.52 Historical Water Year 2010 - 2012 Contra Costa Water District Middle River Intake Mean Daily Flows**

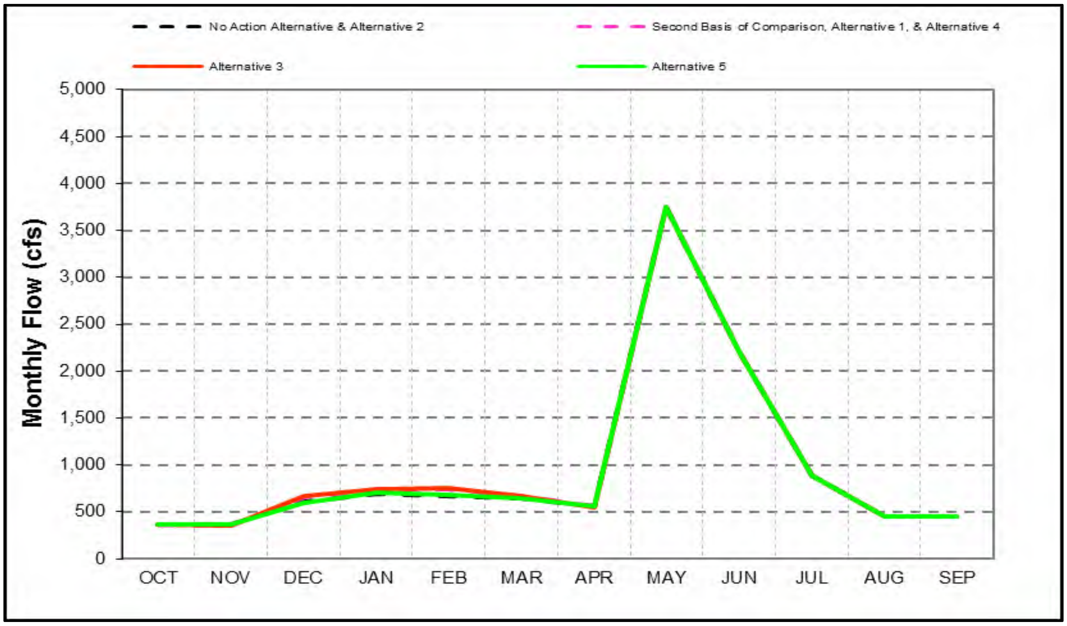



**Figure 5.53 Trinity River below Lewiston Reservoir, Long-Term Average Flow[15]**

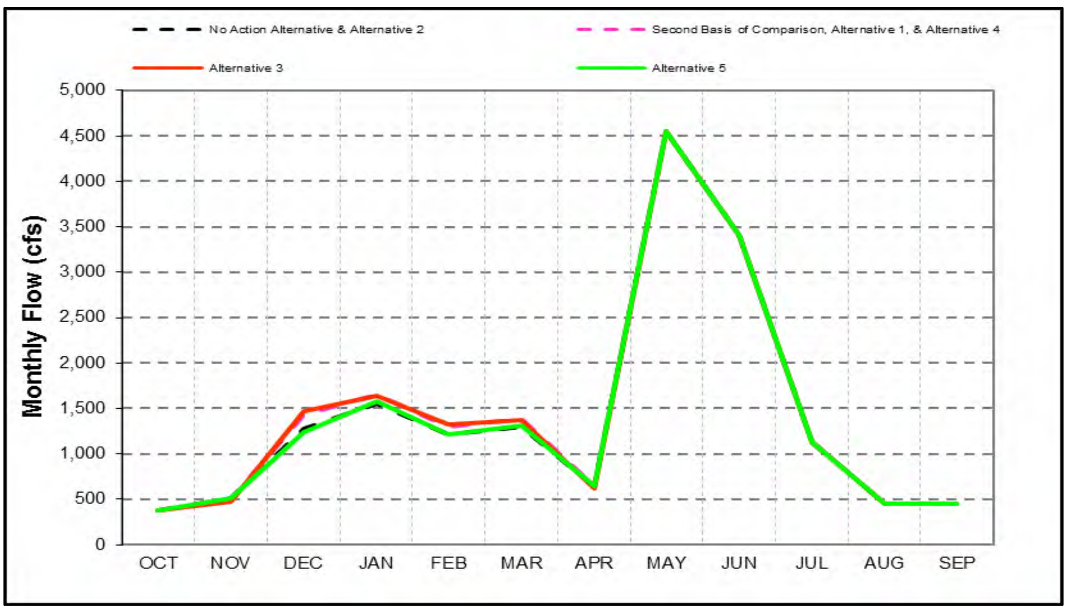



**Figure 5.54 Trinity River below Lewiston Reservoir, Wet Year Long-Term Average Flow[15,16]**

---

[15] Based on the 82-year simulation period; Notes: 1) All alternatives are simulated with projected hydrology and sea level at Year 2030 conditions. 2) Model results for Alternatives 1, 4, and Second Basis of Comparison are the same, therefore Alternatives 1 and 4 results are not presented. Qualitative differences, if applicable, are discussed in the text. 3) Model results for Alternative 2 and No Action Alternative are the same, therefore Alternative 2 results are not presented. Qualitative differences, if applicable, are discussed in the text.

[16] Wet-Year and Dry-Year as defined by the Sacramento 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999), projected to year 2030

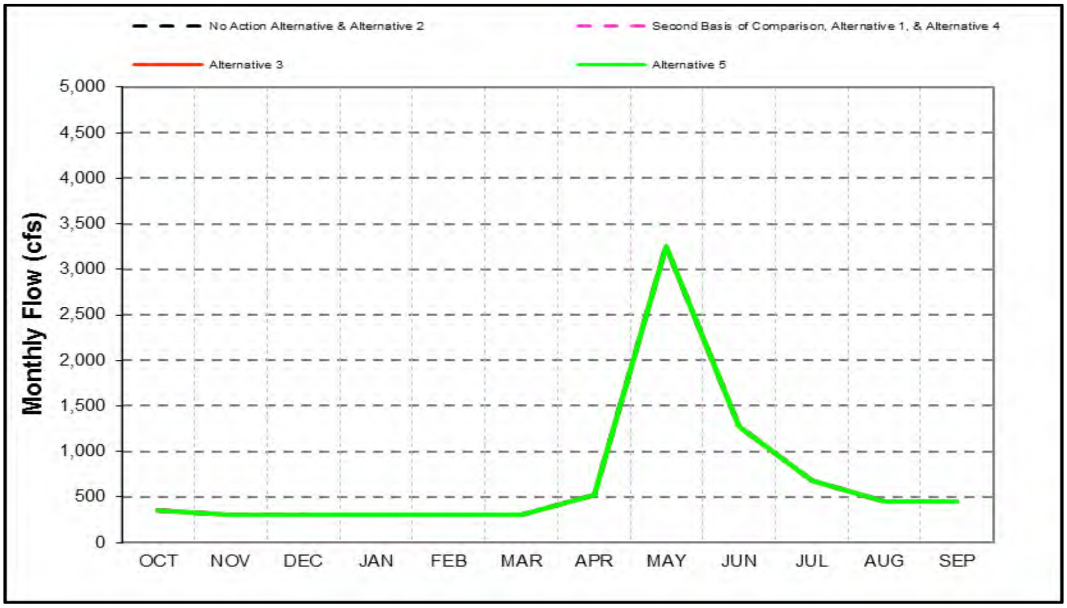



**Figure 5.55 Trinity River below Lewiston Reservoir, Dry Year Long-Term Average Flow[15,16]**

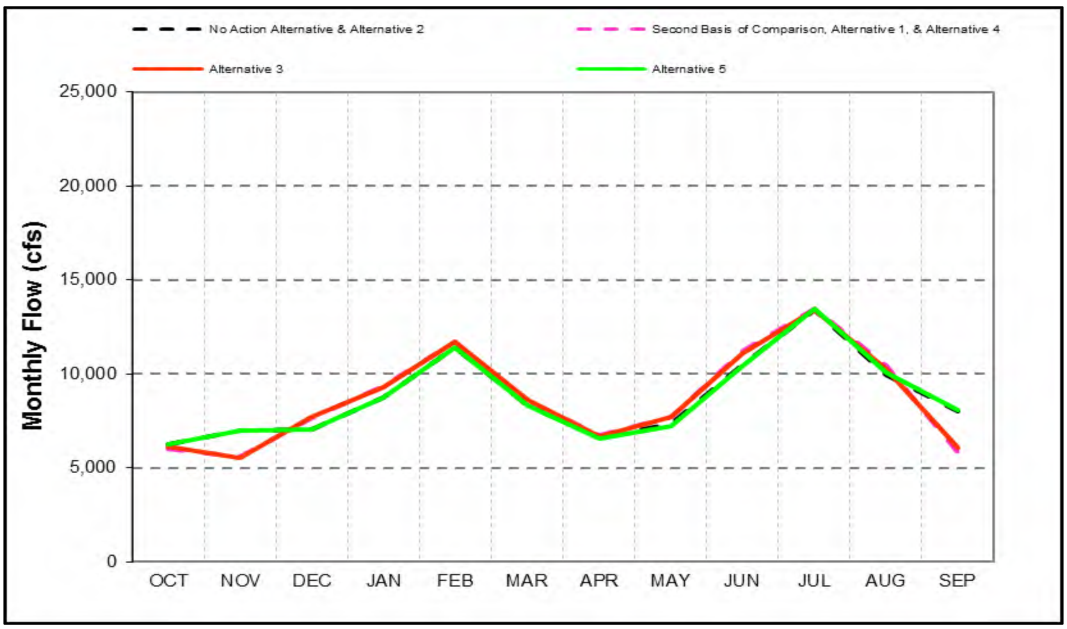



**Figure 5.56 Sacramento River downstream of Keswick Reservoir, Long-Term Average Flow[15]**

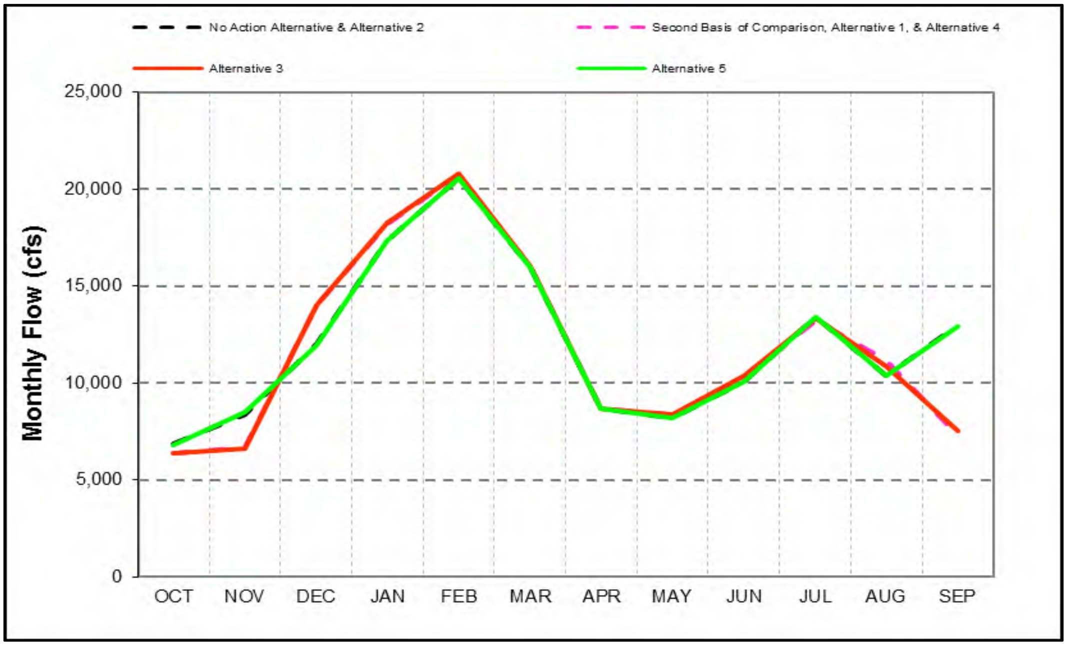



**Figure 5.57 Sacramento River downstream of Keswick Reservoir, Wet Year Long-Term Average Flow[15,16]**

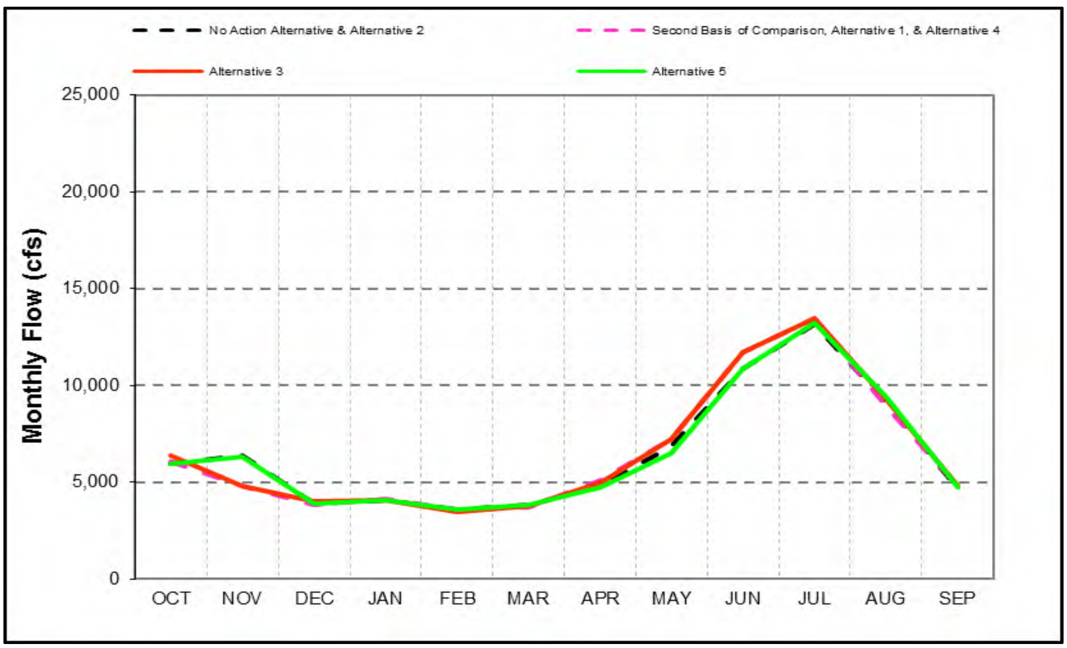



**Figure 5.58 Sacramento River downstream of Keswick Reservoir, Dry Year Long-Term Average Flow[15,16]**

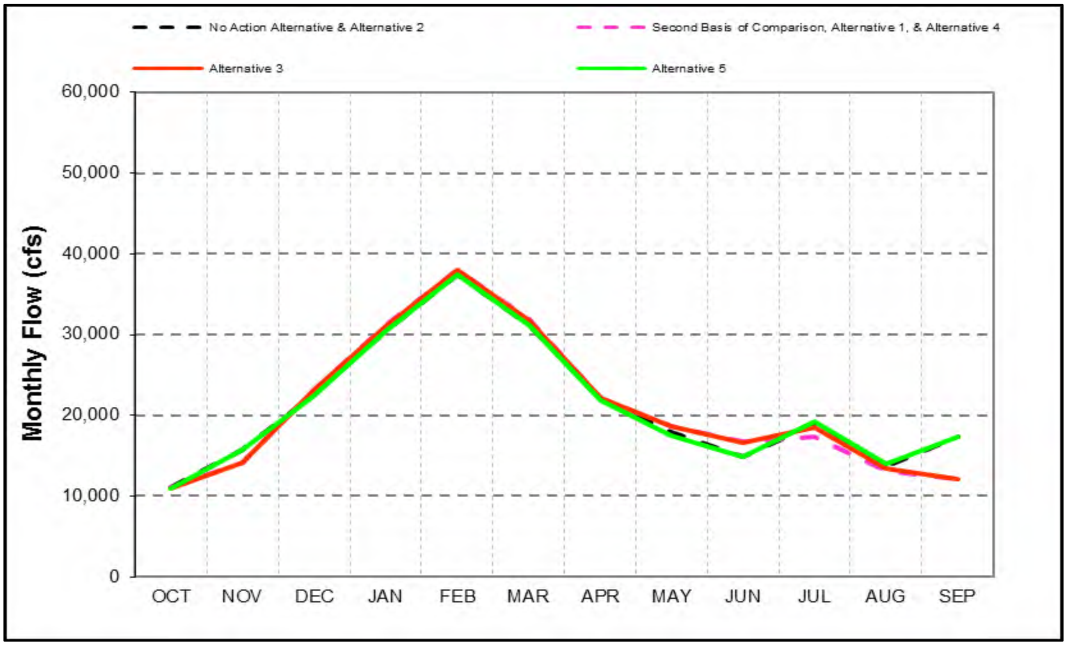



**Figure 5.59 Sacramento River at Freeport, Long-Term Average Flow[15]**

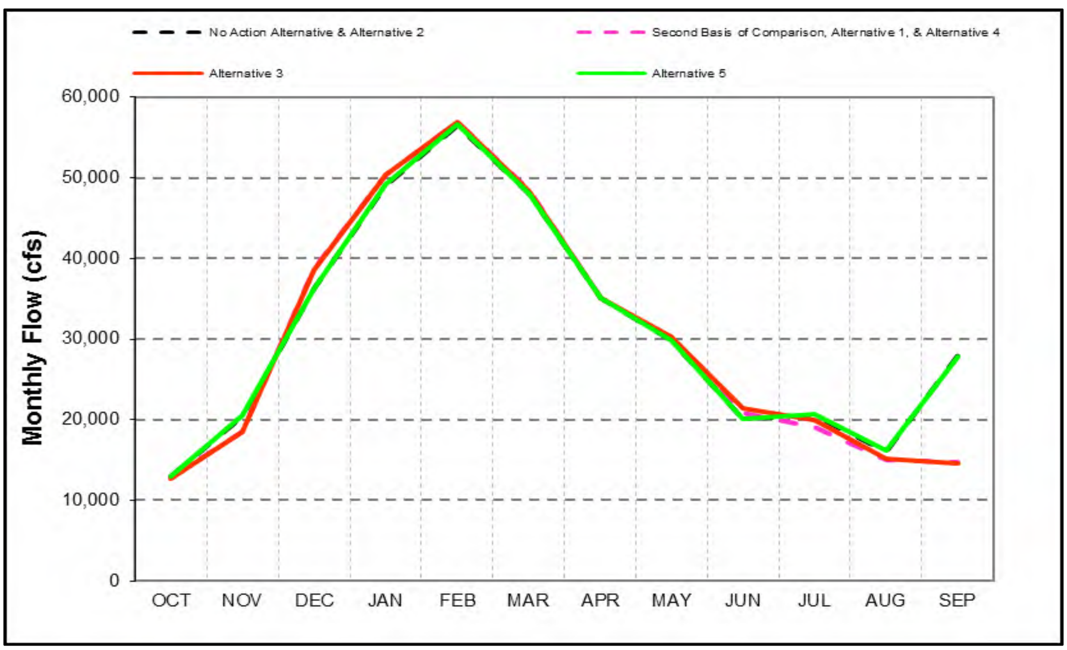



**Figure 5.60 Sacramento River at Freeport, Wet Year Long-Term Average Flow[15,16]**

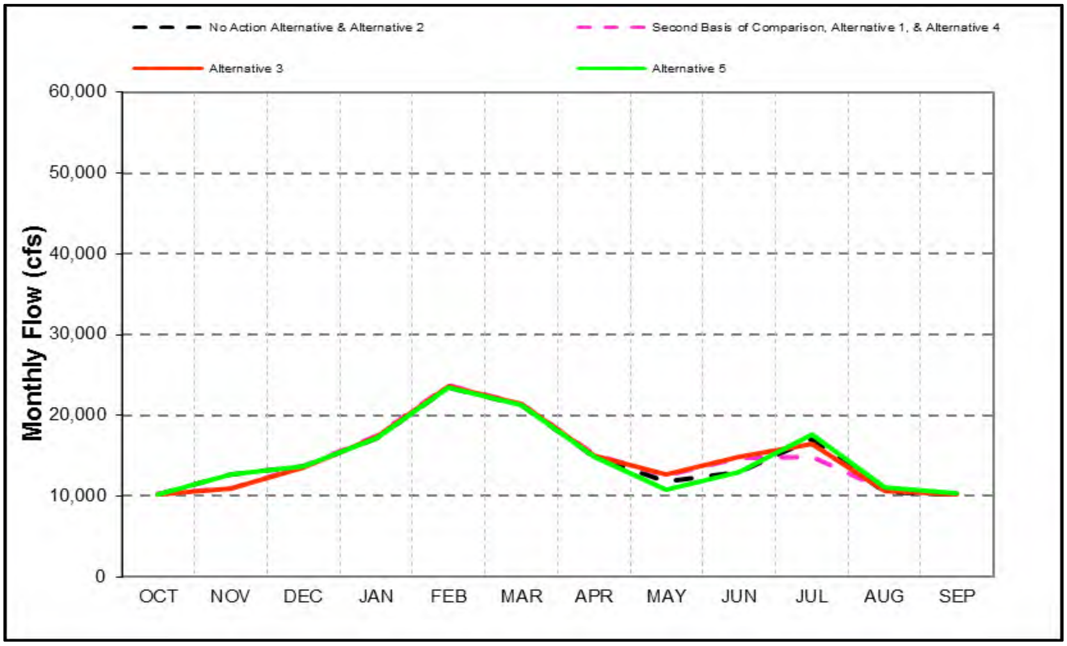



**Figure 5.61 Sacramento River at Freeport, Dry Year Long-Term Average Flow[15,16]**

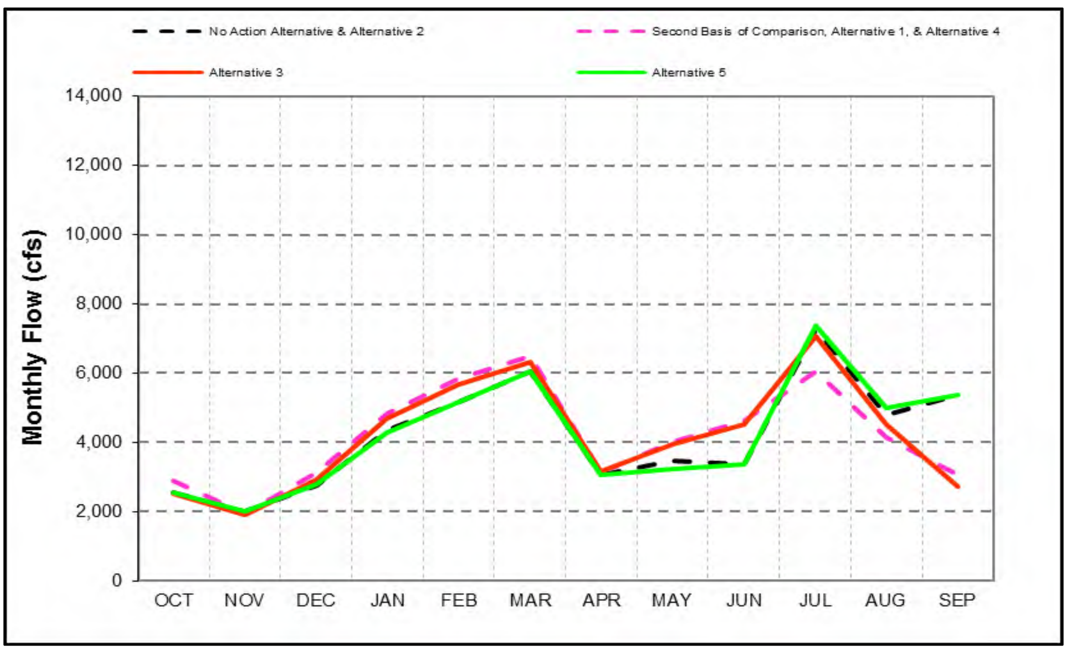



**Figure 5.62 Feather River downstream of Thermalito, Long-Term Average Flow[15]**

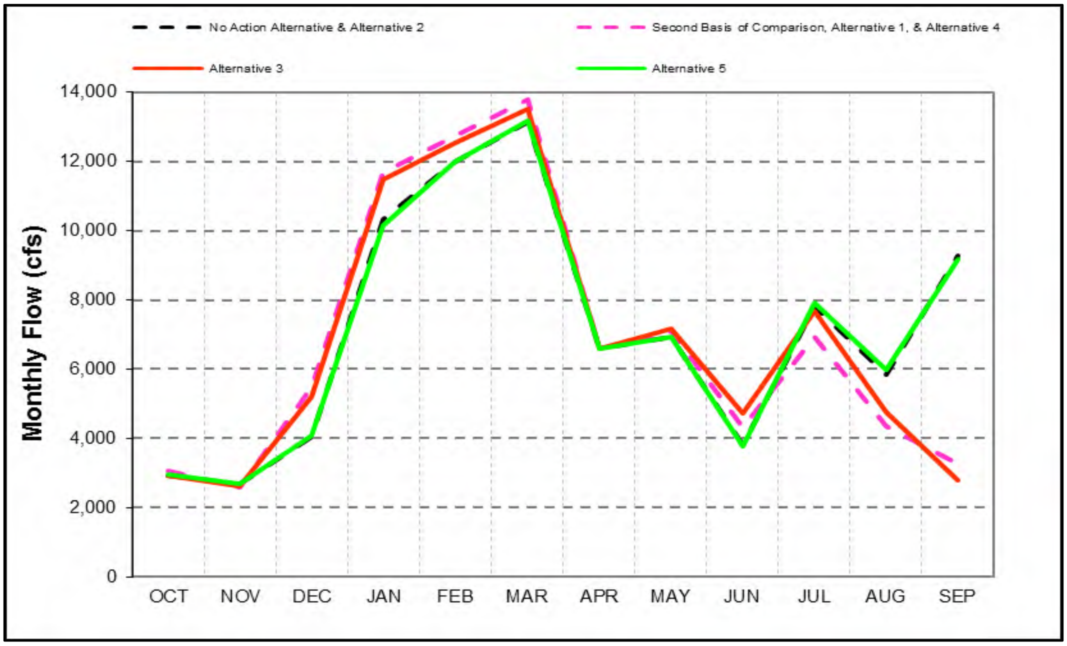



**Figure 5.63 Feather River downstream of Thermalito, Wet Year Long-Term Average Flow[15,16]**

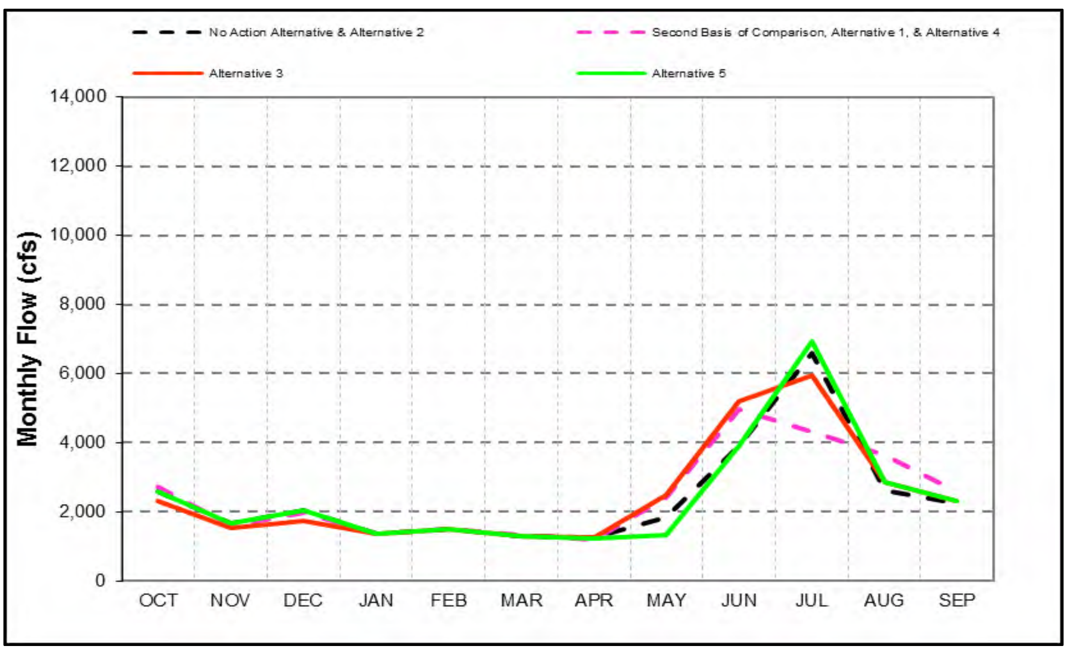



**Figure 5.64 Feather River downstream of Thermalito, Dry Year Long-Term Average Flow[15,16]**

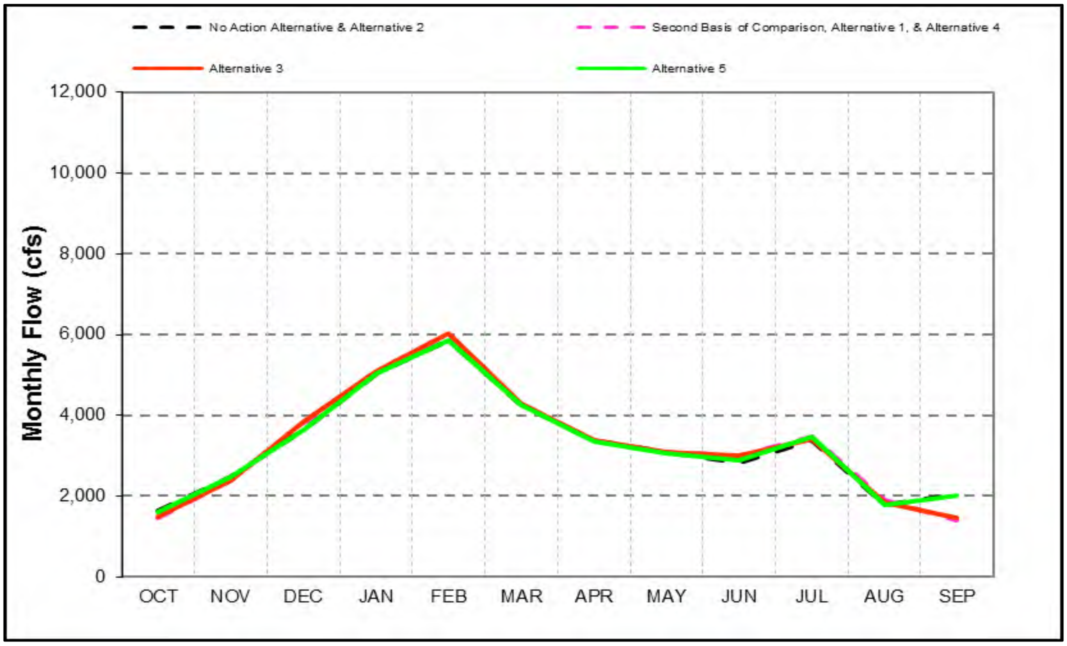



**Figure 5.65 American River downstream of Nimbus Dam, Long-Term Average Flow[15]**

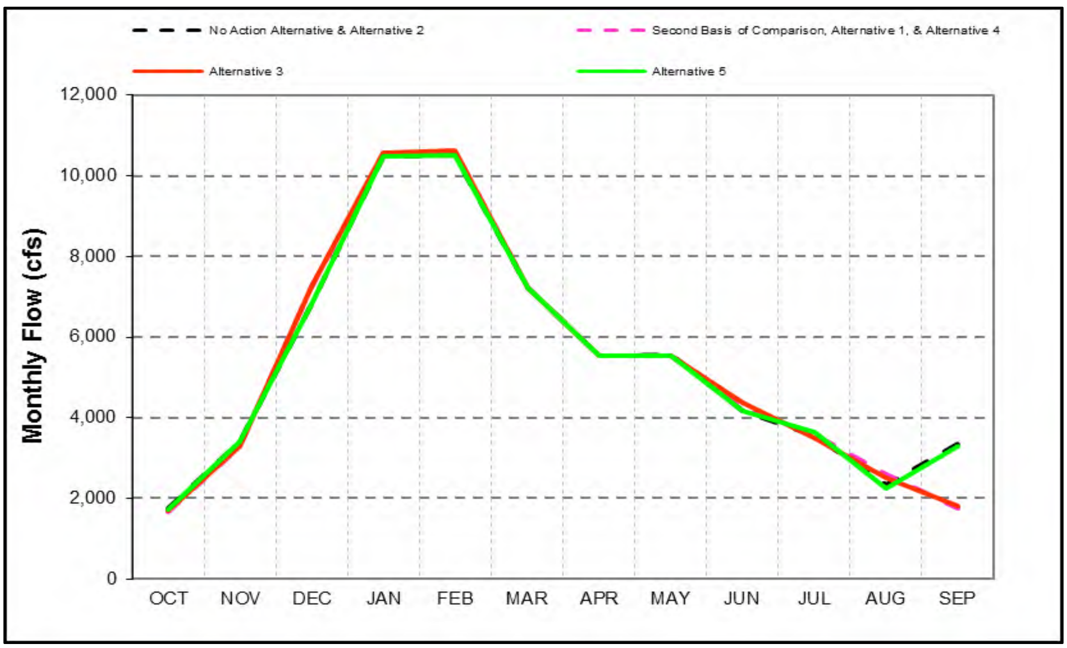



**Figure 5.66 American River downstream of Nimbus Dam, Wet Year Long-Term Average Flow[15,16]**

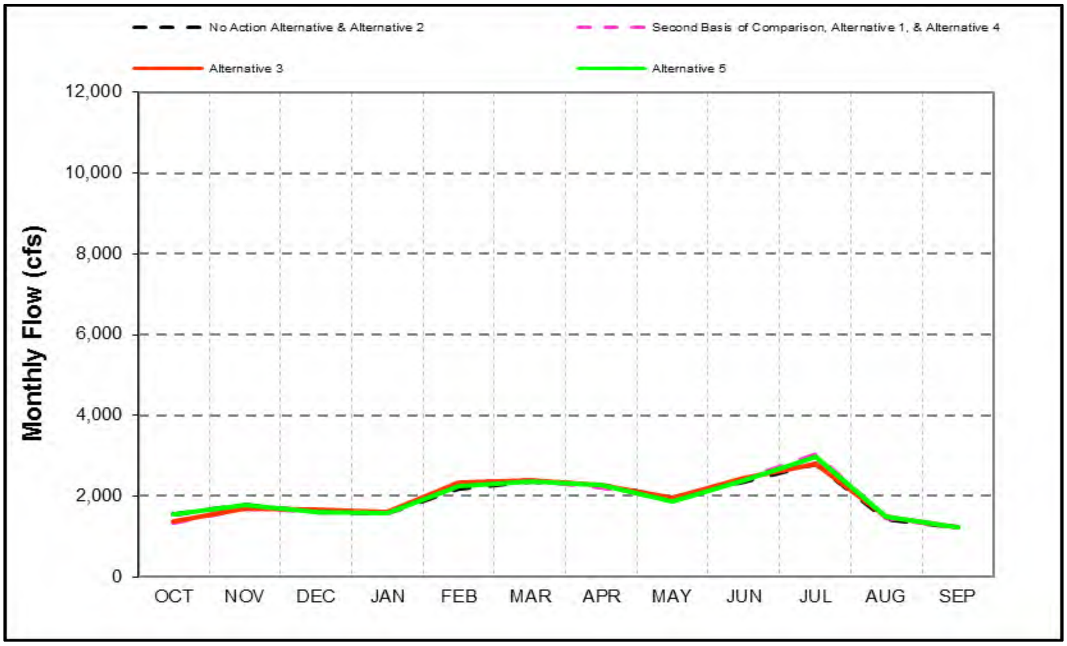



**Figure 5.67 American River downstream of Nimbus Dam, Dry Year Long-Term Average Flow[15,16]**

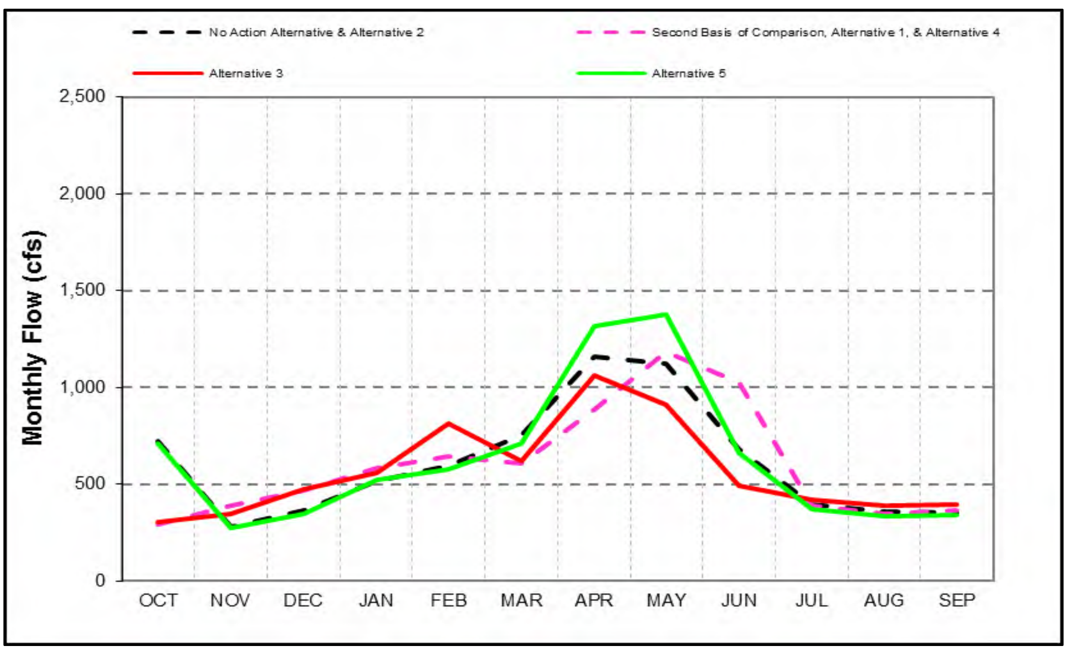



**Figure 5.68 Stanislaus River below Goodwin, Long-Term Average Flow[15]**

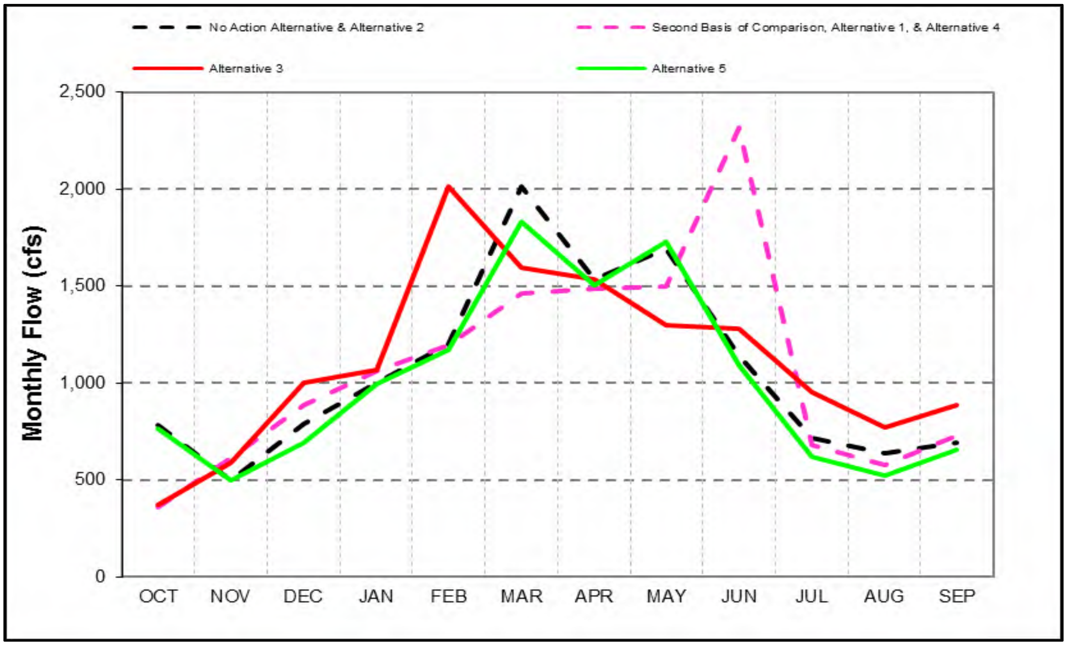



**Figure 5.69 Stanislaus River below Goodwin, Wet Year Long-Term Average Flow[15,16]**

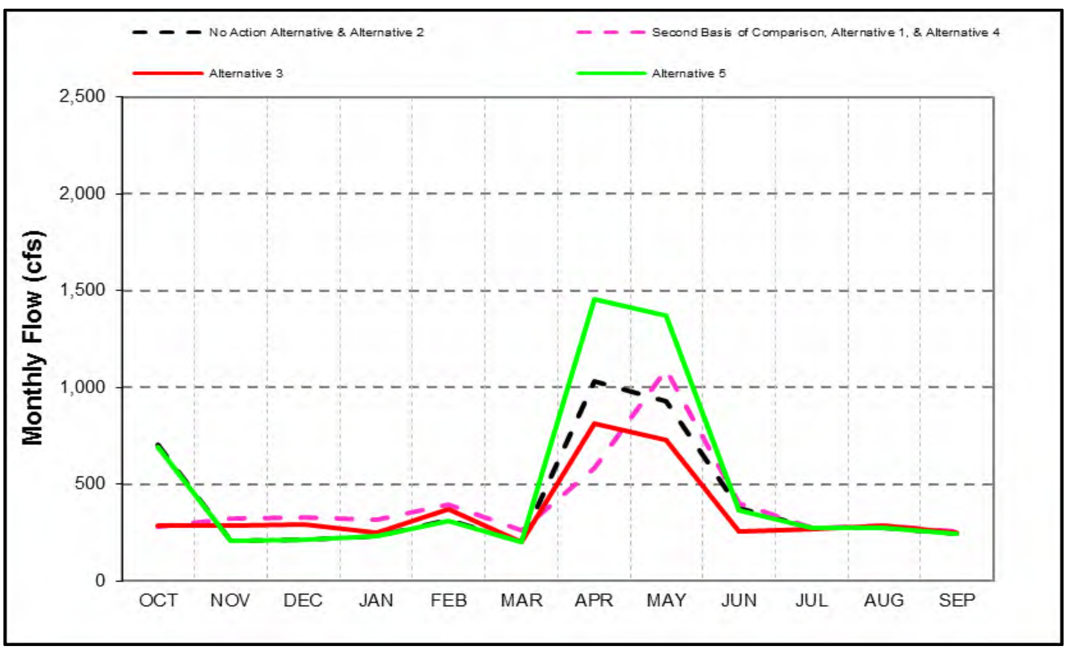



**Figure 5.70 Stanislaus River below Goodwin, Dry Year Long-Term Average Flow[15,16]**

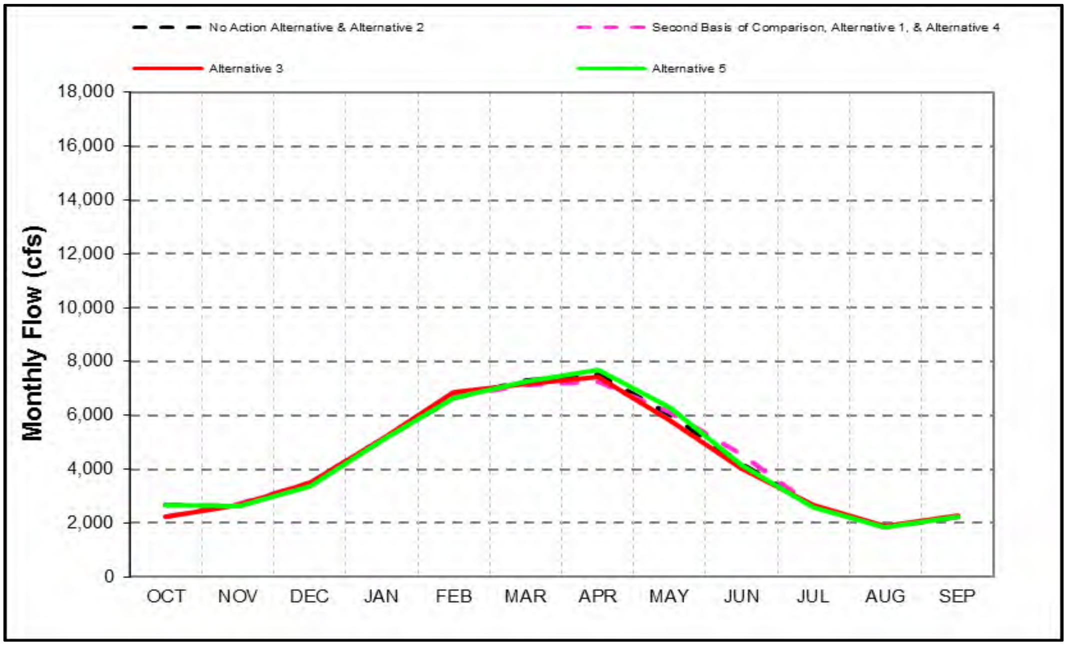



**Figure 5.71 San Joaquin River at Vernalis, Long-Term Average Flow[15]**

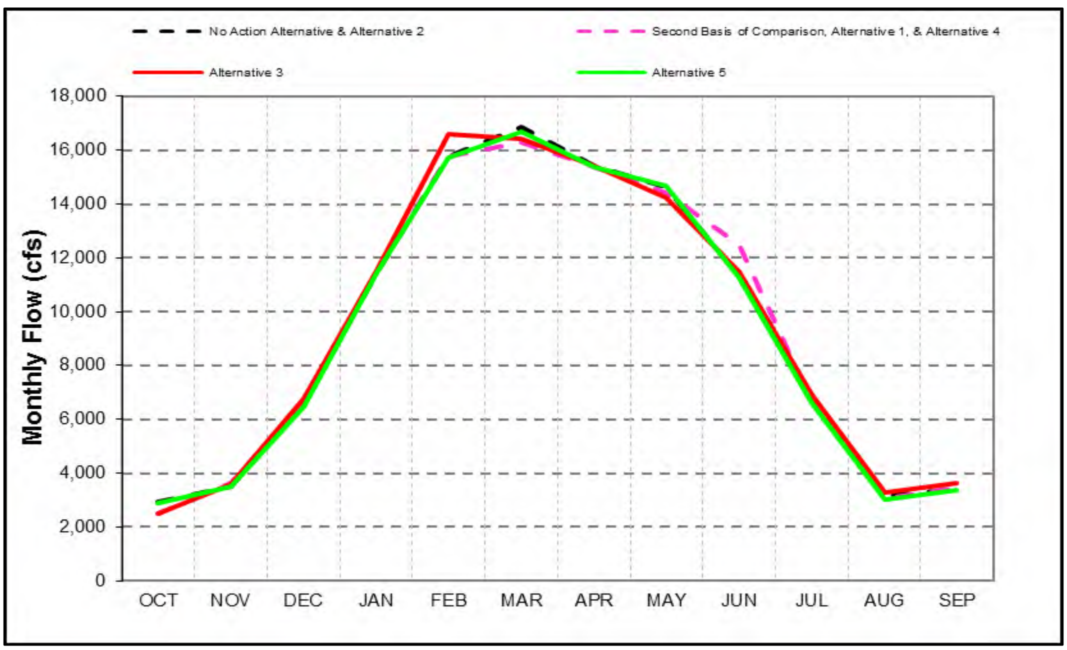



**Figure 5.72 San Joaquin River at Vernalis, Wet Year Long-Term Average Flow[15,16]**

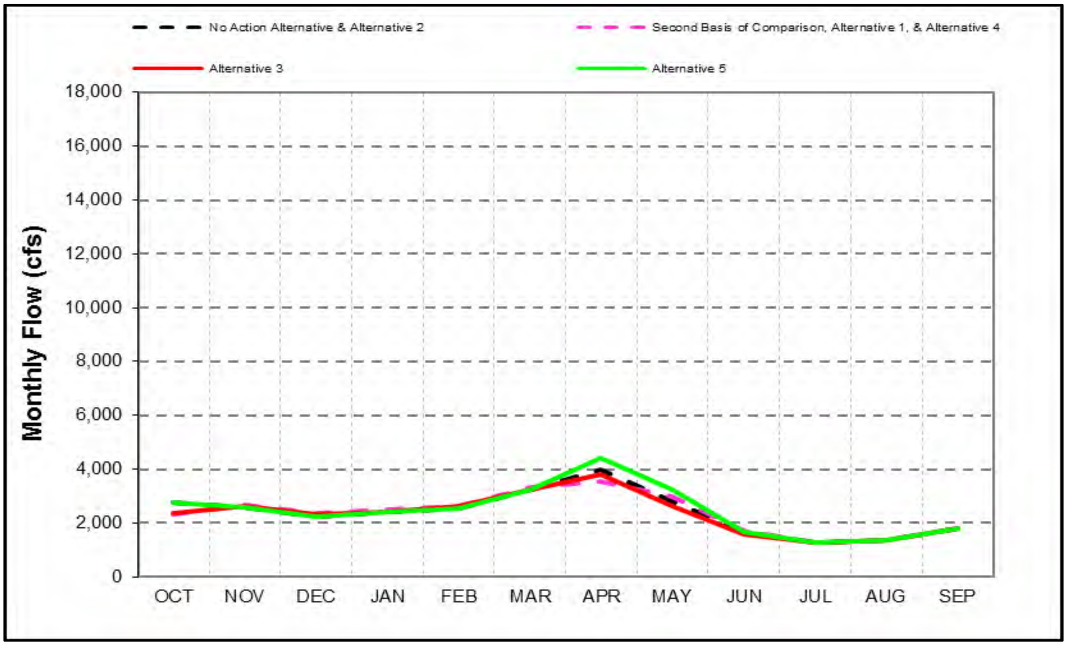



**Figure 5.73 San Joaquin River at Vernalis, Dry Year Long-Term Average Flow[15,16]**

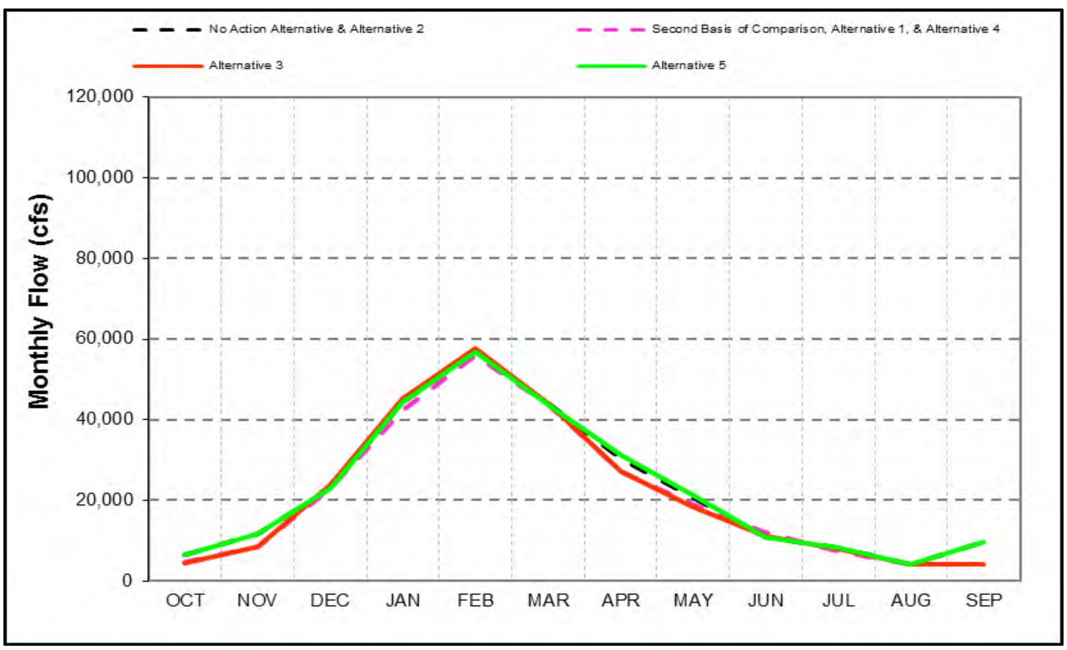



**Figure 5.74 Sacramento/San Joaquin River Delta Outflow, Long-Term Average Flow[15]**

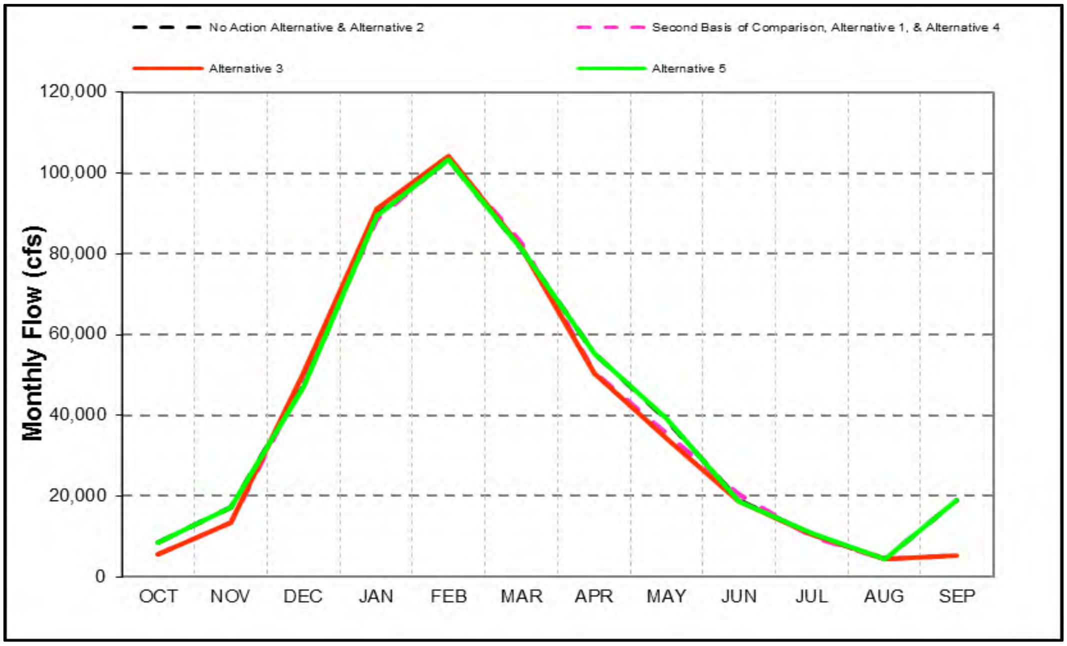



**Figure 5.75 Sacramento/San Joaquin River Delta Outflow, Wet Year Long-Term Average Flow[15]**

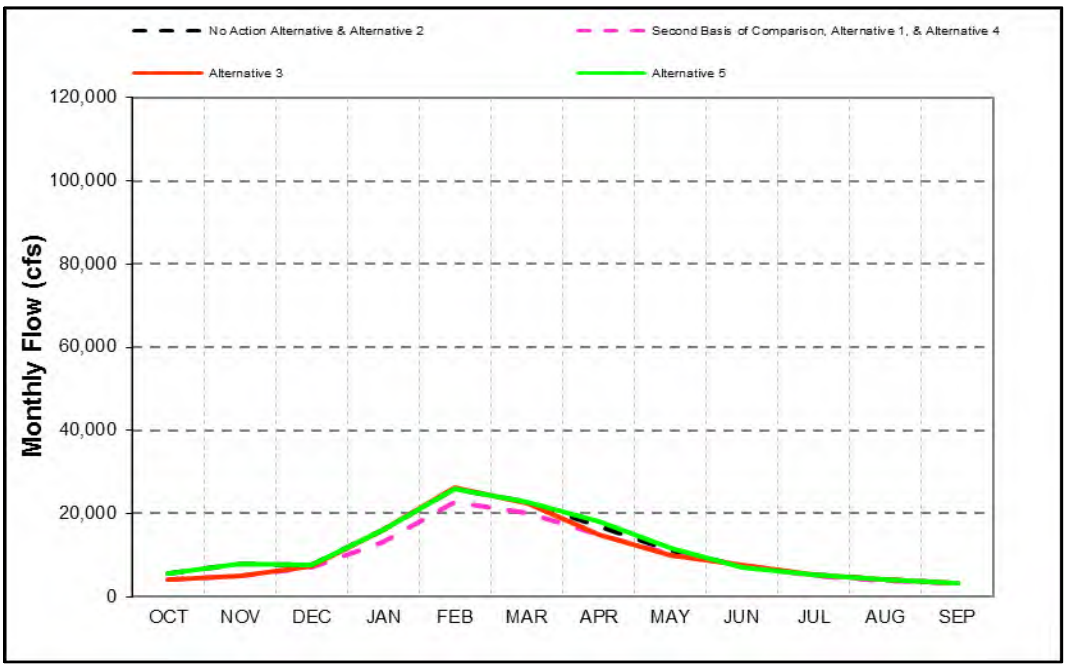



**Figure 5.76 Sacramento/San Joaquin River Delta Outflow, Dry Year Long-Term Average Flow[15]**

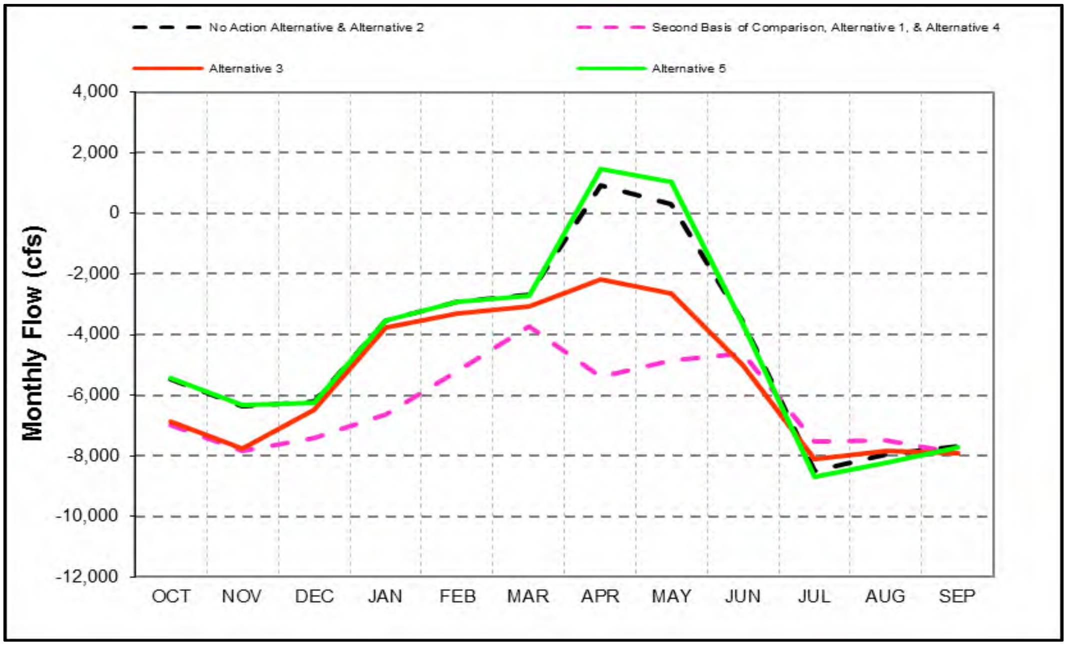



**Figure 5.77 Old and Middle River, Long-Term Average Flow[15]**

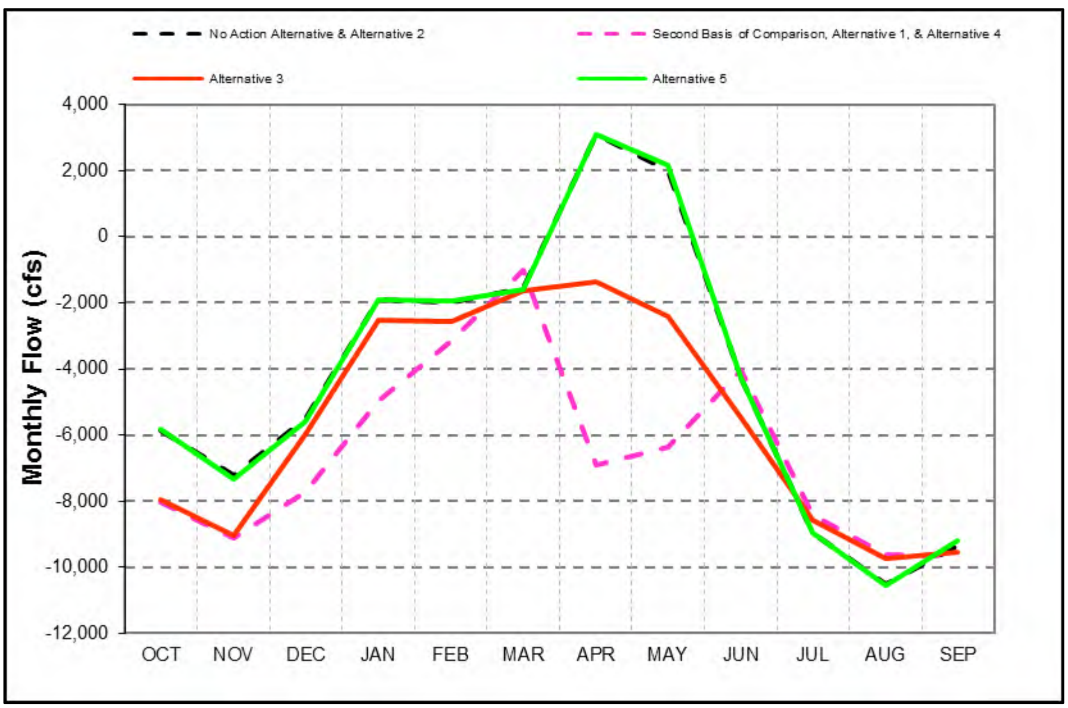



**Figure 5.78 Old and Middle River, Wet Year Long-Term Average Flow[15, 16]**

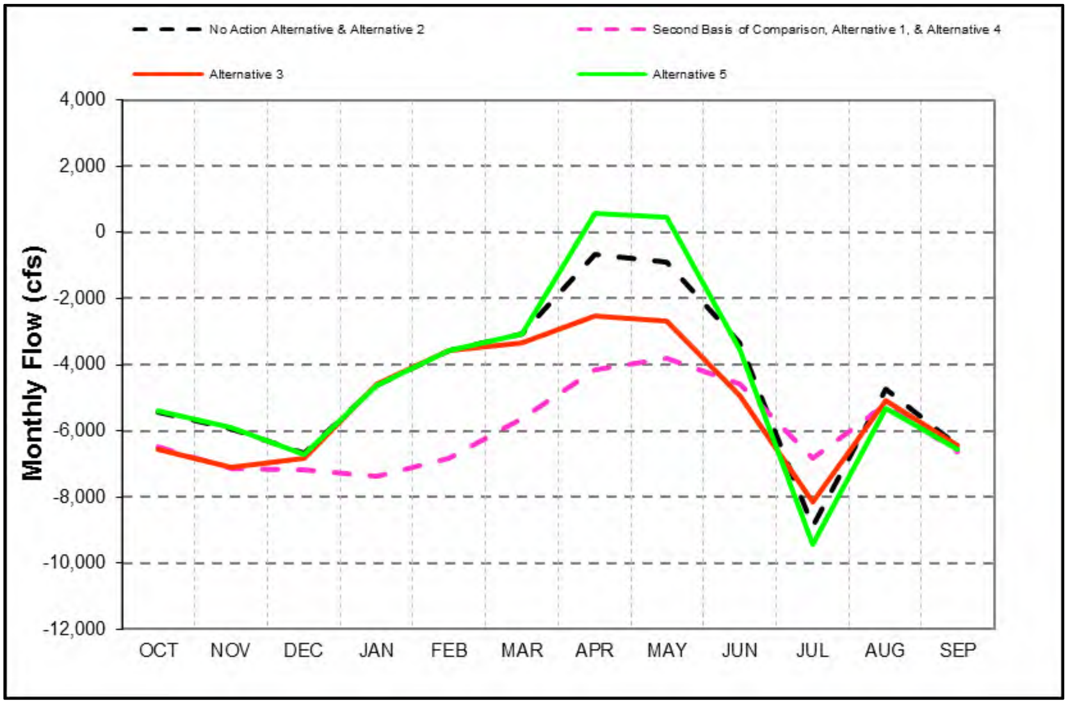



**Figure 5.79 Old and Middle River, Dry Year Long-Term Average Flow[15, 16]**

This page left blank intentionally.

**Chapter 6**

# Surface Water Quality

## 6.1 Introduction

This chapter describes Surface Water Quality in the study area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 6.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect surface water resources impacted by changes in the operations of CVP or SWP reservoirs and in the vicinity of and lands served by CVP and SWP water supplies. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

Several of the Federal and state laws and regulations that provide quantitative criteria to determine compliance also are summarized in this subsection of this chapter to provide context for information provided in the remaining sections of this chapter.

### 6.2.1 Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act)

The Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), established the institutional structure for the U.S. Environmental Protection Agency (USEPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The CWA was further amended through the CWA of 1977 and the Water Quality Act of 1987. The California State Water Resources Control Board (SWRCB) has been designated by the USEPA to develop and enforce water quality objectives and implementation plans in California, as described below under State Policies and Regulations.

The California RWQCBs have adopted, and the SWRCB has approved, water quality control plans (basin plans) for each watershed basin in the State. The basin plans designate the beneficial uses of waters within each watershed basin, and water quality objectives designed to protect those uses pursuant to

Section 303 of the CWA. The beneficial uses together with the water quality objectives that are contained in the basin plans constitute State water quality standards.

Under the CWA section 303(d), the USEPA identifies and ranks water bodies for which existing pollution controls are insufficient to attain or maintain water quality standards based upon information prepared by all states, territories, and authorized Indian tribes (referred to collectively as "states" in the CWA). This list of impaired waters for each state comprises the state's 303(d) list. Each state must establish priority rankings and develop Total Maximum Daily Load (TMDL) values for all impaired waters. TMDLs calculate the greatest pollutant load that a water body can receive and still meet water quality standards and designated beneficial uses.

Section 305(b) of the CWA requires every state to submit a biennial water quality assessment of all state waters. These state-wide reports serve as the basis for USEPA's national Water Quality Inventory Report to Congress. Each water body is assessed regarding its ability to support the most common beneficial uses: aquatic life, drinking water supply, fish consumption, non-contact recreation, shell fishing, and swimming; also known as core beneficial uses (SWRCB 2010a).The USEPA requires states to integrate the 303(d) and 305(b) reports. For California, this report is called the California 303(d)/305(b) Integrated Report, and is prepared by the SWRCB using Integrated Reports submitted by each RWQCB (SWRCB 2010a). The 303(d) and 305(b) processes are further explained below under State Policies and Regulations.

The California Environmental Protection Agency, SWRCB, and RWQCBs have identified numerous water bodies within the project area that do not comply with applicable water quality standards and either adopted or are developing TMDLs, shown below in Table 6.1.

**Table 6.1 Constituents of Concern per the 303(d) list within the Study Area**

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| Trinity and Lower Klamath Rivers | Trinity Lake (was Claire Engle Lake) | Mercury | Expected: 2019 |
| | Trinity River HU, Lower Trinity HA; Trinity River HU, Middle HA; Trinity River HU, South Fork HA; Trinity River, Upper HA; Trinity River HU, Upper HA, Trinity River, East Fork | Sedimentation/Siltation, Temperature[2], Mercury[3] | Approved: 2001 |
| | Klamath River HU, Lower HA, Klamath Glen HAS | Nutrients, Organic, Enrichment/Low Dissolved Oxygen, Water Temperature | Approved: 2010 |
| | | Sedimentation/Siltation | Expected: 2025 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| Sacramento River Basin | Shasta Lake (where West Squaw Creek Enters); Keswick Reservoir (portion downstream from Spring Creek); Spring Creek, Lower (Iron Mountain Mine to Keswick Reservoir) | Acid Mine Drainage[4], Cadmium, Copper, Zinc | Expected: 2020 |
| | Shasta Lake; Whiskeytown Lake (areas near Oak Bottom, Brandy Creek Campgrounds and Whiskeytown); Clear Creek (below Whiskeytown Lake, Shasta County) | Mercury | Expected: 2021 |
| | Sacramento River (Keswick Dam to the Delta)[5] | Unknown Toxicity | Expected: 2019 |
| | | Chlordane[6], DDT, Mercury[7], PCBs, Dieldrin[8] | Expected: 2021 |
| | Colusa Basin Drain | Diazinon | Expected: 2008 |
| | | Malathion | Expected: 2010 |
| | | Azinphos-methyl (Guthion), Group A Pesticides, Unknown Toxicity | Expected: 2019 |
| | | DDT, Dieldrin, E. coli, Low Dissolved Oxygen, Mercury, Carbofuran | Expected: 2021 |
| | Oroville Lake; Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento River), Yuba River, Lower[9] | Group A Pesticides | Expected: 2011 |
| | | Chlorpyrifos, Unknown Toxicity | Expected: 2019 |
| | | Mercury, PCBs | Expected: 2021 |
| | Folsom Lake; Natoma, Lake; American River, Lower (Nimbus Dam to confluence with Sacramento River)[10] | Mercury | Expected: 2019 |
| | | Unknown Toxicity, PCBs | Expected: 2021 |
| | Cache Creek, Lower (Clear Lake Dam to Cache Creek Settling Basin near Yolo Bypass) | Mercury | Approved: 2007 |
| | | Unknown Toxicity | Expected: 2019 |
| | | Boron | Expected: 2021 |
| San Joaquin River and Tulare Basins | Mendota Pool; Panoche Creek (Silver Creek to Belmont Avenue) | Mercury[11] | Expected: 2021 |
| | | Selenium | Expected: 2019 |
| | | Sediment Toxicity[12] | Expected: 2021 |
| | | Sedimentation/Siltation[12] | Expected: 2007 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| | Agatha Canal (Merced County); Grasslands Marshes; Mud Slough, North (downstream of San Luis Drain); Salt Slough (upstream from confluence with San Joaquin River)[13] | Selenium[14] | Approved: 2002 |
| | | Chlorpyrifos | Approved: 2008 |
| | | Boron, Electrical Conductivity, Pesticides, Unknown Toxicity[15] | Expected: 2019 |
| | | Escherichia coli, Mercury, pH, Prometryn | Expected: 2021 |
| | San Luis Reservoir | Mercury | Expected: 2021 |
| | O'Neil Forebay | | Expected: 2012 |
| | Millerton Lake; San Joaquin River (Friant Dam to Stanislaus River)[16] | Selenium[17, 18] | Approved: 2002 |
| | | Chlorpyrifos, Diazinon[19] | Approved: 2007 |
| | | DDE20, DDT, Group A Pesticides | Expected: 2011 |
| | | | Expected: 2012 |
| | | Boron[21], Invasive Species[23], Unknown Toxicity | Expected: 2019 |
| | | Arsenic[24], Electrical Conductivity[18, 22], Mercury[18], Water Temperature[26] | Expected: 2021 |
| | | alpha.-BHC[20], Escherichia coli[18, 25], | Expected: 2022 |
| | San Joaquin River (Stanislaus River to Delta Boundary) | Chlorpyrifos, Electrical Conductivity | Approved: 2007 |
| | | DDE, DDT, Group A Pesticides | Expected: 2011 |
| | | Mercury | Expected: 2012 |
| | | Toxaphene, Unknown Toxicity | Expected: 2019 |
| | | Diuron, Escherichia coli, Water Temperature | Expected: 2021 |
| | Merced River, Lower; Tuolumne River, Lower; New Melones Reservoir; Tulloch Reservoir; Stanislaus River, Lower[27] | Diazinon | Expected: 2010 |
| | | Group A Pesticides | Expected: 2011 |
| | | Chlorpyrifos, Mercury, Water Temperature | Expected: 2021 |
| | | Unknown Toxicity | Expected: 2022 |
| | | Invasive Species | Expected: 2019 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| | Cosumnes River, Lower (below Michigan Bar; partly in Delta Waterways, eastern portion) | Escherichia coli, Sediment Toxicity | Expected: 2021 |
| | Mokelumne River, Lower (in Delta Waterways, eastern portion) | Copper, Zinc | Expected: 2020 |
| | | Chlorpyrifos, Mercury, Dissolved Oxygen, Unknown Toxicity | Expected: 2021 |
| | Calaveras River, Lower (from Stockton Diverting Canal to the San Joaquin River; partly in Delta waterways, eastern portion) | Chlorpyrifos, Diazinon | Approved: 2007 |
| | | Pathogens | Approved: 2008 |
| | | Organic Enrichment/Low Dissolved Oxygen | Expected: 2012 |
| | | Mercury | Expected: 2021 |
| | Kings River, Lower (Island Weir to Stinson and Empire Weirs); Kings River, Lower (Pine Flat Reservoir to Island Weir); Kaweah River (below Terminus Dam, Tulare County); Kaweah River, Lower (includes St Johns River)[28] | Electrical Conductivity, Molybdenum, Toxaphene | Expected: 2015 |
| | | Chlorpyrifos[29], pH[30], Unknown Toxicity | Expected: 2021 |
| Sacramento-San Joaquin River Delta | Sacramento San Joaquin Delta | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |
| | Delta waterways (central, eastern, northern, northwestern, western portion, southern portions, export area, and Stockton Ship Channel) | Chlorpyrifos[31], Diazinon, Organic Enrichment/Low Dissolved Oxygen[32] | Approved: 2007 |
| | | Pathogens[32] | Expected: 2008 |
| | | Mercury | Expected: 2009 |
| | | Chlordane[33], DDT, Dieldrin[33], Group A Pesticides | Expected: 2011 |
| | | Dioxin[32], Electrical Conductivity[34], Furan Compounds[32], Invasive Species, PCBs[35], Unknown Toxicity | Expected: 2019 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| Suisun Bay and Suisun Marsh | Suisun Bay | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |
| | Suisun Marsh Wetlands | Mercury, Nutrients, Organic Enrichment/Low Dissolved Oxygen, Salinity/TDS/Chlorides | Expected: 2013 |
| San Francisco Bay Region | Carquinez Strait and San Pablo Bay | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |

Source: SWRCB 2011A

Notes:

1 TMDL status is either expected to be completed or approved by USEPA in the year specified

2 Water temperature is only a constituent of concern for the South Fork Trinity River and a TMDL is expected to be completed in 2019.

3 Mercury is only a constituent of concern for the East Fork Trinity River in the upper hydrologic area and a TMDL is expected to be completed in 2019.

4 Acid Mine Drainage is a constituent of concern at Spring Creek only

5 Chlordane, DDT, PCBs, Dieldrin not constituents of concern for Sacramento River (Keswick Dam to Red Bluff)

6 Chlordane not a constituent of concern for Sacramento River (Red Bluff to Knights Landing)

7 Mercury not a constituent of concern for Sacramento River (Keswick Dam to Cottonwood Creek). Mercury TMDL is expected to be complete in 2012 for Sacramento River (Knights Landing to the Delta)

8 Dieldrin TMDL for Sacramento from Knights Landing to the Delta is expected to be completed in 2022.

9 Mercury is the only constituent of concern for Yuba River and a TMDL is expected to be complete in 2021. Mercury TMDL expected to be complete in 2021 for Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento River). Mercury and PCBs are the only constituents of concern for Lake Oroville and TMDLs are expected to be complete in 2021 for both constituents.

10 Mercury is the only constituent of concern for Folsom Lake and Lake Natoma. Mercury TMDL is expected to be completed in 2010 for American River, Lower (Nimbus Dam to confluence with Sacramento River)

11 Mercury TMDL for Panoche Creek (Silver Creek to Belmont Avenue) expected to be complete in 2020.

12 Not a constituent of concern for Mendota Pool

13 pH and selenium are the only constituents of concern for Agatha Canal (Merced County). Electrical conductivity and Selenium are the only constituents of concern for Grasslands Marshes. Boron, Electrical Conductivity, Pesticides, Selenium, and Unknown Toxicity are the only constituents of concern for Mud Slough, North (downstream of San Luis Drain). pH, selenium, and pesticides are not constituents of concern for Salt Slough (upstream from confluence with San Joaquin River)

14 The CVRWQCB completed a TMDL for selenium in the lower San Joaquin River (downstream of the Merced River) in 2001 and Salt Slough in 1997/1999, and USEPA approved this in 2002.

15 The unknown toxicity TMDL for Mud Slough (downstream of San Luis Drain) is expected to be written and complete in 2021.

16 Mercury is the only constituent of concern for Millerton Lake and a TMDL is expected to be complete in 2019.

17 Selenium is only a constituent of concern in San Joaquin River (Mud Slough to Merced River)

18 Electrical conductivity, Escherichia coli, mercury and selenium are not constituents of concern for San Joaquin River (Mendota Pool to Bear Creek). The Electrical Conductivity TMDL for San Joaquin River (Bear Creek to Merced River) is expected to be written and complete in 2019. The Mercury TMDL for San Joaquin River (Bear Creek to Stanislaus River) is expected to be written and complete in 2012.

19 Diazinon not a constituent of concern for San Joaquin River (Bear Creek to Mud Slough and Merced River to Tuolumne River)

20 DDE and alpha.-BHC is only a constituent of concern in San Joaquin River (Merced River to Tuolumne River)

21 The Boron TMDL for San Joaquin River (Merced to Tuolumne River) was approved by the USEPA in 2007. Boron is not a constituent of concern for the San Joaquin River (Tuolumne River to Stanislaus River).

22 The Electrical Conductivity TMDL for San Joaquin River (Tuolumne River to Stanislaus River) is expected to be written and complete in 2021.

23 Invasive species only a constituent of concern for the San Joaquin River (Friant Dam to Mendota Pool).

24 Arsenic not a constituent of concern in San Joaquin River except Bear Creek to Mud Slough.

25 Escherichia coli is not a constituent of concern for San Joaquin River (Mendota Pool to Bear Creek and Merced River to Stanislaus River). The Escherichia coli TMDL for San Joaquin River (Bear Creek to Mud Slough) is expected to be written and complete in 2021.

26 Water temperature is only a constituent of concern for San Joaquin River (Merced River to Stanislaus River)

27 Mercury is the only constituent of concern for New Melones Reservoir and Tulloch Reservoir. The diazinon TMDL for lower Merced River and lower Stanislaus River is expected to be complete in 2008. The Chlorpyrifos TMDL for the lower Merced River is expected to be complete in 2008. The Mercury TMDL for lower Merced River is expected to be complete in 2019 and lower Stanislaus River TMDL is expected to be complete in 2020. The Unknown Toxicity TMDL for lower Stanislaus River is expected to be complete in 2019 and lower Merced River is expected in 2021.

28 The only constituents of concern for Kings River, Lower (Island Weir to Stinson and Empire Weirs) are electrical conductivity, toxaphene, molybdenum.

29 Chlorpyrifos is only a constituent of concern for Kings River, Lower (Pine Flat Reservoir to Island Weir).

30 pH is only a constituent of concern for Kaweah River (below Terminus Dam, Tulare County).

31 Chlorpyrifos TMDL for Delta waterways (central portion) expected to be complete in 2019. Chlorpyrifos TMDL for Delta waterways (western portion) expected to be complete in 2006.

32 Not a constituent of concern for Delta waterways except for Stockton Ship Channel.

33 Not a constituent of concern for Delta waterways except for northern portion.

34 Not a constituent of concern for Delta waterways (central, northern, eastern portions, and Stockton Ship Channel)

35 Not a constituent of concern for Delta waterways except for the northern portion and the Stockton Ship Channel.

National Toxics Rule (NTR) was established by USEPA in accordance with CWA section 303 to provide ambient water quality criteria for priority toxic pollutants to protect aquatic life and human health.

The Secretary of the Interior established the first antidegradation policy in 1968. In 1975, USEPA included the antidegradation requirements in the Water Quality Standards Regulation (40 Code of Federal Regulations [CFR] 130.17, 40 CFR 55340-41). The requirements were included in the 1987 CWA amendment in section 303(d)(4(B)). The Federal antidegradation policy requires states to develop regulations to allow increases in pollutant loadings or changes in surface water quality only if: 1) existing surface water uses are maintained and protected, and established water quality requirements are met; 2) if water quality requirements cannot be maintained by a project, water quality must be maintained to fully protect "fishable/swimmable" uses and other existing uses; and 3) for Outstanding National Resource Waters water quality criteria where "States may allow some limited activities which result in temporary and short-term changes in water quality" (Water Quality Standards Regulations) but would not impact existing uses or special use of these waters.

### 6.2.2 Major California Water Quality Regulations

The Porter Cologne Water Quality Control Act (Porter-Cologne Act) established the SWRCB and divided the state into nine regions, each overseen by a RWQCB. The nine RWQCBs have the primary responsibility for the coordination and control of water quality within their respective jurisdictional boundaries. The SWRCB and the RWQCBs have been delegated Federal authority to implement the requirements of the Federal CWA in California. The RWQCBs that have jurisdiction over the water bodies in the project area are the NCRWQCB, CVRWQCB, SFB RWQCB, Central Coast RWQCB, Los Angeles RWQCB, Santa Ana RWQCB, San Diego RWQCB, Lahontan RWQCB, and Colorado River RWQCB. The Porter-Cologne Act requires the RWQCBs to prepare and periodically update basin plans. Basin plans establish beneficial uses of water, water quality objectives, and implementation programs for achieving the objectives.

The State of California has adopted several water quality policies that are similar to federal water quality policies, including the California Toxics Rule (CTR) and the Policy for Implementing Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (State Implementation Policy).

The CTR is applicable to all State waters, as are the USEPA advisory National Recommended Water Quality Criteria. Fresh water criteria apply to waters of salinity less than 1 parts per thousand 95 percent or more of the time, seawater criteria are for water greater than 10 parts per thousand 95 percent or more of the time, and estuarine waters use the more stringent of the two possible criteria, in absence of estuary-specific criteria.

The State Implementation Policy for water quality control, adopted in 2000, applies to discharges of toxic pollutants into the inland surface waters, enclosed bays, and estuaries of California subject to regulation under the Porter-Cologne Act and the Federal CWA. This policy establishes:

- Implementation provisions for priority pollutant criteria promulgated by the USEPA through the NTR and the CTR, and for priority pollutant objectives established by RWQCBs in their basin plans;
- Monitoring requirements for 2,3,7,8-tetrachlorodibenzodioxin (TCDD) equivalents; and
- Chronic toxicity control provisions.

#### *6.2.2.1 Basin Plans*

The RWQCBs are required to formulate and adopt basin plans for all areas under their jurisdiction under the Porter-Cologne Act. Each basin plan must contain water quality objectives to ensure the reasonable protection of beneficial uses, as well as a program of implementation for achieving water quality objectives with the basin plans.

Section 13050(f) of the Porter-Cologne Act lists the beneficial uses of the waters of the state that may be protected against water quality degradation, which include but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, and wildlife and other aquatic resources or preserves. Basin plans must designate and protect beneficial uses in the region. A uniform list of beneficial uses is defined by the SWRCB, however each RWQCB may identify additional beneficial uses specific to local water bodies.

Basin plans must adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. These water quality standards include: designated beneficial uses; water quality objectives to protect the beneficial uses; implementation of the Federal and State policies for antidegradation; and general policies for application and implementation.

The basin plans are subject to modification, considering applicable laws, policies, technologies, water quality conditions and priorities. Basin plans must be assessed every three years for the appropriateness of existing standards and evaluation and prioritization of basin planning issues. In California however, water bodies are assessed every two years for CWA 303(d) and 305(b) requirements. Revisions are accomplished through Basin Plan amendments. Once a Basin Plan amendment is adopted in noticed public hearings, it must be approved by the SWRCB, Office of Administrative Law and in some cases, the USEPA.

##### 6.2.2.1.1 California 303(d)/305(b) Integrated Reports

The California 303(d)/305(b) Integrated Report is updated biennially for inclusion in the USEPA's national Water Quality Inventory Report to Congress. The report is composed of the current California 303(d) list, and all current listing decisions for contaminants in impaired water bodies. The statewide report is the compilation of 303(d)/305(b) Integrated Reports submitted by each RWQCB. The final California 303(d) list must be submitted to and approved by the USEPA before it becomes effective.

The most recent statewide report is the 2010 California 305(b)/303(d) Integrated Report, accompanied by the 2010 Staff Report, which outlines the process by which water bodies were assessed for impairment and by which listing decisions were made. Each successive 303(d) list updates the previous approved 303(d) list, in this case the 2006 Section 303(d) list. The updates are made by each RWQCB in accordance with the Water Quality Control Policy for Developing California's CWA Section 303(d) list ("Listing Policy").

For the 2010 Integrated Report, the data assessed included the 2006 California CWA Section 303(d) list and its supporting data and information, applicable Surface Water Ambient Monitoring Program (SWAMP) data from 2000 to 2007, data from several local monitoring programs, and data provided during public solicitation. Data incorporated into the assessment were existing and readily available to RWQCB staff.

Data were assessed to identify the beneficial uses for each water body, and whether water quality criteria were being met. The core beneficial uses most commonly evaluated were aquatic life, drinking water supply, fish consumption, non-contact recreation, shell fishing, and swimming. The water quality criteria considered included water quality objectives set forth by RWQCB Basin Plans, criteria included in Statewide Basin Plans, the CTR, and maximum contaminant level MCLs. Narrative "Evaluation Guidelines" were designated for pollutants without numeric Basin Plan Objectives, MCLs or CTR criteria, as described in the Listing Policy.

The data and assessment results were summarized in LOEs for water body segment-contaminant combinations. The LOEs include specific information used to determine whether water quality standards are being met for the water body segment, including: affected beneficial uses; relevant pollutant; relevant water quality criteria; and detailed information regarding data samples and quality assurance information. Fact sheets were prepared that summarize the LOEs and the reasoning for inclusion or exclusion of the water body-pollutant combination from the 303(d) list. The fact sheets are stored in the Water Boards' California Water Quality Assessment (CalWQA) database.

Water body segment-contaminant combinations were categorized into one of three Beneficial Use Support Ratings: fully supporting (supporting), not supporting, and insufficient information. These Beneficial Use Support Ratings were used as the basis for categorizing the water bodies into Integrated Report categories.

For water bodies that are in need of a TMDL, the Listing Policy provides instruction for scheduling TMDL development, based on, among other factors, the significance of the water segment, the degree that water quality objectives are not met or that beneficial uses are threatened, and the potential threat to human health and the environment.

The 2010 California 305(b)/303(d) Integrated Report results in a significant increase in proposed 303(d) listings in comparison to previous years. This is likely the result of a large volume of water quality data available for the 2010 assessment, which was not available for the 2006 assessment. There are also more protective water quality standards for some water bodies, requiring their addition to the 303(d) list.

#### *6.2.2.2 Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)*

In 2006, the CVRWQCB, the SWRCB, and stakeholders began a joint effort to address salinity and nitrate problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. This effort is referred to as the CV-SALTS Initiative. The goal of CV-SALTS is to develop a comprehensive region-wide Salt and Nitrate Management Plan (SNMP) describing a water quality protection strategy that will be implemented through a mix of voluntary and regulatory efforts. The SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or basin plan revisions. The SNMP will serve as the basis for amendments to the three water quality control plans that cover the Central Valley Region (Sacramento River and San Joaquin River Basin Plan, the Tulare Lake Basin Plan and the Sacramento/San Joaquin Rivers Bay-Delta Plan) and the San Francisco Bay Area Region Basin Plan. The Basin Plan Amendments (BPAs) will likely establish a comprehensive implementation plan to achieve water quality objectives for salinity (including nitrate) in the Region's surface waters and groundwater; and the SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or Basin Plan revisions.

## 6.3 Affected Environment

This section describes surface water quality that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in water quality due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, and Central Coast and Southern California regions. Changes to surface water bodies and water supplies are described in Chapter 5, Surface Water Resources and Water Supplies.

This chapter focuses on constituents of concerns that could be affected by changes in CVP and SWP water operations. The constituents of concern have been identified in the Final California 2010 Integrated Report (303(d) List/305(b) Report) as well as other water quality reports. This section provides descriptions of sources of constituents, water quality effects, water quality objectives and/or guidelines, and plans to improve water quality.

### 6.3.1 Beneficial Uses of Surface Waters in the Study Area

Water quality conditions throughout the study area are assessed and described by the RWQCB Basin Plans and Integrated Reports. Each region has specific beneficial uses, as summarized in Table 6.2 and water quality constituents of concern; however, several pollutants are prevalent throughout the study area. The origins and prevalence of these pollutants are discussed below.

**Table 6.2 Designated Beneficial Uses within Project Study Area**

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trinity and Lower Klamath Rivers** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lower Klamath River and Klamath Glen Hydrologic Subarea | E | E | P | P | E | E | E | P | E | E | E | E | E | E | E | E | E | E | E | E | P | E | – | – | – |
| Trinity Lake | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | – | P | E | – | – | P | – | – | – | – |
| Lewiston Reservoir | E | E | P | P | E | E | E | E | E | E | E | P | E | E | E | – | P | E | – | – | E | – | – | – | – |
| Middle Trinity River and Surrounding Hydrologic Area | E | E | E | P | E | E | E | P | E | E | E | – | E | E | E | – | E | E | – | – | E&P | – | – | – | – |
| Lower Trinity River and Surrounding Hydrologic Area[1] | E&P | E&P | E | E&P | E | E | E | E&P | E | E | E | – | E | E | E | – | E | E | P | – | E&P | E[2] | – | – | – |
| **Sacramento River Basin** | | | | | | | | | | | | | | | | | | | | | | | | | |

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shasta Lake | E | E | – | – | – | – | – | E | E | E | – | E[4] | E[4] | E | – | – | – | E[5,6] | – | – | – | – | – | – | – |
| Sacramento River: Shasta Dam to Colusa Basin Drain | E | E | E | – | – | – | E | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Colusa Basin Drain | – | E | – | – | – | – | – | – | E[3] | – | – | E[4] | P[4] | E | – | – | E[6] | E[6] | – | – | – | – | – | – | – |
| Sacramento River: Colusa Basin Drain to Eye (“I”) Street Bridge | E | E | – | – | – | – | E | – | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Whiskeytown Lake | E | E | – | – | – | – | – | E | E | E | – | E[4] | E[4] | E | – | – | – | E[6] | – | – | – | – | – | – | – |
| Clear Creek below Whiskeytown Lake | E | E | – | – | – | – | – |  | E[3] | E | – | E[4] | E[4] | E | – | – | E[5] | E[5,6] | – | – | – | – | – | – | – |

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feather River below Lake Oroville (Fish Barrier Dam to Sacramento River) | E | E | – | – | – | – | – | – | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| American River below Lake Natoma (Folsom Dam to Sacramento River) | E | E | E | – | – | – | – | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Yolo Bypass[7] | – | E | – | – | – | – | – | – | E | E | – | E[4] | P[4] | E | – | – | E[5,6] | E[6] | – | – | – | – | – | – | – |
| **Sacramento-San Joaquin River Delta** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sacramento-San Joaquin River Delta[7,8,9] | E | E | E | E | E | – | E | – | E | E | E | E[4] | E[4] | E | E | – | E[5,6] | E[6] | E | E | – | – | – | – | – |
| **San Joaquin River and Tulare Basin** | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Joaquin River: Friant Dam to Mendota Pool | E | E | – | E | – | – | | | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[6], P[5] | – | | | | | | |

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Joaquin River: Mendota Dam to the Mouth of Merced River | P | E | – | E | – | – | | | E[3] | E | – | E[4] | – | E | – | | E[5,6] | E[6], P[5] | – | | | | | | |
| San Joaquin River: Mouth of Merced River to Vernalis | P | E | – | E | – | | | | E[3] | E | – | E[4] | – | E | – | | E[5,6] | E[6] | – | – | – | – | – | – | – |
| New Melones Reservoir | E | E | – | – | – | – | – | E | E | E | – | – | E[4] | E | – | – | – | – | – | – | – | – | – | – | – |
| Tulloch Reservoir | P | E | – | – | – | – | – | E | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |
| Stanislaus River: Goodwin Dam to San Joaquin River | P | E | E | E | – | – | – | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5] | E[5,6] | – | – | – | – | – | – | – |
| San Luis Reservoir | E | E | E | – | – | – | – | E | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |
| O'Neill Reservoir | E | E | – | – | – | – | – | – | E | E | – | E[4] | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California Aqueduct | E | E | E | E | – | – | – | E | E | E | – | – | – | E | – | – | – | – | – | – | – | – | – | – | – |
| Delta-Mendota Canal | E | E | – | – | – | – | – | – | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |

Sources: Central Valley RWQCB 2004, SWRCB 2006a, Hoopa Valley TEPA 2008, Central Valley RWQCB 2011, North Coast RWQCB 2011,

Notes:

E: Existing Beneficial Use; P: Potential Beneficial Use

1 Includes beneficial uses for the Trinity River within the Hoopa Valley Indian Reservation as designated by the Hoopa Valley Indian Reservation Water Quality Control Plan, which, in addition to beneficial uses shown, also designates the Lower Trinity River as a Wild and Scenic waterway, providing for scenic, fisheries, wildlife and recreational purposes.

2 Not all beneficial uses are present uniformly throughout this water body. They have been summarized to reflect beneficial uses present in multiple segments of the water body.

3 Canoeing and rafting included in REC-1 designation.

4 Resident does not include anadromous. Any Segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.

5 Cold water protection for salmon and steelhead.

6 Warm water protection for striped bass, sturgeon, and shad.

7 Beneficial uses vary throughout the Delta and will be evaluated on a case-by-case basis. COMM is a designated beneficial use for the Sacramento San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins and not any tributaries to the listed waterways or portions of the listed waterways outside of the legal Delta boundary unless specifically designated.

8 Delta beneficial uses are shown as designated by the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin, and the Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary.

9 Per State Water Board Resolution No. 90-28, Marsh Creek and Marsh Creek Reservoir in Contra Costa County are assigned the following beneficial uses: REC-1 and REC-2 (potential uses), WARM, WILD and RARE. COMM is a designated beneficial use for Marsh Creek and its tributaries listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins within the legal Delta boundary.

#### 6.3.1.1 Water Temperature

Water temperature is a concern in regions throughout California including the lower Klamath River, Trinity Lake, Sacramento River, and the San Joaquin River. These regions support warm and cold fresh water habitat and other aquatic beneficial uses. Water bodies in these areas must maintain water temperatures supportive of resident and seasonal fish species habitats, particularly for endangered species. Common narrative and numeric water quality objectives for water temperature in water bodies within the study area are specified in each of the basin plans for the North Coast, Central Valley, Tulare Lake and the San Francisco Bay regions (NCRWQCB 2011; CVRWQCB 2004, and 2011; SFB RWQCB 2013):

- The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses.
- At no time or place shall the temperature of cold or warm-intrastate waters be increased by more than 5° F above natural receiving water temperature.

Water quality objectives for water temperature within the project study area are also specified in the SWRCB *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Statewide Temperature Plan)*.

Further information on the measurement and enforcement of water quality objectives for temperature is included in the Statewide Temperature Plan (SWRCB 1998).

#### 6.3.1.2 Salinity

Salinity, a measure of dissolved salts in water, is a concern in the tidally-influenced Delta as it can cause impacts on domestic supply, agriculture, industry, and wildlife (CALFED 2007). The impacts of salinity on the domestic supply of water in the Delta include aesthetic (skin or tooth discoloration), or cosmetic (taste, odor, or color) effects, and increasing the need to reduce salinity for M&I uses by blending which can lead to a reduction in the quantity of usable water. Salts, such as bromide, in drinking water can increase the formation of harmful byproducts (see the Bromide, Organics, and Pathogens section). Salinity in the Delta impacts agriculture by reducing crop yields and salinity in the soil can cause plant stress. Another salt ion, chloride, in high concentrations in municipal and industrial supply has been known to cause corrosion in canned goods because of residual salts in paper boxes or linerboard.

Some fish and wildlife are also affected by salinity concentrations in the Delta because certain levels of salinity are required during different life stages to survive. One measure of salinity in the western Delta is “X2.” X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs. The X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

The SWRCB D-1641 includes "spring X2" criteria that require operations of the CVP and SWP to include upstream reservoir releases from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. In addition, the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) also includes an additional Delta salinity requirement in September and October in wet and above normal water years (Fall X2), as described in Chapter 5, Surface Water Resources and Water Supplies.

#### *6.3.1.3 Mercury*

Mercury is a constituent of concern throughout California, both as total mercury and as biologically-formed methylmercury, which is more available for food chain exposure and toxicity. Mercury present in the Delta, its tributaries, Suisun Marsh, and San Francisco Bay is derived both from current processes and as a result of historical deposition. Most of the mercury present in these locations is the result of historical mining of mercury ore in the Coast Ranges (via Putah and Cache creeks to the Yolo Bypass) and the extensive use of elemental mercury to aid gold extraction processes in the Sierra Nevada (via Sacramento, San Joaquin, Cosumnes, and Mokelumne rivers) (Alpers et al. 2008; Wiener et al. 2003). Elemental mercury from historical gold mining processes appears to be more bioavailable than that from mercury ore tailings because mercury used in gold mining processes was purified before use (CVRWQCB 2010a). Additional sources of mercury include atmospheric deposition from both local and distant sources, and discharges from wastewater treatment plants (SWRCB 2014a).

Methylation of mercury is an important step in the entrance of mercury into food chain (USEPA 2001a). This transformation can occur in both sediment and the water column. Methylmercury is absorbed more quickly by aquatic organisms than inorganic mercury, and it biomagnifies (i.e., increases the concentration of methylmercury in predatory fish from eating smaller contaminated fish and invertebrates). The pH of water, the length of the aquatic food chain, water temperature, and dissolved organic material and sulfate are all factors that can contribute to the bioaccumulation of methylmercury in aquatic organisms. The proportion of an area that is wetlands, the soil type, and erosion can also contribute to the amount of mercury that is transported from soils to water bodies. These effects can be seen in the variability in bioaccumulated mercury in the Sacramento-San Joaquin River Delta.

Consumption of contaminated fish is the major pathway for human exposure to methylmercury (USEPA 2001a). Once consumed, methylmercury is almost completely absorbed into the blood and transported to all tissues, and is also transmitted to the fetus through the placenta. Neurotoxicity from methylmercury can result in mental retardation, cerebral palsy, deafness, blindness, and dysarthia in utero, and in sensory and motor impairments in adults. Cardiovascular and immunological effects from low-dose methylmercury exposure have also been reported.

In an effort to protect aquatic and human health, USEPA recommended maximum concentrations "without yielding unacceptable effects" in 2001 for acute exposure, identified as the criteria maximum concentration (CMC), and for chronic exposure, identified as the criterion continuous concentration (CCC) (USEPA 2001a and USEPA 2014a). Current state-wide water quality criteria for mercury were established in the CTR in 2000 (USEPA 2000a). Under these requirements, total recoverable mercury for the protection of human health was set as limits for consumption of water and organisms as well as consumption of organisms only, as summarized in Table 6.3. Mercury objectives are also included in some California RWQCB basin plans, as discussed in subsequent sections of this chapter. Where both a CTR criterion and a Basin Plan objective exist, the more stringent value applies (SWRCB 2006a).

**Table 6.3 Water Quality Criteria for Mercury and Methylmercury (as Total Mercury)**

| | | | |
|---|---|---|---|
| NRWQC | For the protection of freshwater species | | CMC = 1.4 µg/l |
| | | | CCC = 0.77 µg/l |
| | For the protection of saltwater species | | CMC = 1.8 µg/l |
| | | | CCC = 0.94 µg/l |
| | For the protection of human health[1] | | 0.3 mg/kg [2] |
| CTR | For the protection of human health | Consumption of water + organism | 0.050 µg/l |
| | | Consumption of organism only | 0.051 µg/l |

Source: NRWQC (National Recommended Water Quality Criteria) - USEPA 2014a; CTR (California Toxic Rule) - USEPA 2000a, USEPA 2001b

Notes:

1 For the consumption of organisms only and based on a total consumption 0.0175 kg fish and shellfish per day.

2 Methylmercury in fish tissue (wet weight)

A review of the mercury human health criteria by USEPA in 2001 concluded that a fish tissue (including shellfish) residue water quality criterion for methylmercury is more appropriate than a water-column-based water quality criterion (USEPA 2001a). A fish tissue criterion directly addresses the dominant human exposure route for methylmercury, and thus is more closely tied to the CWA goal of protecting public health. The USEPA also strongly encourages States and authorized Tribes to develop local or regional water quality criteria if they will be more appropriate for the target population.

The SWRCB is considering adopting statewide objectives for methylmercury based on the USEPA criteria, which would apply to inland waters, enclosed bays, and estuaries (SWRCB 2006a). These objectives would be applicable to waters that are not listed as impaired or that do not require a TMDL. Potential elements include a methylmercury fish tissue objective, a total mercury water quality objective, a methylmercury water quality objective, or some combination of these. Implementation procedures related to the NPDES permitting process also may be included.

The CTR criterion may be implemented as a fish tissue-based objective (FTO), or it may be converted into an ambient methylmercury water quality objective (AWQO), the latter reflecting the USEPA's fish consumption rate of 0.0175 kg fish/day, or site-specific consumption rates that more accurately reflect local consumption patterns (SWRCB 2006a). A USFWS evaluation of the USEPA criterion for methylmercury concluded that the FTO of 0.3 mg methylmercury/kg fish would be insufficient to protect three species that may occur in the study area including California Least Tern, California Clapper Rail, and Bald Eagle evaluated in the study.

#### *6.3.1.4 Selenium*

Selenium is a constituent of concern in the project area because of its potential effects on water quality and on aquatic and terrestrial resources primarily in the San Joaquin Valley and the San Francisco Bay, as well as some locations in Southern California (SWRCB 2011a). Elevated concentrations of selenium in soil and waterways within the San Joaquin Valley, and to some extent in the San Francisco Bay, are due primarily to erosion of uplifted selenium-enriched Cretaceous and Tertiary marine sedimentary rock located at the base of the east-facing side of the Coastal Range (Presser and Piper 1998; Presser 1994). The selenium-enriched soil derived from the eroded rock has been transported to the western San Joaquin Valley through natural processes; selenium is mobilized from the soil by irrigation practices and transported to waterways receiving agricultural drainage (Presser and Ohlendorf 1987). Other sources of selenium to the western Delta and San Francisco Bay include several oil refineries located in the vicinity of Carquinez Strait and San Pablo Bay (Presser and Luoma 2013; SWRCB 2011a). The specific water bodies within these areas that may be affected by the project and are impaired by selenium, as specified on the California CWA Section 303(d) list, include the Panoche Creek (from Silver Creek to Belmont Avenue), Mendota Pool, Grasslands Marshes, San Joaquin River (from Mud Slough to Merced River), Sacramento-San Joaquin Delta, and Suisun Bay (SWRCB 2011a).

Adverse effects of selenium may occur as a result of either a selenium deficiency or excess in the diet (ATSDR 2003; Ohlendorf 2003); the latter is the primary concern in the case of the impaired water bodies on the 303(d) list. Because of the known effects of selenium bioaccumulation from water to aquatic organisms and to higher trophic levels in the food chain, the fresh water, estuarine and wildlife habitat; spawning, reproduction, and/or early development; and rare, threatened, or endangered species beneficial uses of the water bodies are the most sensitive receptors to selenium exposure. Thus, excessive exposure can lead to selenium toxicity or selenosis and result in death or deformities of fish embryos, fry, or larvae (Ohlendorf 2003, Janz et al. 2010). Consequently, regulatory agencies have established exposure criteria to protect the beneficial uses of the water bodies.

Agencies such as the Agency for Toxic Substances and Disease Registry (ATSDR), California Office of Environmental Health Hazard Assessment (OEHHA), USEPA, SWRCB, and RWQCBs have determined acceptable selenium exposure levels for humans and water bodies in California. The ATSDR has stated the minimum risk levels (MRLs) for selenium to be ingested over a one-year period is 0.005 mg/kg/day, with an uncertainty factor of 3 (ATSDR 2013a). The 0.005 mg/kg/day value is also used by OEHHA to develop guidelines for consuming fish (OEHHA 2008). USEPA has set 50 µg/l as the maximum MCL for selenium in drinking water and OEHHA has set a more stringent draft public health goal (PHG) of 30 µg/l for selenium in drinking water (USEPA 2009a; OEHHA 2010). USEPA has also specified through the California Toxics Rule that the water quality criteria for aquatic life in all of California's fresh water bodies except for the San Joaquin River from Merced River to Vernalis are 20 µg/l for short-term (1-hour average) and 5 µg/l for long-term (4-day average) exposure (USEPA 2000a). For the San Joaquin River from Merced River to Vernalis, the short-term exposure is 12 µg/l and long-term limit is 5 µg/l, as stated in the Sacramento-San Joaquin River Basin Plan (CVRWQCB 2011). The water quality criteria for aquatic life in all of California's water bodies is 5 µg/l (4-day average exposure) and 20 µg/l (1-hour exposure) (USEPA 2014a).

The USEPA, Reclamation, the SWRCB, and the RWQCBs have created plans to reduce the toxic levels of selenium in California's impaired water bodies. The USEPA's Action Plan consists of recommendations to restore water quality and to protect aquatic species in the San Francisco Bay and Sacramento-San Joaquin Delta, which include strengthening selenium water quality criteria to reduce long-term exposure of sensitive aquatic and terrestrial species to selenium (USEPA 2012a). Grasslands Marshes, located in the San Joaquin Valley, include an area contaminated with selenium from agricultural irrigation and drainage practices when the marshes were irrigated with a blend of subsurface agricultural drainage water and higher-quality water. Reclamation's Grasslands Bypass Project reroutes the discharge of selenium-laden subsurface agriculture water from upstream agricultural dischargers that formerly passed through the Grassland Water District and nearby wildlife refuges and wetlands to Mud Slough by conveying it through a portion of the San Luis Drain. The project began in 1996 and has since reduced the selenium load discharged from the Grassland Drainage Area from 9,600 lbs to 2,200 lbs in 2011 (GBPOC 2013). Both the USEPA Action Plan and the Grasslands Bypass Project reduce selenium levels in waterways to meet the water quality objective targeted for December 2019. The CVRWQCB released a draft waste discharge requirement in May 2014 that suggests a performance goal of 15 µg/l (monthly mean) and water quality objective of 5 µg/l (4-day average) for Mud Slough (north) and the San Joaquin

River (CVRWQCB 2014a). This water quality objective for a 4-day average selenium concentration is consistent with the TMDL for the lower San Joaquin River (CVRWQCB 2001). The USEPA also released draft water quality criteria for the protection of freshwater aquatic life from toxic effects of selenium, shown in Table 6.4 (USEPA 2014b).

**Table 6.4 Draft Water Quality Criteria for Selenium**

| **Media Type** | **Fish Tissue** | **–** | **Water Column[3]** | **–** |
|---|---|---|---|---|
| Criterion Element | Egg/Ovary[1] | Fish Whole-Body or Muscle[2] | Monthly Average Exposure | Intermittent Exposure[4] |
| Magnitude | 15.2 mg/kg | 8.1 mg/kg whole body or 11.8 mg/kg muscle (skinless, boneless filet) | 1.3 µg/l in lentic aquatic systems<br>4.8 µg/l in lotic aquatic systems | $WQC_{int} = \frac{WQC_{30-day} - C_{bkgrnd}(1 - f_{in}}{f_{int}}$ |
| Duration | Instantaneous measurement[5] | Instantaneous measurement[5] | 30 days | Number of days/month with an elevated concentration |

Source: USEPA 2014b

1 Overrides any whole-body, muscle, or water column elements when fish egg/vary concentrations are measured.

2 Overrides any water column element when both fish tissue and water concentrations are measured,

3 Water column values are based on dissolved total selenium in water

4 Where $WQC_{30\text{-}day}$ is the water column monthly element, for either a lentic or lotic system, as appropriate. $C_{bkgrnd}$ is the average background selenium concentration, and $f_{int}$ is the fraction of any 30-day period during which elevated selenium concentrations occur, with $f_{int}$ assigned a value ≥0.033 (corresponding to 1 day).

5 Instantaneous measurement. Fish tissue data provide point measurements that reflect integrative accumulation of selenium over time and space in the fish at a given site. Selenium concentrations in fish tissue are expected to change only gradually over time in response to environmental fluctuations.

#### *6.3.1.5 Nutrients*

Nutrients are a constituent of concern in the lower Klamath River hydrologic area (Klamath Glen HSA) and the Suisun Marsh Wetlands (SWRCB 2011a) (Klamath Glen HSA; SWRCB 2011a). Nutrients, such as nitrogen and phosphorus, come from natural sources such as weathering of rocks and soil, and from the ocean when nutrients are mixed in the water current, as well as animal manure, atmospheric deposition, and nutrient recycling in sediment (NOAA 2014; USEPA

1998). Anthropogenic sources include fertilizers, detergents, sewage treatment plants, septic systems, combined sewer overflows, and sediment mobilization (USEPA 1998).

Nutrients are essential to maintaining a healthy water system. However, over enrichment of nitrogen and phosphorus can contribute to a process known as eutrophication where there is an excessive growth of macrophytes, phytoplankton, or potentially toxic algal blooms. Eutrophication may also lead to a decrease of dissolved oxygen, typically at night, when plants stop producing oxygen through photosynthesis but continue to use oxygen. Low dissolved oxygen levels can kill fish, cause an imbalance of prey and predator species, and result in a decline in aquatic resources (USEPA 1998). Severely low dissolved oxygen conditions are referred to as anoxic and may enhance methylmercury production (SFB RWQCB 2012a). Over enrichment can also contribute to cloudy or murky water clarity by increasing the amount of materials (i.e., algae) suspended in the water.

#### *6.3.1.6 Dissolved Oxygen*

Dissolved oxygen is a constituent of concern in the project area primarily in the lower Klamath River, Sacramento-San Joaquin River Delta, and Suisun Marsh Wetlands (SWRCB 2011a). Oxygen in water comes primarily from the atmosphere through diffusion at the water surface, as well as from groundwater discharge into streams and when plants undergo photosynthesis releasing oxygen in exchange for carbon dioxide (USGS 2014; NOAA 2008a). Levels of dissolved oxygen vary with several factors including season, time of day, water temperature, salinity, and organic matter. The season and time of day dictate photosynthesis processes, which require sunlight. Increases in water temperature and salinity reduce the solubility of oxygen (NOAA 2008b). Fungus and the bacteria use oxygen when decomposing organic matter in water bodies. So, the more organic matter present in a water body, the more potential for dissolved oxygen levels to decline.

Adverse effects of low dissolved oxygen are a concern for water quality and aquatic organisms. Low dissolved oxygen impairs growth, immunity, reproduction, and causes asphyxiation and death (NCRWQCB 2011).

To protect aquatic life, USEPA has established water quality standards for dissolved oxygen (USEPA 1986a). However, to protect the beneficial uses of California's water bodies (Table 6.2), including warm and cold freshwater habitats in both tidal and non-tidal waters, site-specific water quality objectives were established.

Future plans to maintain a healthy level of dissolved oxygen in water bodies are also site-specific, such as plans for the San Joaquin River and the Stockton Deep Water Ship Channel (CVRWQCB 2011).

#### *6.3.1.7 Pesticides*

Pesticides are constituents of concern throughout the study area and particularly in the Central Valley. Major pesticides of concern include organophosphate (OP) pesticides – primarily diazinon and chlorpyrifos, and organochlorine (OC) pesticides – mainly Dichloro-Diphenyl-Trichloroethane (DDT) and Group A compounds. The toxicity and fates of these pesticides are described in the following sections.

#### 6.3.1.7.1 Organophosphate Pesticides

The two most prevalent OP pesticides in the study area are man-made pesticides, diazinon and chlorpyrifos, which have been used extensively in agricultural and residential applications. Former and current uses of diazinon and chlorpyrifos have resulted in the contamination of water bodies throughout the Central Valley, as identified on the 303(d) list (SWRCB 2011a). The CVRWQCB has also identified hot spots of contamination, particularly in the Delta and in urban areas of Stockton and Sacramento (CVRWQCB 2003).

Pesticides are primarily transported into streams and rivers in runoff from agriculture (CVRWQCB 2011) but also occur or have occurred in urban non-point runoff and stormwater discharges. Treated municipal wastewater can also be a point source. However, OP pesticides, diazinon and chlorpyrifos, have been banned from non-agricultural uses since December 31st, 2004 and December, 2001, respectively. Reported non-agricultural pesticide use of diazinon and chlorpyrifos declined substantially in some counties between 2000 and 2009 (CVRWQCB 2014b). However, the reduction of OP pesticide use has resulted in the increasing use of pyrethroids and carbamates as alternative pesticides in urban and agricultural areas.

Diazinon was one of the most common insecticides in the U.S. for household lawn and garden pest control, indoor residential crack and crevice treatments and pet collars until all residential uses of diazinon were phased out, between 2002 and 2004 (USEPA 2004). Diazinon usage was then prohibited for several agricultural uses in 2007, with only a few remaining agricultural uses permitted, including uses on some fruit, vegetable, nut and field crops, and as an ear-tag on non-lactating cattle (USEPA 2007). The highest continued use of diazinon is on almonds and stone fruits (USEPA 2004).

#### 6.3.1.7.2 Organochlorine Pesticides

Organochlorine (OC) pesticides are mainly comprised of Dichloro-Diphenyl-Trichloroethane (DDT) and Group A Pesticides (CVRWQCB 2010b). DDT is a persistent chemical that binds tightly to soil and sediment, and breaks down slowly in the environment. It degrades to the isomers o,p’- and p,p’- DDT; o,p’- and p,p’-Dicholoro-Diphenyl-Dichloroethylene (DDE) and o,p’- and p,p’-Dichloro-Diphenyl-Dichloroethane (DDD). Group A Pesticides are made up of the total concentration of the OC pesticides: aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, chlordane (total), hexachlorocyclohexane (total) including Lindane (gamma-BHC), alpha-BHC, endosulfan (total), and toxaphene. These pesticides have similar chemical properties to DDT and are also persistent in the environment.

Transport of OC pesticides into streams and rivers is primarily from agriculture runoff (CVRWQCB 2011). Other potential point sources of OC pesticides include storm sewer discharges and historic spills. Non-point sources can include areas of previous residential applications, open space and channel erosion, and some background sources through wet and dry atmospheric deposition. Most OC pesticides were previously deposited on terrestrial soils, thus erosion and transport of contaminated sediments continue to contribute to detectable levels in stream bed sediment (CVRWQCB 2010b).

OC pesticides have historically been used as insecticides, fungicides and antimicrobial chemicals in residential and agricultural pest control (CVRWQCB 2010b). Most were banned in the mid-1970s, and fish tissue concentrations declined rapidly since the ban through the mid-1980s (Greenfield et al., 2004); however, they continue to be detected in fish tissue, the water column, and sediment in the Central Valley.

#### 6.3.1.7.3 Pyrethroid Pesticides

Pyrethroids (e.g., bifenthrin, permethrin, cypermethrin) are synthetic insecticides used in agriculture and households. The Surface Water Ambient Monitoring Program (SWAMP) studies indicate that the replacement of organophosphate pesticides by pyrethroids has resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011) In the water column, toxicity to the water flea *Ceriodaphnia dubia (C. dubia)* is caused by organophosphate and pyrethroid pesticides. Pyrethroids are also the major chemical class of concern in urban storm water, as indicated by the highly sensitive amphipod *Hyalella azteca (H. azteca)* which is highly sensitive to pyrethroids (Weston and Lydy 2010). Non-polar organic compounds, especially herbicides, and the herbicide Diuron have been identified as causes of algal toxicity in the Central Valley. Of the pyrethroid pesticides, bifenthrin is of major concern (Markiewicz et al. 2012).

Sediment criteria are also under development for pyrethroids that may inform waterbody impairment evaluations (SWRCB 2014b). With regard to sediment, as indicated by *H. azteca*, the majority of toxicity has been attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012).

#### 6.3.1.7.4 Other Pesticides

Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea or DCMU) was introduced in 1954 and is currently is one of the most-used herbicides in California (CVRWQCB 2012b). It is an herbicide that inhibits photosynthesis and is targeted on controlling annual broadleaf and grassy weeds. EPA has not developed a WQC specific to Diuron but a TMDL in development will include the development of WQO for Diuron in the Central Valley.

#### 6.3.1.7.5 General Pesticide Regulations

In addition to the existing water quality objectives and FCGs for pesticides in the study area, a Basin Plan Amendment for the Sacramento and San Joaquin River watersheds and the Delta is in progress to address those pesticides which currently impact or could potentially impact aquatic life uses in surface waters. The Basin

Plan Amendment will include the establishment of numeric water quality objectives for these selected pesticides. By addressing a greater grouping of pesticides than those included in the current Section 303(d) impaired water body list, the Basin Plan Amendment will help prevent the increased use of those pesticides not included on the 303(d) list (CVRWQCB 2006a).

#### *6.3.1.8 Polychlorinated Biphenyls (PCBs)*

Polychlorinated biphenyls, a group of synthetic organic chemicals, is a constituent of concern throughout California including the Sacramento River region (Sacramento River, Feather River, and American River), the Sacramento-San Joaquin River Delta, Suisun Bay, Carquinez Strait, and San Pablo Bay (SWRCB 2011a). PCBs cause harmful environmental effects and also pose a risk to human health (ATSDR 2000).

PCBs are mixtures of a variety of individual chlorinated biphenyl components, known as congeners. In the United States, many of these mixtures were sold under the trade name Aroclor, manufactured from 1930 to 1977 primarily for use as coolants and lubricants in transformers, capacitors, and other electrical equipment. Although manufacture was banned in 1979, PCBs continue to cause environmental degradation because they are environmentally persistent, easily redistributed between air, water and soil, and tend to accumulate and biomagnify in the food chain (ATSDR 2000, OEHHA 2008).

The "weathering" of PCBs is a process by which the composition of Aroclor mixtures undergo differential partitioning, degradation, and biotransformation. This results in differential environmental persistence and bioaccumulation of the mixtures, where these increase with the degree of chlorination of new mixtures. (OEHHA 2008). The biphenyls with more chlorine atoms tend to be heavier and remain close to the source of contamination, whereas those with fewer chlorine atoms are easily transported in the atmosphere. Atmospheric deposition is the primary source of PCBs to surface waters, although redissolution of sediment-bound PCBs also contributes to surface water contamination. PCBs leave the water column through sorption to suspended solids, volatilization from water surfaces, and concentration in plants and animals (ATSDR 2000).

PCBs cannot be distinctly assessed for health effects, as their toxicity is determined by the interactions of individual congeners and by the interactions of PCBs with other structurally related chemicals, including those combined with or used in the production of PCBs. However, several general health effects of PCB exposure have been identified. When PCBs are absorbed, they are distributed throughout the body and accumulate in lipid-rich tissues, including the liver, skin tissue, and breast milk. They can also be transferred across the placenta to the fetus. Studies have linked oral exposure to cancer and to adverse neurological, reproductive, and developmental effects. The International Agency for Research on Cancer has thus listed PCBs as probable human carcinogens, and OEHHA has administratively listed PCBs on the Proposition 65 list of chemicals known to the State of California to cause cancer (OEHHA 2008).

### 6.3.2 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

This water quality analysis includes Trinity Lake, Lewiston Lake, Trinity River downstream of Lewiston Dam, and the Klamath River from its confluence with the Trinity River to the Pacific Ocean. The analysis does not include Trinity River upstream of Trinity Lake, the South Fork of the Trinity River, or the Klamath River upstream of Trinity River, because these areas are not affected by changes in CVP operations.

Several water quality requirements affect the Klamath River and Trinity River basins. Beneficial uses and water quality objectives provided by the NCRWQCB and the Hoopa Valley Tribal Environmental Protection Agency (Hoopa Valley TEPA) are described below, as well as relevant TMDLs. The Yurok Tribe Basin Plan for the Yurok Indian Reservation and the Resighini Rancheria Tribal Water Quality Ordinance also regulate portions of the Trinity and Klamath Rivers that flow into and through the reservations; however, because they have not yet been approved by the USEPA, their objectives are not described in detail here. Oregon water quality requirements also affect the water quality of the Klamath River which originates in Oregon. However, this chapter only discusses the requirements within the Trinity and lower Klamath River Basins.

#### *6.3.2.1 Beneficial Uses*

Beneficial uses for all water bodies in the study area are determined by the NCRWQCB and the Hoopa Valley TEPA (Table 6.2). In addition to the beneficial uses listed in the Trinity and Klamath River basins, the North Coast Basin Plan notes that recreational use (i.e., water contact recreation [REC-1] and non-contact water recreation [REC-2]) occurs in all hydrologic units of the Klamath River Basin, with Trinity River being one of the rivers receiving the largest levels of recreational use (NCRWQCB 2011). Fish and wildlife reside in virtually all of the surface waters within the North Coast Region (NCRWQCB 2011). These species include several that are designated as rare, threatened and endangered. Trinity Dam also provides the beneficial use of hydroelectric power (i.e., POW).

#### *6.3.2.2 Constituents of Concern*

The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development are summarized in Table 6.1 and discussed below.

##### 6.3.2.2.1 Water Temperature

The majority of the Trinity and Klamath Rivers are not listed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature. However, the hydrologic area of the South Fork Trinity River and the lower hydrologic area of the Klamath River (Klamath Glen HSA) are listed for elevated water temperatures adversely affecting the cold freshwater habitat (SWRCB 2011c-h).

The Trinity River and lower Klamath River watersheds must maintain water temperatures to protect and support resident and seasonal fish species habitats. The North Coast Basin Plan designates narrative and numeric water temperature objectives applicable to surface waters in the Trinity River and the lower Klamath River basins. Other objectives and criteria specific to each region are specified below.

*Trinity River*

The South Fork Trinity River flows from its headwaters to the confluence with the mainstem of the Trinity River. It then flows into the lower Klamath River and out to the Pacific Ocean. Elevated water temperatures in the South Fork Trinity River can be attributed to the loss of shade trees due to habitat modification, range grazing, removal of riparian vegetation, streambank modification and destabilization, and water diversions (SWRCB 2011d). This reach supports steelhead, Chinook Salmon, and Coho Salmon (below Grouse Creek) (USDAFS 2014). The mainstem of the Trinity River also supports steelhead, Coho Salmon, and Chinook Salmon.

Water temperature objectives, summarized in Table 6.5, were set forth in the North Coast Basin Plan specifically applicable to the Trinity River, from Lewiston Dam to Douglas City and to the confluence with the North Fork Trinity River. These criteria are reach dependent, and vary seasonally. They were specifically developed to enhance the productivity of Trinity River Fish Hatchery, specifically for salmon and steelhead trout populations (NCRWQCB 2011).

**Table 6.5 Water Quality Objectives for Temperature in the Trinity River**

| Period | Daily Average Temperature Not to Exceed | Trinity River Reach |
|---|---|---|
| July 1 – September 14 | 60° F | Lewiston Dam to Douglas City Bridge |
| September 15 – October 1 | 56° F | Lewiston Dam to Douglas City Bridge |
| October 1 – December 31 | 56° F | Lewiston Dam to confluence of North Fork Trinity River |

Source: NCRWQCB 2011

*Hoopa Valley Indian Reservation*

Natural causes of temperature exceedances, such as unusually excessive ambient air temperatures coupled with flows, intended to protect aquatic habitat specified in the Trinity River Flow Evaluation report (TRFE), will not be considered to violate the water quality objectives stated in the Hoopa Valley Indian Reservation Basin Plan.

Temperature objectives for the Trinity River as it passes through the Hoopa Valley Reservation vary seasonally and are precipitation dependent (Table 6.6).

The water quality objectives are based on temperature-flow relationships that maintain TRFE flow regimes and protect adult salmonids holding and spawning. The objectives are also consistent with the temperature standards specified in the NCRWQCB Basin Plan (Hoopa Valley TEPA 2008).

**Table 6.6 Trinity River Temperature Criteria for the Hoopa Valley Indian Reservation**

| Dates | Running 7-Day Average Temperature not to Exceed[1,2] | |
|---|---|---|
| | **Extremely Wet, Wet and Normal Water Years** | **Dry and Critically Dry Water Years** |
| May 23 – June 4 | 59º F | 62.6º F |
| June 5 – July 9 | 62.6º F | 68º F |
| July 10 – September 14 | 72.0º F | 74.0º F[3] |
| September 15 – October 31 | 66.0º F | 66.0º F |
| November 1 – May 22 | 55.4º F | 59.0º F |

Source: Adapted from Hoopa Valley TEPA 2008

1 Temperature standards will be monitored at the Weitchpec temperature monitoring station operated and maintained by Reclamation.

2 Temperature standard violations will be determined if more than ten percent of seven-day running averages exceed the standard, to be determined by the number of days exceeded for that seasonal period (i.e., for June 16 – September 14, a 91 day period, ten percent exceedance will equate to nine days).

3 For the seasonal period of June 16 – September 14, temperatures on the mainstem Trinity River at the Weitchpec gauging station were used to determine running seven-day averages.

The Hoopa Valley TEPA established a goal of attaining a temperature of 21º C (69.8º F) during the July 10 – September 14 period within five years of the adoption of these standards (Hoopa Valley TEPA 2008). If monitoring reveals that temperatures continue to increase, the Hoopa Valley TEPA will employ adaptive management strategies until temperatures begin to decrease

In addition to the seasonal water temperature criteria, the Hoopa Valley TEPA has established varying criteria for each life stage of salmonids (Table 6.7).

**Table 6.7 Tributary Temperature Criteria for the Hoopa Valley Indian Reservation**

| Dates | Maximum Weekly Average Temperature (MWAT)[1,2] Extremely Wet, Wet and Normal Water Years | Dry and Critically Dry Water Years | Applicable Salmonid Life Stage(s)[3] |
|---|---|---|---|
| May 23 – June 4 | 55.4º F | 57.2º F | Adult holding; coho incubation and emergence; spawning; smoltification |
| June 5 – Jul 9 | 60.8º F | 62.6º F | Adult holding; peak temperatures timeframe according to Hoopa Tribal data |
| July 10 – September 14 | 64.4º F | 68.0º F | Adult holding |
| September 15 – October 31 | 57.2º F | 60.8º F | Adult holding; spawning |
| November 1 – May 22 | 50.0º F | 53.6º F | Adult incubation and emergence (including coho); smoltification; spawning |

Source: Adapted from Hoopa Valley TEPA 2008

1 The MWAT is defined as the highest 7-day moving average of equally spaced water temperature measurements for a given time period. In this application, the time period is the duration of the existing salmonids life stage. For the MWAT objective, temperatures may not exceed the numeric objective for every 7-day period during the given life stage.

2 Applicable where a given species and life stage time period exist, and when and where the species and life stage time period existed historically, and have the potential to exist again.

3 Adult migration and juvenile rearing are considered all year life stages.

Water temperature data for Trinity River between 2001 and 2012 show seasonal trends and the warming effect of ambient conditions at the downstream location (Table 6.8 and Figure 6.1). Compliance locations for water quality monitoring along the Trinity River are shown in Figure 6.2.

**Table 6.8 Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations**

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Douglas City** | | | | | | | | | | | | | |
| 2001 | D | 51.9 | 46.6 | 44.2 | 42.0 | 43.2 | 47.5 | 50.7 | 54.4 | 55.5 | 58.5 | 57.0 | 54.2 |
| 2002 | D | 51.0 | 47.7 | 42.7 | 43.1 | 43.8 | 46.6 | 52.5 | 49.4 | 56.1 | 58.9 | 56.2 | 54.4 |
| 2003 | AN | 49.8 | 46.5 | 44.6 | 44.9 | 44.8 | 48.0 | 48.8 | 50.4 | 52.8 | 57.0 | 56.6 | 52.7 |
| 2004 | BN | 51.2 | 46.6 | 43.7 | 41.5 | 43.7 | 47.5 | 51.4 | 50.3 | 51.4 | 54.7 | 56.4 | 53.0 |
| 2005 | AN | 50.9 | 47.4 | 42.9 | 42.8 | 45.3 | 48.2 | 50.8 | 49.9 | 52.2 | 57.9 | 59.5 | 54.7 |
| 2006 | W | 51.5 | 47.4 | 43.9 | 45.5 | 44.4 | 44.2 | 47.5 | 48.4 | 49.3 | 54.9 | NA | NA |
| 2007 | D | NA | NA | 43.0 | 39.8 | 43.1 | 48.4 | 52.5 | 47.9 | 55.8 | 58.7 | 57.2 | 54.1 |
| 2008 | C | 50.3 | 46.9 | 41.8 | 39.8 | 41.2 | 46.4 | 50.0 | 48.6 | 50.8 | 53.4 | 58.0 | 55.3 |
| 2009 | D | 51.4 | 49.3 | 43.5 | 43.0 | 43.4 | 46.8 | 51.7 | 50.9 | 56.6 | 60.5 | 58.1 | 55.9 |
| 2010 | BN | 51.2 | 47.5 | 42.2 | 44.3 | 45.2 | 46.8 | 48.4 | 48.4 | 52.3 | 57.3 | 58.5 | 55.1 |
| 2011 | W | 51.4 | 46.7 | 44.4 | 42.3 | 42.6 | 45.2 | 48.8 | 47.7 | 50.4 | 54.4 | 57.6 | 53.9 |
| 2012 | BN | 50.5 | 45.5 | 41.2 | 40.2 | 43.5 | 45.2 | 48.9 | 49.3 | 50.9 | 55.2 | 55.6 | 52.4 |
| **WY** | **WYT** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **North Fork Trinity near Helena** | | | | | | | | | | | | | |
| 2001 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2002 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2003 | AN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2004 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2005 | AN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 64.5 | 58.2 |
| 2006 | W | 53.4 | 47.8 | 44.0 | 45.7 | 44.8 | 44.9 | 48.3 | 49.6 | 51.4 | 59.0 | NA | NA |
| 2007 | D | NA | NA | 42.5 | 39.6 | 43.5 | 48.9 | 53.2 | 49.3 | 59.8 | 65.4 | 63.0 | 58.3 |
| 2008 | C | 52.5 | 48.3 | 42.0 | 40.6 | 42.3 | 46.6 | 50.1 | 50.1 | 53.2 | 56.7 | 62.8 | 59.2 |
| 2009 | D | 53.3 | 49.6 | 43.0 | 42.5 | 43.4 | 47.0 | 51.8 | 52.6 | 59.7 | 66.0 | 62.9 | 60.0 |
| 2010 | BN | 53.4 | 47.7 | 41.9 | 44.8 | 45.9 | 47.1 | 48.4 | 49.4 | 53.7 | 60.9 | 63.3 | 59.0 |
| 2011 | W | 53.9 | 47.1 | 45.1 | 43.1 | 43.0 | 45.2 | 45.5 | NA | NA | NA | NA | NA |
| 2012 | BN | 52.8 | 46.4 | 40.9 | 39.9 | 43.8 | 45.1 | 49.1 | 50.6 | 53.3 | 59.3 | 60.3 | 55.9 |
| **WY** | **WYT** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **Weitchpec** | | | | | | | | | | | | | |
| 2001 | D | 57.9 | 48.2 | 44.8 | 41.9 | 43.5 | 48.8 | 52.1 | 60.9 | 65.8 | 73.8 | 72.1 | 67.0 |
| 2002 | D | 59.3 | 51.2 | 46.0 | 44.7 | 45.8 | 47.4 | 53.9 | 55.9 | 66.1 | 73.6 | 71.1 | 67.2 |
| 2003 | AN | 57.5 | 49.1 | 46.7 | 49.3 | 50.8 | 54.2 | 54.8 | 58.6 | 69.5 | 70.2 | 71.3 | 64.6 |
| 2004 | BN | 59.7 | 50.4 | 46.3 | 45.3 | 46.8 | 53.5 | 58.7 | 56.6 | 62.3 | 70.4 | 72.1 | 64.4 |
| 2005 | AN | 58.6 | 49.9 | 45.0 | 44.3 | 46.7 | 50.0 | 51.5 | 54.6 | 59.5 | 69.8 | 73.0 | 64.9 |
| 2006 | W | 58.8 | 50.6 | 46.4 | 48.8 | 47.5 | 47.8 | 50.2 | 53.8 | 57.1 | 65.2 | NA | NA |
| 2007 | D | NA | NA | 47.9 | 44.9 | 48.3 | 52 | 56.2 | 56.3 | 66.6 | 73.2 | 72.6 | NA |
| 2008 | C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2009 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2011 | W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2012 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Source: DWR 2014a,b,c

Temperatures in the Trinity River within the Reservation boundary will be monitored based on water-year type as established by the TRFE and determined by the Bureau of Reclamation.

Activities that increase water temperatures must comply with Tribal and Federal anti-degradation policies. The responsible party must not increase water temperatures, even if caused by their actions coupled with natural factors (Hoopa Valley TEPA 2008). In some streams, the numeric objectives may not be attainable due to site specific limitations. If this is the case, and provided that the stream has been restored to its full site potential; and the salmonid population is at a level consistent with the National Marine Fisheries Service (NMFS) concept of a 'Viable Salmonid Population'(McElhany et al. 2000), then the Hoopa Valley TEPA may not be applicable.

#### 6.3.2.2.2 Mercury

Trinity Lake and the upper hydrologic area of the East Fork Trinity River are two water bodies in the North Coast that were placed on the Section 303(d) list, approved by USEPA in 2010 (SWRCB 2011a), as impaired due to mercury. Mercury in Trinity Lake can be attributed to atmospheric deposition, natural sources, resource extractions, and other unknown sources (SWRCB 2011b). Significant mercury contamination is likely due to historical gold and mercury mining activities along the East Fork Trinity River at the inactive Altoona Mercury Mine (May et al. 2004).

The commercial or recreational collection of fish, shellfish, or organisms was deemed impaired since fish tissue exceeded USEPA's recommended Fish Tissue Residue Criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2011b-g). This criterion is based on the consumption-weighted rate of 0.0175 kg of total fish and shellfish per day. Fourteen out of fifty seven fish tissue samples from fish in the North and the East Fork of the lake in September 2001 and 2002 exceeded this fish tissue criterion. Composite fish tissue samples that exceeded the criterion were from White Catfish, Smallmouth Bass, and Chinook Salmon.

For the protection of marine aquatic life, water quality objectives for mercury were set for discharges within the area specified in the North Coast Region Water Quality Control Board Basin Plan as follows (NCRWQCB 2011).

- Six-Month Median: 0.04 µg/l
- Daily Maximum: 0.16 µg/l
- Instantaneous Maximum: 0.4 µg/l (conservative estimate for chronic toxicity)

In an effort to meet the water quality standards in Trinity Lake and the East Fork of Trinity River, a TMDL is expected to be completed by 2019. An approach for calculating effluent limitations was established in the NCRWQCB Basin Plan (NCRWQCB 2011).

#### 6.3.2.2.3 Nutrients

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for being impaired by nutrients (SWRCB 2011a). Nutrient levels in the Klamath Estuary may cease to be a limiting factor and can promote levels of algal growth that cause a nuisance or adversely affect beneficial uses when excess growth is not consumed by animals or exported by flows (DOI and DFG 2012).

The Klamath River receives the greatest nutrient loading from the Upper Klamath basin, comprising approximately 40 percent of its total contaminant load (NCRWQCB 2010). Tributaries to the Klamath River are the greatest contributors of the remaining nutrient loads, with the Trinity River contributing the most.

The Hoopa Valley TEPA also designates water quality objectives to address contamination by nutrients (Table 6.9).

**Table 6.9 Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation**

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Maximum Annual Periphyton Biomass | – | 150 mg chlorophyll *a*/m$^2$ of streambed area |
| pH | MUN-designated waters: 5.0 – 9.0<br>All other designated uses: 7.0 – 8.5 | 7.0 – 8.5 |
| Total Nitrogen[1] | – | 0.2 mg/l |
| Total Phosphorus[1] | | 0.035 mg/l |
| Microcystis aeruginosa cell density | – | < 5,000 cells/mL for drinking water<br>< 40,000 cells/mL for recreational water |
| Microcystin toxin concentration | | < 1 µg/l total microcystins for drinking water<br>< 8 µg/l total microcystins for recreational water |
| Total potentially toxigenic blue-green algal species[2] | | < 100,000 cells/mL for recreational water |

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Cyanobacterial scums | | There shall be no presence of cyanobacterial scums |

Source: Hoopa Valley TEPA 2008

1 There should be at least two samples per 30-day period. If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus. Through consultation, the ongoing TMDL process for the Klamath River is expected to further define these natural conditions.

2 Includes: Anabaena, Microcystis, Planktothrix, Nostoc, Coelsphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia, and Oscillatoria.

In addition to the water quality criteria established by the Hoopa Valley TEPA (2008), the 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provides TMDLs for nutrients which address elevated pH levels (DOI and DFG 2012). Nutrient targets include numeric targets for total phosphorus (TP), total nitrogen (TN) (NCRWQCB 2010).

The Klamath River nutrient TMDLs are in the process of being implemented by the NCRWQCB and other affiliated agencies, including the SWRCB, the USEPA, Reclamation, the USFWS, the Oregon Department of Environmental Quality, responsible for implementation of the Klamath TMDLs in Oregon, and other state, federal, and private agencies with operations that affect the Klamath River (NCRWQCB 2010).

#### 6.3.2.2.4 Organic Matter

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for impairment due to organic enrichment (SWRCB 2011a).

The Klamath River has several natural sources of organic matter. The river originates from the Upper Klamath Lake, which is a naturally shallow, eutrophic lake, with high levels of organic matter (algae), including nitrogen fixing blue-green algae (NCRWQCB 2010). Other sources of organic matter include runoff from agricultural lands (i.e., irrigation tailwater, storm runoff, subsurface drainage, and animal waste), flow regulations/modification, industrial point sources, and municipal point sources (SWRCB 2011).

To protect the beneficial uses of the lower Klamath River, including cold freshwater habitat, a TMDL was established in 2010 for organic matter and other constituents. The TMDL equals 143,019 pounds of Carbonaceous Biochemical Oxygen Demand (CBOD) per day from the Klamath River (NCRWQCB 2011h). The average organic matter (measured as CBOD) loads from all other Klamath River tributaries are sufficient to meet other related objectives, including dissolved oxygen and biostimulatory substances objectives, in the Klamath River (NCRWQCB 2010). The dissolved oxygen objectives are the primary targets associated with organic matter as well as nutrients. Organic matter allocations were also established for the Klamath River below Salmon River, and the major tributaries to the Klamath, including Trinity River.

Implementation actions and other objectives were established to ensure the TMDL is met to protect the beneficial uses of the Klamath River and other water bodies downstream. The North Coast Basin Plan states that a water quality study will be completed to identify actions for monitoring, evaluating, and implementing any necessary actions to address organic matter loading so that the TMDL will be met (NCRWQCB 2011).

##### 6.3.2.2.5 Dissolved Oxygen

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a).

Sources that contribute to low dissolved oxygen include sources of organic enrichment, specified in the previous section; water temperature; and salinity, explained further in Section 6.3.2.6. Other sources that contribute to low dissolved oxygen are runoff from roads and agriculture that can transport nutrients into water bodies and lower dissolved oxygen through biostimulatory effects (NCRWQCB 2010). Over-enrichment and growth of algae and aquatic plants can produce oxygen during the day through photosynthesis but those same plants can deplete dissolved oxygen at night.

To protect the beneficial uses of the lower Klamath River, including the cold freshwater habitat, water quality objectives were established in the North Coast Basin Plan (2010) and the Hoopa Valley TEPA (2008) for dissolved oxygen in the Klamath River and its major tributary, the Trinity River (Table 6.10 and Table 6.11) (NCRWQCB 2011). Site Specific Objectives (SSOs) for dissolved oxygen were calculated as part of TMDLs developed by the NCRWQCB (2011), and have been incorporated into the North Coast Basin Plan (2011) (Table 6.12). For those waters without location-specific dissolved oxygen criteria, dissolved oxygen shall not be reduced below minimum levels, shown in Table 6.13, at any time to protect beneficial uses.

**Table 6.10 Water Quality Objectives for Dissolved Oxygen in Trinity and Lower Klamath**

| Water body | Dissolved Oxygen (mg/l) | |
|---|---|---|
| | **Minimum** | **50% Lower Limit[1]** |
| Trinity Lake and Lewiston Reservoir | 7.0 | 10.0 |
| Lower Trinity River | 8.0 | 10.0 |
| Lower Trinity Area Streams | 9.0 | 10.0 |
| Lower Klamath River Area Streams | 8.0 | 10.0 |

Source: NCRWQCB 2011

1: 50 percent lower limit represents the 50 percentile values of the monthly means for a calendar year. 50 percent or more of the monthly means must be greater than or equal to the lower limit.

**Table 6.11 Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation**

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Minimum Water Column Dissolved Oxygen Concentration | 11.0 mg/l | SPWN-designated waters[1]: 11.0 mg/l[2]<br>COLD-designated waters: 8.0 mg/l[2] |
| Minimum Inter-gravel Dissolved Oxygen Concentration | 8.0 mg/l | SPWN-designated waters[1]: 8.0 mg/l[2] |

Source: Hoopa Valley TEPA 2008

1 Whenever spawning occurs, has occurred in the past or has potential to occur.

2 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

**Table 6.12 Site Specific Objectives for Dissolved Oxygen in the Klamath River[1]**

| Location[2] | Percent Dissolved Oxygen Saturation Based On Natural Receiving Water Temperatures[3] | Time Period |
|---|---|---|
| Downstream of Hoopa-California Boundary to Turwar | 85 | June 1 through August 31 |
| | 90 | September 1 through May 31 |
| Upper and Middle Estuary | 80 | August 1 through August 31 |
| | 85 | September 1 through October 31 and June 1 through July 31 |
| | 90 | November 1 through May 31 |
| Lower Estuary | For the protection of estuarine habitat (EST), the dissolved oxygen content of the Lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors. | |

Source: NCRWQCB 2011

1 States may establish site specific objectives equal to natural background (USEPA 1986a. Ambient Water Quality Criteria for Dissolved Oxygen, EPA 440/5-86-033; USEPA Memo from Tudor T. Davies, Director of Office of Science and Technology, USEPA Washington, D.C. dated November 5, 1997). For aquatic life uses, where the natural background condition for a specific parameter is documented, by definition that condition is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans (Davies 1997). These dissolved oxygen objectives are derived from the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 Modeling Scenarios: Klamath River Model for TMDL Development (Tetra Tech and WR and TMDL Center 2009). They represent natural dissolved oxygen background conditions due only to non-anthropogenic sources and a natural flow regime.

2 These objectives apply to the maximum extent allowed by law. To the extent that the State lacks jurisdiction, the Site Specific Dissolved Oxygen Objectives for the Mainstem Klamath River are extended as a recommendation to the applicable regulatory authority.

3 Corresponding dissolved oxygen concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 (Tetra Tech and WR and TMDL Center 2009). Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available. After opportunity for public comment, any update or improvements to the estimate of natural receiving water temperature must be reviewed and approved by Executive Officer before being used for this purpose.

**Table 6.13 Water Quality Objectives for Dissolved Oxygen for Specified Beneficial Uses**

| Beneficial Use Designation | Minimum Dissolved Oxygen Limit (mg/l) |
|---|---|
| WARM, MAR, or SAL | 5.0 |
| COLD | 6.0 |
| SPWN | 7.0 |
| SPWN – during critical spawning and egg incubation periods | 9.0 |
| Klamath River Water Column[1] | |
| SPWN-designated waters[2]: | 11.0 mg/l[3] |
| COLD-designated waters: | 8.0 mg/l[3] |
| Klamath River Inter Gravel[1] SPWN-designated waters[2]: | 8.0 mg/l[3] |

Source: NCRWQCB 2011

1 Hoopa Valley TEPA (2008)

2 Whenever spawning occurs, has occurred in the past or has potential to occur.

3 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be

dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

The 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provide numerical targets for dissolved oxygen and other constituents (NCRWQCB 2010). Site specific objectives for dissolved oxygen were proposed in this TMDL and adopted into the North Coast Basin Plan (Table 6.29). The dissolved oxygen objectives are the primary targets associated with nutrient and organic matter, with additional dissolved oxygen-related TMDLs prescribed for total phosphorus (TP), total nitrogen (TN) and organic matter (CBOD) loading, and numerical targets provided for benthic algae biomass, suspended algae chlorophyll-a, *microcystis aeruginosa*, and microcystin toxin discussed in their corresponding sections.

Plans to monitor dissolved oxygen and other constituents in the Klamath River below Trinity River, near Turwar, and the Klamath River Estuary were established in Chapter 7 of the Klamath River TMDLs to further protect the beneficial uses of the Trinity and lower Klamath Rivers (NCRWQCB 2010). The TMDL also includes a proposal to revise SSOs for dissolved oxygen in the Klamath River.

#### 6.3.2.2.6 Sedimentation and Siltation

Sedimentation and siltation are not caused by operation of the CVP. However, the lower Klamath River and Trinity River were placed on the 303(d) list approved in 2010 as impaired by sedimentation and siltation (SWRCB 2011a).

*Trinity River*

Disturbance of sediment and silt is a natural part of stream ecosystems, which can contribute to fluctuating salmonid populations in response to fine sediment embedded in spawning gravels. However, human activities have resulted in an increased severity and frequency of habitat disturbance (TRRP and NCRWQCB 2009). In the Mainstem Trinity River, sediment loading can be attributed to runoff from areas of active or past mining, timber harvest, and road-related activities. Natural sources, such as landsliding, bank erosion, and soil creep, contribute the greatest sediment loads each year (NCRWQCB 2008). Future point sources of sedimentation into the Trinity River Basin, including CalTrans facilities and construction sites larger than five acres have to meet discharge requirements pursuant to California's NPDES general permit for construction site runoff (USEPA 2001f).

The primary adverse impacts of excess sedimentation are those affecting the spawning habitat for anadromous salmonids (TRRP and NCRWQCB 2009). The main affected beneficial uses include commercial or sport fishing, cold fresh water habitat, migration of aquatic organisms, spawning, reproduction, and/or early development; and rare, threatened and endangered species. Recreation in the Trinity River Basin, such as boating, fishing, camping, swimming, sightseeing, and hiking, is also potentially affected because sedimentation can affect the water clarity and water quality (USEPA 2001f). Water quality objectives for sedimentation and siltation were established in the North Coast Basin Plan.

Turbidity criteria for all waters within the Hoopa Valley Indian Reservation are also under development (Hoopa Valley TEPA 2008).

In addition to these water quality objectives, the North Coast Basin Plan also prohibits the discharge of soil, silt, bark, sawdust, or other organic and earthen material from any logging, construction, or associated activity into any stream or watercourse in quantities harmful to beneficial uses, and the placing or disposal of such materials in locations where they can pass into any stream or watercourse in quantities harmful to beneficial uses (NCRWQCB 2011).

Sediment loading in the mainstem Trinity River exceeds applicable water quality standards, and is being addressed by the Trinity River TMDL for sediment, approved by the USEPA in December 2001 (SWRCB 2011b-g, USEPA 2001f). Assimilation capacity for sediment loading was determined for this TMDL and the percent reduction of managed sediment discharge required to meet the TMDL is provided for each subarea. These allocations are adequate to protect aquatic habitat, and are expected to be evaluated on a ten year rolling basis (USEPA 2001f).

*Lower Klamath River*

The Klamath River downstream of Weitchpec has also been included on the 303(d) list for contamination from sedimentation and siltation, due to exceedances of the sediment water quality criteria, and long-term sedimentation and siltation influxes (SWRCB 2011h).

Major sources of sediment discharge in the lower Klamath River are from ongoing logging and runoff from major storm events. According to reports cited by the SWRCB, water quality in runoff from timber harvest in all lower Klamath watersheds exceed cumulative effect thresholds (SWRCB 2011h).

The *Long Range Plan for the Klamath River Basin Fishery Conservation Area Restoration Program* (1986 to 2006) emphasizes sedimentation in the lower Klamath Basin, and notes that the sediment is creating problems with fish passage and stream bed stability (Klamath River Basin Fisheries Task Force 1991). The near extinction of the eulachon indicated problems with sediment supply, size and bed load movement, and that aggradations in salmon spawning reaches are expected to persist for decades (SWRCB 2011h). Increased sediment loads also result from the widening of stream channels, through processes like bank erosion, and with the related reduction of riparian shade can contribute to elevated stream temperatures (NCRWQCB 2010). The North Coast Basin Plan includes the TMDLs for the region, which include those that address sedimentation and siltation (NCRWQCB 2011).

## 6.3.3 Central Valley Region

### *6.3.3.1 Sacramento Valley*

Major watersheds within the Sacramento Valley that could be affected by CVP and SWP operations include the Sacramento River, Feather River, and the lower American River watersheds.

This water quality analysis section focuses on Shasta Lake, Keswick Reservoir, Whiskeytown Lake, Spring Creek and Clear Creek; the Sacramento River from Shasta Lake to the Delta (near Freeport); the Feather River below Lake Oroville; American River below Lake Natoma; and Yolo Bypass.

Beneficial uses for the Sacramento Valley, as defined in the Central Valley Basin Plan, are summarized in Table 6.2. The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are summarized in Table 6.1.

#### 6.3.3.1.1 Sacramento River from Shasta Lake to Verona

Water quality in the upper Sacramento River is influenced by releases from Shasta Lake and diversions from Trinity Lake. Annual and seasonal flows in the Sacramento River watershed are highly variable from year to year, as described in Chapter 5, Surface Water Resources and Water Supplies. These variations in flow are a source of variability in water quality in the Sacramento drainage.

The water quality constituents that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are: mercury, PCBs, unknown toxicity and multiple pesticides. Chlorpyrifos and diazinon have been addressed by changes to the Basin Plan, cadmium, copper, zinc have been addressed by a TMDL, and temperature is also closely monitored.

*Water Temperature*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature (SWRCB 2011a). However, water bodies in the Upper Sacramento River watershed support the beneficial uses of both warm and cold fresh water habitat, which require that the water bodies maintain water temperatures suitable for multiple fish species (CVRWQCB 2011). Water quality objectives have been established by the SWRCB for Sacramento River, as summarized in Table 6.14 and Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Compliance locations in the upper Sacramento River basin are shown in Figure 6.2. Performance measures to meet temperature requirements are included in the 2009 NMFS BO, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

**Table 6.14 Water Quality Objectives for Temperature in the Sacramento River**

| Applicable Water Bodies | Objective |
|---|---|
| Sacramento River from Keswick Dam to Hamilton City | > 56º F |
| Sacramento River from Hamilton City to the I Street Bridge (during periods when temperature increases will be detrimental to the fishery) | > 68º F |

Source: CVRWQCB 2011

Table 6.15 and Figure 6.3 depict monthly water temperature data at selected compliance locations in the Sacramento River between 2001 and 2012.

**Table 6.15 Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations in °F**

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Balls Ferry** | | | | | | | | | | | | | |
| 2001 | D | 55.0 | 53.2 | 51.4 | 47.9 | 47.0 | 51.5 | 52.5 | 52.9 | 53.6 | 54.5 | 54.3 | 55.3 |
| 2002 | D | 56.1 | 54.3 | 50.0 | 49.4 | 48.8 | 50.5 | 53.9 | 53.7 | 53.7 | 54.4 | 54.4 | 54.0 |
| 2003 | AN | 54.4 | 54.2 | 50.0 | 49.6 | 49.3 | 51.7 | 53.2 | 53.3 | 53.5 | 53.6 | 54.9 | 55.4 |
| 2004 | BN | 54.7 | 52.6 | 50.2 | 48.3 | 47.6 | 50.9 | 52.5 | 53.0 | 53.7 | 54.5 | 54.6 | 56.7 |
| 2005 | AN | 56.5 | 54.9 | 50.6 | 48.8 | 50.0 | 52.1 | 54.1 | 54.2 | 53.5 | 54.0 | 55.4 | 55.6 |
| 2006 | W | 56.2 | 54.5 | 50.5 | ND | 47.8 | 47.7 | 49.7 | 52.7 | 52.8 | 53.6 | 53.8 | 53.5 |
| 2007 | D | 53.4 | 52.4 | 49.7 | 47.7 | 48.4 | 52.0 | 54.0 | 52.9 | 53.8 | 55.2 | 55.1 | 55.7 |
| 2008 | C | 55.9 | 55.3 | 50.1 | 45.7 | 46.8 | 49.8 | 50.9 | 52.9 | 55.6 | 56.0 | 56.4 | 57.0 |
| 2009 | D | 58.1 | 55.8 | 50.1 | 47.5 | 47.8 | 50.6 | 51.6 | 53.8 | 55.0 | 56.0 | 56.0 | 56.5 |
| 2010 | BN | 56.5 | 55.1 | 49.4 | 48.3 | 49.6 | 50.9 | 52.5 | 54.0 | 53.5 | 53.9 | 54.2 | 54.2 |
| 2011 | W | 54.0 | 51.3 | 51.2 | 49.2 | 48.0 | 48.8 | 51.8 | 54.1 | 53.6 | 53.6 | 54.3 | 54.0 |
| 2012 | BN | 53.1 | 51.2 | 49.6 | 48.4 | 48.6 | 49.6 | 53.6 | 54.5 | 53.4 | 53.6 | 54.0 | 54.1 |
| **WY** | **WYT** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **Jelly's Ferry** | | | | | | | | | | | | | |
| 2001 | D | 55.5 | 52.9 | 51.1 | 47.5 | 47.0 | 52.3 | 53.6 | 54.5 | 54.7 | 55.6 | 55.6 | 56.3 |
| 2002 | D | 56.7 | 54.4 | 49.1 | 47.9 | 48.6 | 51.0 | 55.4 | 55.1 | 55.1 | 55.6 | 55.5 | 55.1 |
| 2003 | AN | 54.9 | 54.1 | 50.3 | 50.0 | 49.0 | 52.4 | 53.4 | 54.5 | 55.4 | 55.0 | 56.0 | 56.6 |
| 2004 | BN | 55.3 | 52.5 | 50.0 | 47.9 | 48.1 | 52.0 | 54.0 | 54.7 | 55.1 | 55.5 | 55.8 | 57.5 |
| 2005 | AN | 56.8 | 54.6 | 50.2 | 48.4 | 50.3 | 52.8 | 55.3 | 55.6 | 55.3 | 55.6 | 56.7 | 56.5 |
| 2006 | W | 56.5 | 54.3 | 49.9 | 49.1 | 48.3 | 47.9 | 50.7 | 54.6 | 54.8 | 55.1 | 55.0 | 54.6 |
| 2007 | D | 54.2 | 52.6 | 49.0 | 47.1 | 48.7 | 52.8 | 55.0 | 54.2 | 54.9 | 56.0 | 56.0 | 56.6 |
| 2008 | C | 56.3 | 55.4 | 49.6 | 45.4 | 47.0 | 50.5 | 52.2 | 54.5 | 56.6 | 56.9 | 57.3 | 58.0 |
| 2009 | D | 58.0 | 55.8 | 49.8 | 47.4 | 47.9 | 51.2 | 53.3 | 55.7 | 56.4 | 57.1 | 57.0 | 57.8 |
| 2010 | BN | 57.1 | 54.9 | 48.9 | 48.0 | 49.7 | 51.7 | 53.3 | 55.2 | 55.4 | 55.6 | 55.3 | 55.2 |
| 2011 | W | 54.6 | 51.3 | 50.9 | 48.9 | 47.8 | 48.7 | 52.2 | 55.3 | 55.2 | 55.0 | 55.4 | 55.2 |
| 2012 | BN | 53.7 | 51.2 | 49.1 | 48.1 | 48.8 | 49.9 | 54.4 | 56.0 | 54.8 | 54.6 | 55.1 | 55.3 |

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Bend Bridge** | | | | | | | | | | | | | |
| 2001 | D | 55.7 | 52.8 | 50.8 | 47.3 | 47.0 | 52.6 | 54.1 | 55.0 | 55.1 | 56.0 | 56.0 | 56.8 |
| 2002 | D | 56.9 | 54.4 | 49.0 | 48.1 | 48.9 | 51.2 | 55.8 | 55.6 | 55.6 | 56.0 | 56.2 | 55.6 |
| 2003 | AN | 55.1 | 53.9 | 50.2 | 50.0 | 49.0 | 52.6 | 53.8 | 54.7 | 55.9 | 55.4 | 56.7 | 57.0 |
| 2004 | BN | 55.5 | 52.3 | 49.4 | 48.0 | 48.2 | 52.2 | 54.2 | 55.5 | 55.6 | 56.1 | 56.2 | 57.9 |
| 2005 | AN | 57.0 | 54.4 | 50.0 | 48.3 | 50.4 | 53.1 | 55.7 | 55.9 | 55.5 | 56.0 | 57.2 | 56.9 |
| 2006 | W | 56.6 | 54.2 | 50.0 | 49.2 | 48.4 | 48.0 | 50.7 | 54.9 | 55.1 | 55.6 | 55.4 | 54.9 |
| 2007 | D | 54.4 | 52.3 | 49.1 | 46.9 | 48.8 | 52.9 | 55.1 | 54.9 | 55.5 | 56.6 | 56.6 | 57.0 |
| 2008 | C | 56.4 | 55.1 | 49.3 | 45.6 | 47.1 | 51.0 | 52.6 | 55.0 | 57.4 | 57.5 | 57.9 | 58.5 |
| 2009 | D | 57.4 | 55.8 | 49.4 | 47.3 | 48.1 | 52.0 | 53.6 | 56.1 | 56.9 | 57.7 | 57.2 | 58.0 |
| 2010 | BN | 57.0 | 54.8 | 48.6 | 47.9 | 49.6 | 51.6 | 53.3 | 55.4 | 55.5 | 56.2 | 56.2 | 55.8 |
| 2011 | W | 54.4 | 51.0 | 50.7 | 49.0 | 48.0 | 49.0 | 52.5 | 55.7 | 55.6 | 55.8 | 56.2 | 55.6 |
| 2012 | BN | 53.9 | 51.3 | 48.8 | 47.9 | 48.9 | 49.9 | 54.8 | 56.5 | 55.4 | 55.1 | 55.5 | 55.8 |

Source: Reclamation 2013b

*Mercury*

The USEPA approved a new decision to place Shasta Lake, Whiskeytown Lake, Clear Creek, and the Sacramento River from Cottonwood Creek to Red Bluff, on the Section 303(d) list in 2010 for mercury contamination (SWRCB 2011a). The Sacramento River from Red Bluff to Knights Landing has been on the 303(d) list for mercury prior to the final decision in 2010. Mercury is not a constituent of concern for the Sacramento River between Shasta Dam and the Cottonwood Creek.

Mercury in the Sacramento River Basin can be attributed to resource extraction as described in Section 6.3.2 (SWRCB 2011i-l). Significant gold mining activity took place within the Whiskeytown watershed, lands inundated by Whiskeytown Reservoir, in the Clear Creek watershed between Whiskeytown Reservoir, the confluence with the Sacramento River, and within the Sacramento River watershed.

A 2008 CALFED report tabulates methylmercury concentrations in the Sacramento River from Redding (0.3ng/l) to Freeport (0.11 ng/l) from 2003 to 2006 (Foe et al. 2008). For the 2010 listing, composite fish tissue samples were collected from Shasta Lake, Whiskeytown Lake, Clear Creek, and the Sacramento River from Cottonwood Creek to Knights Landing. The commercial or recreational collection of fish, shellfish, or organisms were deemed impaired since fish tissue exceeded USEPA's recommended Fish Tissue Residue Criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2011i-l).

In an effort to protect the beneficial uses of these water bodies, including the protection of aquatic and human health, USEPA has recommended maximum exposure concentrations. In addition, a TMDL is expected to be completed in 2021 to meet the water quality standards in these water bodies (SWRCB 2011i-l).

*Cadmium, Copper, and Zinc*

Shasta Lake where West Squaw Creek enters the lake, Spring Creek (from Iron Mountain Mine to Keswick Reservoir), and Keswick Reservoir downstream of Spring Creek were placed on the 303(d) list approved by the USEPA in 2010 for impairment by cadmium, copper, and zinc (SWRCB 2011a). The Upper Sacramento River from Keswick Dam to Cottonwood Creek was previously listed on the 303(d) list for impairment by cadmium, copper, and zinc but was delisted after a TMDL was completed in 2002 and the SWRCB determined the water quality standard was met. The elevated levels were primarily the result of acid mine drainage discharged from inactive mines in the upper Sacramento River watershed, located upstream of Shasta and Keswick dams (CVRWQCB 2002a). There are projects underway to clean up many inactive mine sites that discharge high concentrations of metals (CVRWQCB 2011).

Cadmium, copper and zinc contamination in the Sacramento River have been addressed by the *2002 Upper Sacramento River TMDL for Cadmium, Copper and Zinc*, and by water quality objectives in the Basin Plan (CVRWQCB 2002a). Although cadmium, copper, and zinc are generally found as mixtures in surface water, the mixtures tend to be antagonistic – less toxic than when found as individual components – thus the water quality objectives focus on individual parameters. Levels of water hardness affect the toxicity of these metals, where increased hardness decreases toxicity. Thus the water quality objectives at certain locations are determined using specific levels of water hardness (CVRWQCB 2002a). The TMDL for cadmium, copper, and zinc in Shasta Lake, Spring Creek, and Keswick Reservoir is expected to be completed in 2020 (SWRCB 2011i,m,n).

*Pesticides*

The Sacramento River from Red Bluff to Knights Landing was placed on the 303(d) list approved by the USEPA in 2010 as impaired by DDT and the Group A pesticide dieldrin. The Sacramento River from Knights Landing to the Delta was also placed on the 303(d) list as impaired by chlordane, DDT, and dieldrin (SWRCB 2011a). Chlordane, DDT, and dieldrin are legacy pesticides and were discontinued from the early 1970s to the late 1980s.

Although these pesticides have been discontinued since the late 1980's, the narrative water quality objective for toxicity, which applies to single or the interactive effect of multiple pesticides or substances, and states that "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life" has not been met. Fish concentrations of DDT collected in 2005 exceeded the Total DDT OEHHA screening value of 21 µg/kg by up to five times, which was used as a criterion to evaluate the narrative water quality objective by up to five times. Concentrations of dieldrin were also found to exceed the OEHHA Evaluation Guideline of 0.46 µg/kg (SWRCB 2011o).

To protect the beneficial uses of the Sacramento River and other water bodies downstream, including the impaired commercial or recreational collection of fish, shellfish, or organisms, TMDLs for DDT and dieldrin in the Sacramento River from Red Bluff to Knights Landing are expected to be completed in 2021 (SWRCB 2011o). For the Sacramento River from Knights Landing to the Delta, TMDLs are expected to be completed in 2021 for DDT and chlordane, and in 2022 for dieldrin.

Although the Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 for chlorpyrifos and diazinon contamination, these pesticides have also been of concern in the Sacramento River (SWRCB 2011o, CVRWQCB 2007a). Water quality sampling from 1999 to 2006 revealed concentrations of both pesticides at levels of concern in the Sacramento and Feather Rivers. In addition to runoff of applied pesticides into irrigation and storm water runoff into the Sacramento and Feather Rivers, atmospheric transport of diazinon from the Central Valley to the Sierra Nevada Mountains has been noted to occur. Of particular concern were the beneficial uses of Warm and Cold Fresh water Habitat.

*PCBs*

The reach of the Sacramento River from Red Bluff to Knights Landing was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a). According to the *Final California 2010 Integrated Report* (303(d)/305(b) Report) Supporting Information, sources of PCBs in Sacramento River are unknown (SWRCB 2011o). PCBs, a group of synthetic organic chemicals, were manufactured from 1930 to 1977 and were banned in 1979. However, these organic pollutants persistent in the environment (ATSDR 2000).

The OEHHA Fish Contaminant Goal of total PCBs in fish is 3.6 ppb (or 3.6 ng/g) (SWRCB 2011o). Fish tissue samples collected in August and October 2005 exhibited significant exceedances. Six composite samples were analyzed for 48 individual PCB congeners and four Aroclor mixtures, with the four exceedances reported as 102.499 ng/g in channel catfish at Colusa, 9.151 ng/g in channel catfish at Grimes, 6.504 ng/g in Sacramento sucker at Colusa, and 5.767 ng/g in Sacramento sucker at Woodson Bridge.

To protect the beneficial uses of the Sacramento River, including the impaired beneficial use of commercial and sport fishing, a TMDL is expected to be completed in 2021 (SWRCB 2011o).

*Unknown Toxicity*

The Sacramento River from Keswick Reservoir to Knights Landing was placed on the 303(d) list as impaired for unknown toxicity (SWRCB 2011a).

Results of survival, growth, and reproductive toxicity tests performed from 1998 to 2007 showed an increase in mortality and a reduction in growth and reproduction in *C. dubia*, the Fathead Minnow *Pimephales promelas* (*P. promelas*) and the alga *Pseudokirchneriella subcapitata* (*P. subcapitata*, formerly known as *Selenastrum capricornutum*) (SWRCB 2011l,o-q). Observations violated the narrative toxicity objective found in the Sacramento – San Joaquin River Basin Plan, which states that all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, or aquatic life (CVRWQCB 2011). This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Further research is being conducted on the causes of toxicity in the Sacramento River. The TMDL for unknown toxicity in the Upper Sacramento River is expected to be completed in 2019 (SWRCB 2011l,o-q).

A 2012 SWAMP report summarized the occurrences and causes of toxicity in the Central Valley (Markiewicz et al.2012). The SWRCB's Surface Water Ambient Monitoring Program (SWAMP) defines toxicity as a statistically significant adverse impact on standard aquatic test organisms in laboratory exposures. In order to assess the causes of toxicity in California waterways, SWAMP testing uses laboratory test organisms as surrogates for aquatic species in the environment (Anderson et al.2011).

Sediment toxicity was noted to be higher in urban areas including Sacramento, Yuba City, Redding, and Antioch, while sediments from agricultural areas were generally non-toxic (Markiewicz et al.2012). Moderate water toxicity was observed throughout the agricultural and urban-agricultural areas in the upper Sacramento watershed, including in the Colusa Basin, in the vicinity of the Sutter Buttes, and along the eastern valley floor between Chico and Lincoln.

SWAMP studies indicate that the replacement of organophosphate pesticides by pyrethroids has resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011). With regard to sediment, as indicated by H. azteca, the majority of toxicity has been attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012). Of the pyrethroid pesticides, bifenthrin is of major concern.

#### 6.3.3.1.2 Sacramento River from Verona to Freeport

The water quality of the lower Sacramento River is influenced by the upstream sources discussed above as well as by inflows from the American River and from surrounding urban and agricultural runoff. The major water quality constituents of concern are described below. Water temperature is not a major concern in this lower reach of the Sacramento River because the vitality of aquatic species in this reach are not dependent on temperature.

*Mercury*

The Sacramento River from Verona to Freeport is on the 303(d) list approved by USEPA in 2010 for mercury contamination (SWRCB 2011a).

Mercury in this reach of the river can be attributed to waterborne inputs from the upper Sacramento River, Feather River, Yuba River, and American River (SWRCB 2011q). These major tributaries are also listed as impaired due to mercury. As in the Klamath and Trinity River basins, historic mining has resulted in significant mercury contamination in the Sacramento River Basin.

Flows from the Yuba River are an important source of mercury loading to the lower Sacramento River. Tailings discharged from gold mines in the Sierra Nevada mountains during the nineteenth century contained significant amounts of mercury-laden sediment, due to the use of mercury to extract gold. These discharges caused the formation of anthropogenic alluvial fans at the base of the Sierra Nevada, most notably the Yuba Fan. Singer et al. (2013) predicted that mercury-laden sediment from the original fan deposit will continue to be transported to the Sacramento River for the next 10,000 years.

The Sacramento River is a key source of mercury contamination into the Sacramento – San Joaquin River Delta. Over 80 percent of total mercury flux to the Delta can be attributed to the Sacramento River Basin (CVRWQCB 2010a). The CVRWQCB (2010a) compiled data from 2000 to 2003 and reported an average of 0.10 ng/l in the Sacramento River at Freeport. Similarly, CALFED reported that the Sacramento River at Freeport contributed an average of 0.11 ng/l of methylmercury to the Delta from 2003 to 2006 (Foe et al. 2008).

Water samples were collected from the lower Sacramento River and its tributaries from March 2003 to June 2006 (Foe et al. 2008). For comparison, concentrations in samples from the upper Sacramento River from Redding to Colusa were lower, ranging from 0.03 to 0.10 ng/l. Major tributaries to the lower Sacramento River, including the Feather River (0.05 ng/l), American River (0.06 ng/l), Colusa Basin Drain (0.21 ng/l), and Yuba River (0.05 ng/l), contributed to the mean methylmercury concentration of 0.11 ng/l at Freeport in the Sacramento River.

The commercial or recreational collection of fish, shellfish, or organisms were deemed impaired prior to the current 303(d) list approved in 2010 (SWRCB 2011q). However, no new data were available to be assessed for this updated listing.

Table 6.16 presents streambed sediment mercury concentrations from the Sacramento River and Delta regions in 1995, sampled as part of the National Water Quality Assessment (NWQA) Program for the Sacramento River Basin (MacCoy and Domagalski 1999). Limited data for mercury in sediment exist; however, these data exhibit levels of mercury greatly exceeding the average amount of mercury found on the earth's surface, of about 0.05 µg/g. The highest streambed sediment concentrations of mercury were measured downstream from the Sierra Nevada and Coast Ranges. Within the Sacramento River, sites downstream of the Feather River had higher concentrations of mercury than sampled locations upstream of this confluence. The highest reported mercury concentrations were from the Yuba River, Bear River, Sacramento River at Verona, and the Feather River which exceeded the threshold effect concentration (0.18 µg/g), but not the probable effect concentration (1.06 µg/g) reported by MacDonald et al. (2000).

**Table 6.15 Streambed sediment concentrations of mercury in the Sacramento River and Delta regions**

| Water body/Site | Concentration |
|---|---|
| **Feather River sites** | |
| Feather River | 0.21 µg/g |
| Yuba River | 0.37 µg/g |
| Bear River | 0.37 µg/g |
| Feather & Sacramento Rivers<br>Downstream of the confluence at Verona | 0.24 µg/g |
| **Sacramento River sites** | |
| Bend Bridge | 0.16 µg/g |
| Freeport | 0.14 µg/g |
| Cache Creek | 0.15 µg/g |
| Arcade Creek | 0.13 µg/g |
| American River | 0.16 µg/g |

Source: MacCoy and Domagalski 1999

Reported in bottom material <63 micron fraction dry weight.

* Concentration exceeds the MacDonald et al. (2000) threshold effect concentration (0.18 µg/g dry weight) but not the probable effect concentration (1.06 µg/g dry weight).

In an effort to protect the beneficial uses of the Sacramento River, including the impaired commercial and recreational collection of fish, shellfish, or organisms, the CVRWQCB (2011) made recommendations for the future reduction of mercury contamination. Additionally, the Delta Mercury Control Program (MERP 2012) provides potential load allocations for mercury pertaining to the Sacramento River and the Yolo Bypass, while the Cache Creek Watershed Mercury Program provides load allocations for Cache Creek, Bear Creek, Sulphur Creek, and Harley Gulch.

*Pesticides*

The Sacramento River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by the pesticides chlordane, DDT, and dieldrin from Knights Landing to the Delta. These three pesticides listings were based on the evaluation of fish contaminant data from 2005. Chlordane, DDT, and dieldrin are legacy pesticides that were discontinued from the early 1970s to the late 1980s. However, samples collected in the Sacramento River at the Veterans Bridge in September 2005 revealed elevated pesticide concentrations (SWRCB 2011q).

A composite sample of carp and a composite sample of channel catfish had total chlordane concentrations of 6.72 µg/kg and 10.20 µg/kg, respectively, both exceeding OEHHAs (2008) FCG of 5.6 µg/kg for total chlordane in fish tissue (SWRCB 2011q).

Composite samples of carp and Channel Catfish contained total DDT concentrations of 59. µg/kg and 109. µg/kg, respectively. These concentrations exceeded the OEHHAs (2008) FCG of 21 µg/kg (SWRCB 2011q).

Composite samples of carp and Channel Catfish contained total dieldrin concentrations of 0.98 µg/kg and 1.49 µg/kg, respectively, These concentrations both exceeded the OEHHAs (2008) FCG of 0.46 µg/kg (SWRCB 2011q).

*PCBs*

The Sacramento River from Knights Landing to the Delta was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

According to the Final California 2010 Integrated Report (303(d)/305(b) Report) Supporting Information, sources of PCBs in this reach of the Sacramento River are unknown (SWRCB 2011q).

The Sacramento River from Knights Landing to the Delta has also been newly listed as contaminated by PCBs. Three of three composite samples analyzed for total PCBs in September 2005 exceeded the OEHHA Fish Contaminant Goal for total PCBs of 3.6 ppb (or 3.6 ng/g), wet weight. The exceeding concentrations were recorded at 53 ng/g in channel catfish, 6.0 ng/g in Sacramento sucker, and 26 in carp (SWRCB 2011q).

A TMDL for PCBs in the Sacramento River from Knights Landing to the Delta is expected to be completed in 2021 to protect the beneficial uses of the Sacramento River and downstream waterbodies (SWRCB 2011q).

*Dissolved Oxygen*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a).

*Salinity, Electrical Conductivity, and Total Dissolved Solids*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 as impaired by salinity (SWRCB 2011a).

*Selenium*

Water bodies in the Sacramento River Basin were not listed on the 303(d) list as impaired by selenium. Waterborne selenium concentrations in the Sacramento River near Verona are relatively low compared to concentrations in the San Joaquin River Basin. However, the much larger flow that the Sacramento River contributes to the Delta, in comparison to the San Joaquin River, results in a substantial contribution to the mass loading of selenium to the Delta from the Sacramento River (Cutter and Cutter 2004; SWRCB 2008a). Loads to the Delta from the Sacramento River were projected to be about half of what the Grasslands basin was projected to contribute to the San Joaquin River, with subsequent loading to the Delta from the San Joaquin River dependent on flow (Presser and Luoma 2006).

Data for selenium in fish from the Sacramento River are limited, but Largemouth Bass were sampled in 1999, 2000, 2005, and 2007 from the lower Sacramento

River, San Joaquin River, and Delta by the CVRWQCB. The fillet data and whole-body selenium concentrations, estimated using an equation from Saiki et al. (1991), were used to evaluate potential human and wildlife health risks (Foe 2010). Selenium concentrations in fillets and whole bodies of the bass from the Sacramento River at Veterans Bridge were well below the draft criteria released in May 2014 (11.8 mg/kg for fillets and 8.1 mg/kg for whole body) (USEPA 2014b).

*Unknown Toxicity*

The Sacramento River from Knights Landing to the Delta is listed as impaired by toxicity due to the results of survival, growth and reproductive toxicity tests performed in 2006 and 2007. Observations of increased mortality and reduction in growth and reproduction in *C. dubia* and *P. promelas* compared to laboratory controls violated the narrative toxicity objective of the Basin Plan. The TMDL for toxicity in this reach of the river is expected to be completed in 2019 (SWRCB 2011q).

#### 6.3.3.1.3 Colusa Basin Drain

The Colusa Basin Drain receives inflow from local creeks and discharge and runoff from the Colusa agricultural basin. Under conditions of low water levels, it drains by gravity into the Sacramento River at Knights Landing; however, when the water levels at Knights Landing are too high for this gravity flow to occur, discharge from the Colusa Basin Drain is routed directly to the Yolo Bypass through the Ridge Cut canal (USGS 2002). During the non-storm season, flows from the Colusa Basin Drain can contribute over ten percent of Sacramento River flows at Verona when there are floods in the Colusa Basin, high irrigation discharges, and/or low Sacramento River flows (Colusa Basin Drain Steering Committee 2005).

Beneficial uses designated for the Colusa Basin Drain include agricultural irrigation and stock watering, water contact recreation, and warm and cold water habitat, migration and spawning for aquatic biota (CVRWQCB 2011). In spite of the many uses of the waterway, the Colusa Basin Drain is listed as impaired for numerous contaminants. Water quality constituents of concern impact both local beneficial uses and the water quality of receiving waterways, including the Sacramento River and the Yolo Bypass. Suspended solids, agricultural chemicals, heavy metals and organic matter are often present in concentrations that exceed those in the Sacramento, Feather, and American Rivers (Colusa Basin Drain Steering Committee 2005, SWRCB 2011r, USGS 2002)

*Mercury*

The Colusa Basin Drain is listed on the 303(d) list for contamination by mercury due to multiple exceedances of the USEPA Fish Tissue Residue Criterion for methylmercury in fish of 0.3 mg/kg (or 0.3 ppm) for the protection of human health (SWRCB 2011r). Samples exceeding the criterion included two of seven samples collected at the County Road 99E bridge crossing between 1997 and 2002 (one carp composite sample with a concentration of 0.41 ppm and one white catfish composite sample with concentration of 0.30 ppm) and one of ten samples collected in the Colusa Basin Drain at Abel Road between 1980 and 1988 (one brown bullhead composite sample with concentration of 0.58 ppm).

The Delta mercury TMDL study reported an average concentrations of methylmercury in the Colusa Basin Drain was reported to be 0.214 ng/l between 2000 and 2003. The Colusa Basin Drain contributed 3.3 percent of total mercury inputs to the Sacramento Basin between 1984 and 2003 (CVRWQCB 2010a). A TMDL for the Colusa Basin Drain is expected to be completed in 2021 (SWRCB 2011r).

*Pesticides*

The Colusa Basin Drain is listed as contaminated by the organophosphate pesticides azinphos-methyl (Guthion), diazinon, DDT and malathion. Azinphos-methyl and malathion have been included on the 303(d) list since 2006; thus, supporting information for their listing is not readily available. However, diazinon has been listed due to samples collected between 1996 and 2000 and again in 2004 exceeding the CDFW acute criterion of 0.16 µg/l one hour average. Samples collected in 2004 also exceeded the four day average criterion of 0.10 µg/l. Diazinon was addressed by a 2008 basin plan amendment but has not been removed from the 303(d) list (SWRCB 2011r).

Two of two samples assessed for DDT in the Colusa Basin Drain in 2005 greatly exceeded the OEHHA 2008 FCG for DDT, of 21 µg/kg of total DDT in fish tissue. Concentrations of 44.009 µg/kg and 65.903 µg/kg were recorded in composite samples of white catfish and carp, respectively. The TMDL for DDT is expected to be completed in 2021 (SWRCB 2011r).

The organochlorine pesticide dieldrin, and the Group A pesticides generally, are included on the 303(d) list for the Colusa Basin Drain (SWRCB 2011r). The Group A pesticides have been listed since 2006, thus supporting information is not readily available. Dieldrin is listed due to two of two samples collected in August 2005 exceeding the OEHHA FCGs for dieldrin of 0.46 µg/kg dieldrin in fish tissue. One composite sample of white catfish recorded a concentration of 0.7 µg/kg and one composite sample of carp recorded a value of 1.14 µg/kg. Contamination by organochlorine pesticides in the Colusa Basin Drain will be addressed by the Central Valley Organochlorine Pesticide TMDL and Basin Plan Amendment.

The carbamate pesticide carbofuran is also included on the 303(d) list for the Colusa Basin Drain. It has been listed since 2006; thus, supporting information is not readily available. A TMDL is expected by 2021 (SWRCB 2011r).

*Dissolved Oxygen*

The Colusa Basin Drain was placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a). According to the Final California 2010 Integrated Report (303(d)/305(b) Report) Supporting Information, sources of contributing to the dissolved oxygen impairment in the Colusa Basin Drain are unknown (SWRCB 2011r).

Samples collected from the Colusa Basin Drain (at Maxwell Road, above Knights Landing, at Highway 162, and at "Colusa Basin Drain #5") between September 2004 and October 2006 and were tested for dissolved oxygen (SWRCB 2011r). Thirty of the 73 samples exceeded the general number water quality objectives for COLD and SPWN beneficial uses. Five of the samples exceeded the water quality objective for WARM beneficial uses.

*Other Constituents of Concern*

The Colusa Basin Drain is also listed as contaminated by *E. coli*, low dissolved oxygen, and unknown toxicity (SWRCB 2011r). Knights Landing Ridge Cut is listed as contaminated by boron, low dissolved oxygen, and salinity. A USGS study of Yolo Bypass water quality in 2000 also reported that significant concentrations of ammonium and dissolved organic carbon in the Yolo Bypass were correlated with high concentrations in the Colusa Basin Drain, and that the Colusa Basin Drain was a major discharger of sulfate to the Yolo Bypass (USGS 2002)

#### 6.3.3.1.4 Feather River from Lake Oroville to the Confluence with the Sacramento River

Water quality constituents of concern in the Lower Feather River have the potential to affect several supported beneficial uses, including municipal and agricultural water supply, contact and non-contact water recreation, and fish habitat and migration uses, for cold and warm water. The 303(d) listed contaminants in this reach of the Feather River.

*Water Temperature*

The Lower Feather River (downstream of Lake Oroville) is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). However, water temperature in the lower Feather River is crucial to maintaining fresh water habitat for both warm and cold fresh water fish species in downstream habitats (DWR 2007). The SWP operates Lake Oroville and the Thermalito Reservoir Complex to meet temperature objectives established through a 1983 agreement with California Department of Fish and Wildlife and biological opinions issued by NMFS, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Releases from Lake Oroville determine initial river temperatures. Water is released at different depths through shutters at the intake structures (DWR 2007). Although Lake Oroville releases determine water temperatures initially, atmospheric conditions modify downstream river temperatures. Water temperatures vary seasonally and spatially between the low flow channel (LFC) and high flow channel (HFC) of the Lower Feather River downstream of the fish barrier dam. The LFC is the reach of the river between the Fish Barrier Dam and the confluence with the Thermalito Afterbay Outlet and it is managed to protect cold water fish species. The HFC is the downstream reach of the river, from the Thermalito Afterbay Outlet to the confluence with the Sacramento River.

Warmer temperatures in the LFC start to appear in March, reaching maximum temperatures in July and early August ranging from 61° F upstream of the Feather

River Fish Hatchery to 69º F upstream of the Thermalito Afterbay Outlet (DWR 2007a). Cooling of the LFC begins in September, with a minimum temperature of approximately 45º F occurring in February. At the Feather River Fish Hatchery, water temperatures are generally compliant with the 1983 Agreement. Temperatures from 2002 to 2004 were in compliance 95 percent of the time, exceeding requirements for 23 days during an extended warm period in fall 2002, and dropping below requirements for 13 days during the warm summer months. Water temperatures at Robinson Riffle are almost always met when the fish hatchery temperatures are met. Agricultural temperature requests cannot always be satisfied due to the requirements of the fish species and the fluctuating meteorological conditions.

Temperatures in the HFC are influenced by releases from the Thermalito Afterbay and flow contributions from Honcut Creek, the Yuba River, and the Bear River from April through October (DWR 2007). Except for during high flows from the Thermalito Afterbay (occurring frequently in July and August), releases in the warm season generally raise the water temperature. Honcut and Bear River inflows tend to increase downstream temperatures as well, while flows from the Yuba River tend to cool downstream temperatures during the warmer months.

Warming water temperatures appear in the HFC starting in March, with maximum temperatures occurring in July and August, ranging from 71 to 77º F (DWR 2007). In late august, the HFC begins to cool, reaching minimum temperatures of 44 to 45º F by January or February.

In addition to effects on fish species, agriculture is potentially affected by changes in water temperature, because the temperatures of irrigation water can affect crop growth (DWR 2007). In the Feather River Basin, this is particularly an issue for rice production. Water contact recreation can also be affected by water temperatures, as flows in the LFC are managed for cold water species and thus may be too cold for some water-contact recreation.

*Mercury*

The Lower Feather River is included on the 303(d) list for mercury contamination (SWRCB 2011a). The listing was made before the 2006 Integrated Report; thus, the evidence of water quality exceedance is not readily available. It has been noted, however, that the Feather River has relatively large mercury loadings and high mercury concentrations in suspended sediment, contributing significantly to mercury loading to the Delta. The Feather River transports much of the mercury to the Sacramento River that was released in the Sierra Nevada Mountains during gold mining operations (CVRWQCB 2010a).

FERC relicensing studies indicate that mercury consistently exceeds USEPA guidelines in most fish species and locations, and that biomagnification appears to have caused elevated mercury levels in fish (DWR 2007). A beneficial effect of Lake Oroville is the capture of contaminated sediments, preventing their further transport downstream.

In the Sacramento – San Joaquin Delta Estuary TMDL for methylmercury, the CVRWQCB (2010a) recommends that the Feather River be targeted for mercury reduction during initial efforts focusing on the watersheds that export the largest volumes of highly mercury-contaminated sediment to the Delta.

*Pesticides*

The Feather River below Lake Oroville is listed as contaminated for chlorpyrifos. Samples collected during storm events at the Feather River near Nicolaus in 2004 exceeded the California DFG Hazard Assessment Criteria of 25 ng/l over a one hour average. The TMDL for chlorpyrifos in the Feather River is expected to be completed in 2019 (SWRCB 2011t).

Group A Pesticides have also been detected in exceedance of water quality criteria (SWRCB 2011t). Data collected for organochlorine pesticide contamination in the Feather River between 2000 and 2009 as part of the NPDES permit program did not indicate exceedances of CTR criteria, but did show detections in all samples in the water column. Channel catfish tissue samples from the Feather River at Highway 99 between 1978 and 2008 exhibited high concentrations of DDT and dieldrin. These water quality and fish tissue data were presented as part of supplemental documents in the process to develop a basin plan amendment to address organochlorine pesticides in Central Valley water bodies. This basin plan amendment is currently in development and will include organochlorine pesticides in the Feather River (CVRWQCB 2010c).

*PCBs*

The Lower Feather River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

According to the *Final California 2010 Integrated Report* (303(d)/305(b) Report) Supporting Information, sources of PCBs in the Feather River are unknown (SWRCB 2011t). However, The Draft Environmental Impact Report for the FERC relicensing notes that PCBs have been detected in all fish and crayfish species from all sampled water bodies. Aroclors were also detected in at least some fish in all water bodies, as well as in crayfish in the Feather River downstream from the State Route 70 bridge (DWR 2007). PCBs have been released into the Feather River watershed from several activities. Two events in the 1980s resulted in PCB contamination in the watershed: oil containing PCBs was applied to a dirt road and entered the Ponderosa Reservoir in surface runoff, and PCBs contaminated soil and water at Belden Forebay due to a landslide which damaged powerhouses. Some remediation was performed in response to these events.

The same narrative water quality objective and evaluation criteria of 3.6 ng/g that was used as guidance to place the Sacramento River on the 303(d) list was also used to evaluate the Feather River. Composite samples of Largemouth Bass and crayfish collected in 2002 and 2003 showed high exceedances of the FCG. Upstream of the Thermalito Afterbay Outlet, a composite sample of Largemouth Bass had a concentration of 15.6 ng/g total PCBs, wet weight. Downstream of the outlet, the concentration of total PCBs in two composite samples of Largemouth Bass were 11.2 and 15.0 ng/g. Downstream of the Highway 70 Bridge, the concentration of total PCBs in a composite sample of crayfish was 56 ng/g (SWRCB 2011t)

An additional study performed in 2003 and 2004 also revealed high exceedances of the OEHHA FCG for PCBs. Concentrations of total PCBs in composite samples of hardhead and pikeminnow were 26 ng/g and 31 ng/g wet weight, respectively. All samples were analyzed for 48 individual PCB congeners and two Aroclor mixtures (SWRCB 2011t)

A TMDL for PCBs in the Lower Feather River is expected to be completed in 2021 to protect the beneficial uses of the Feather River and other water bodies downstream (SWRCB 2011t).

*Other Constituents of Concern*

The Lower Feather River is listed as impaired by unknown toxicity due to significant exceedances of the toxicity criteria outlined by the CVRWQCB (SWRCB 2011t, CVRWQCB 2011). Water samples were tested with *C. dubia, P. promelas*, and *P. subcapitata* for survival, growth and/or reproductive toxicity between 1998 and 2007. Of 212 samples tested with *C. dubia* for survival and/or reproductive toxicity, 85 exceeded the narrative toxicity objective. Of 34 samples tested with *P. promelas* for survival and/or growth toxicity, seven exceeded the objective. Of 23 samples tested with *P. subcapitata*, none exceeded the objective. Samples in violation of the toxicity objective were collected in the Feather River at Nicolaus; in the Thermalito Diversion Pool; downstream from the Feather River Hatchery; upstream and downstream from the Thermalito Afterbay Outlet; downstream from the Sewage Commission Oroville Region (SCOR) Outlet; and downstream from the FERC Project 2100 project boundary.

#### 6.3.3.1.5 American River below Lake Natoma

The lower American River flows for 23 miles from Nimbus Dam to its confluence with the Sacramento River. Water quality in this reach of the river is influenced by releases from upstream reservoirs, including Lake Natoma and Folsom Lake. In general, the runoff that flows into Folsom Reservoir and Lake Natoma, upstream of the lower American River, is of high quality (Wallace, Roberts, and Todd et al. 2003). Water quality parameters measured in Folsom Reservoir, upstream of the lower American River, include pH, turbidity, dissolved oxygen (DO), total organic carbon (TOC), nutrients (nitrogen and phosphorus), electrical conductivity, total dissolved solids (TDS), and fecal coliform.

*Water Temperature*

The lower American River is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). The lower American River supports warm and cold fresh water habitat beneficial uses, as well as migration and spawning uses. In particular, in-stream rearing of juvenile steelhead requires certain water temperatures which are targeted through water temperature objectives (CVRWQCB 2011, NMFS 2009).

The CVP operates Folsom Lake to meet temperature objectives, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Mercury*

The American River from Nimbus Dam to the confluence with the Sacramento River was listed on the 303(d) list for mercury contamination in 2010, due to exceedances of OEHHA's guidance tissue levels for mercury (SWRCB 2011u). The major source of mercury to the lower American River is mercury lost during historic mining activities that is now distributed downstream.

The American River contributes mercury to the Sacramento River, and thus the Delta, due to its relatively large mercury loadings and high mercury concentrations in suspended sediment (CVRWQCB 2010a). Like the Feather River, the lower American River is recommended for initial mercury reduction efforts as part of the Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury. In addition to load allocations recommended as part of the Delta TMDL for methylmercury, mercury contamination in the American River and its reservoirs will be addressed as part of the statewide water quality control program for mercury (SWRCB 2014a).

*PCBs*

The lower American River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

Composite samples of white catfish and Sacramento sucker collected in the American River at Discovery Park were analyzed for 48 individual PCB congeners and three Aroclor mixtures (SWRCB 2011u). The total PCBs recorded in the White Catfish and Sacramento Sucker were 3.934 ng/g and 44.094 ng/g, respectively. An additional Sacramento Sucker composite sample collected at Nimbus Dam did not exceed the OEHHA goal.

A TMDL for PCBs in the lower American River is expected to be completed in 2021 to protect the beneficial uses of the American River and other water bodies downstream (SWRCB 2011u).

*Unknown Toxicity*

The lower American River is listed as impaired by unknown toxicity. Toxicity has been indicated for vertebrates and invertebrates from samples collected at Discovery Park, using survival, growth, and reproduction toxicity tests with *C. dubia* and *P. promelas*. These tests, conducted between 1998 and 2007, exhibited significant increases in mortality and reductions in growth and reproduction in the test organisms (SWRCB 2011u). The TMDL is expected to be completed in 2021 (SWRCB 2011u).

#### 6.3.3.1.6 Yolo Bypass

The Yolo Bypass supports a variety of beneficial uses, including agricultural supply, recreational uses, and spawning, migration and habitat use. The Yolo Bypass is used for agriculture in times of low flow, and discharges to the San

Francisco Bay-Delta contribute to drinking water supplies. The Yolo Bypass also supports seasonal fish and bird populations when it is inundated, and resident fish species in its perennial channel. Water quality in the Yolo Bypass is of great importance because of the in-Bypass water uses and its effects on receiving waters downstream (CVRWQCB 2011, Sommer et al. 2001)

*Mercury*

The Yolo Bypass contributes a significant amount of methylmercury and total mercury to the Delta. While the Sacramento River is the primary tributary source of mercury to the Delta in dry years, mercury loading from the Yolo Bypass increases in wet years and is comparable to that of the Sacramento River. Although only two thirds of the Yolo Bypass floodplain lie within the legal Delta, the entire floodplain was evaluated as part of the Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury (Delta Methylmercury TMDL) (CVRWQCB 2010a). Compounding the issue of mercury contamination in the Yolo Bypass, the USGS study noted that the Bypass has conditions conducive to the production of methylmercury, including stagnant waters and marshes with an abundance of sulfate and organic carbon (USGS 2002).

A major source of mercury to the Yolo Bypass is Cache Creek. Mercury mine wastes have contributed relatively large mercury loading and high mercury concentrations in suspended sediment, making this area a priority for mercury reduction as part of the Delta Methylmercury TMDL (CVRWQCB 2010a). Elevated methylmercury concentrations in the Colusa Basin Drain are also a concern (USGS 2002).

The Cache Creek Settling Basin (CCSB) captures sediment and mercury transported by Cache Creek; however, any sediment that is not captured is transported to the Yolo Bypass (approximately half of the sediment transported by Cache Creek). The CTR mercury criterion of 0.050 μg/l for drinking water is exceeded in outflow from the CCSB (and possibly in other tributaries to Yolo Bypass), thus it is anticipated that when the Yolo Bypass is dominated by flows from Cache Creek, it also exceeds the CTR criterion (CVRWQCB 2010a).

The Delta Methylmercury TMDL recommends reducing mercury loads entering the CCSB, and regularly excavating the sediment accumulating in the CCSB, in order to increase its effectiveness and prevent its filling and thus cessation of sediment and mercury deposition. Additional reductions in mercury loading to Cache Creek will be achieved through the existing mercury TMDL in the watershed, which includes measures for mine remediation, erosion control in mercury-enriched areas, and the removal of floodplain sediments containing mercury (CVRWQCB 2010a).

In addition to efforts targeting mercury loading reductions in Cache Creek, the TMDL includes methylmercury and total mercury load and waste load allocations for agricultural drainage, tributary inputs and NDPES facilities in the Yolo Bypass to enable reductions in mercury contamination in water and fish (CVRWQCB 2010a).

*Agricultural Runoff*

The City of Woodland developed a water quality management plan for the Yolo Bypass which included water quality testing to identify pollutants of concern. Water quality was monitored within the Yolo Bypass and in its major tributaries, at the locations where they enter the Bypass. The study indicated that the highest concentrations of several contaminants were found in tributaries receiving predominantly agricultural discharge: the Willow Slough Bypass; Knights Landing Ridge Cut, which drains the Colusa Basin Drain; and for some contaminants, the Z Drain (City of Woodland 2005). Although the Yolo Basin is not included as a water body on the 303(d) list, the Tule Canal is listed as contaminated by several of these agricultural by-products, including boron, salinity, E. coli and fecal coliform. These contaminants will be addressed by TMDLs expected to be completed in 2021 (SWRCB 2011w).

Pesticides are of major concern in the agricultural drains tributary to the Yolo Bypass. DDE, a degradation product of the organochlorine pesticide DDT, was detected in the water column in agricultural drains and in Putah Creek sediment. The organophosphate pesticide chlorpyrifos was detected in excess of the concurrent DFG criterion of 0.009 µg/l in four samples, while diazinon was not reported in excess of its criterion. The carbamate pesticides diuron and methomyl were detected, but did not exceed their applicable criteria. Pyrethroids were not monitored, but were noted to be of increasing concern in the Yolo Bypass as in the rest of the Central Valley (City of Woodland 2005).

### *6.3.3.2 San Joaquin Valley*

Water quality conditions in the San Joaquin River are described for locations that would be influenced by implementation of Alternatives 1 through 5, including Stanislaus River near Caswell Park in the vicinity of the confluence with the San Joaquin River; San Joaquin River near Vernalis, and San Joaquin River near Buckley Cove and Stockton

#### 6.3.3.2.1 San Joaquin River

Water quality concerns in the San Joaquin River near Vernalis are primarily salinity, boron, and selenium which are influenced by low flows due to upstream diversions and water use and agricultural return flows.

*Water Temperature*

The reach of the San Joaquin River from Merced River to Stanislaus River was placed on the Section 303(d) list per the partial approval by USEPA in 2010 and the final approval in 2011 (SWRCB 2011a).

According to the *Final California 2010 Integrated Report* (303(d) list/305(b) Report) Supporting Information, water temperature concerns in San Joaquin River from Merced River to Stanislaus River are attributed to unknown sources (SWRCB 2011x,y). However, declines in fish populations, particularly salmon and steelhead trout, have been linked to increases in water temperatures and suggestions have been made that the population declines may be a result of watershed changes from the construction of dams, water diversions, mining, and harvest (NMFS 2009).

USEPA (2011) evaluated salmonid migration and spawning temperatures to assess the water quality of the San Joaquin River. Recommended water temperature criteria for salmon and steelhead trout life stages are presented in Table 6.16. San Joaquin River temperatures from the Merced River to the Stanislaus River in 1996-2007 exceeded USEPA's recommendations, thus impairing the cold freshwater habitat.

**Table 6.16 San Joaquin River Maximum Temperature Criteria and Recommended Uses for Summer**

| Applicable to: | Criteria: |
|---|---|
| Chinook Salmon Adult Migration | 64 °F |
| Chinook Salmon Spawning | 55 °F |
| Chinook Salmon Smoltification and Juvenile Rearing | 61 °F |
| Steelhead Trout Summer Rearing | 64 °F |

Source: SWRCB 2011x,y; USEPA 2003

TMDLs for the lower reaches in the San Joaquin River (Merced to Tuolumne and Tuolumne to Stanislaus) are expected to be completed in 2021 in an effort to further protect the beneficial uses of this water body (SWRCB 2011).

*Selenium*

San Joaquin River from Mud Slough to Merced River was placed on the Section 303(d) list in 2010 for selenium contamination per the list approved by USEPA (SWRCB 2011a). Other water bodies that drain to the San Joaquin River upstream of this reach and are listed as impaired by selenium contamination on the 303(d) list include Mendota Pool, Panoche Creek from Silver Creek to Belmont Avenue, Agatha Canal, Grasslands Marshes, Mud Slough (North, downstream of San Luis Drain), and Salt Slough (upstream from confluence with San Joaquin River).

TMDLs for selenium were approved by the USEPA for the San Joaquin River (Mud Slough to Merced River) (in 2002), Grasslands Marshes (in 2000), Agatha Canal (in 2000), and Mud Slough (north, downstream of San Luis Drain) (in 2002) (SWRCB 2011z-ac). A TMDL is expected to be completed for Panoche Creek in 2019 and another for Mendota Pool in 2021. Water quality objectives defined in the Basin Plan for the Sacramento River basin and the San Joaquin River basin are shown in Table 6.17 (CVRWQCB 2011).

**Table 6.17 Water Quality Objectives for Selenium in the San Joaquin River Region, mg/l**

| Objective | Applies to: |
|---|---|
| 0.012 (maximum concentration) | San Joaquin River, mouth of the Merced River to Vernalis |
| 0.005 (4-day average) | – |
| 0.020 (maximum concentration) | Mud Slough (north), and the San Joaquin River from Sack Dam to the mouth of Merced River |
| 0.005 (4-day average) | – |
| 0.020 (maximum concentration) | Salt Slough and constructed and re-constructed water supply channels in the Grassland watershed* |
| 0.002 (monthly mean) | – |

Source: CVRWQCB 2011

*Applies to channels identified in Appendix 40 of the CVRWQCB (2011) Basin Plan

The drainage area for the Grasslands Bypass Project is a major but decreasing source of selenium to the San Joaquin River. Selenium from subsurface agricultural drainage waters originating in the Drainage Area was historically transported through the Grassland Marshes through tributaries such as Mud Slough and Salt Slough (CVRWQCB 2001). Efforts to decrease the selenium loading to the San Joaquin River include the Grassland Bypass Project, discussed in more detail below, which has decreased selenium loading by an average of 55 percent from the Grasslands Drainage Area in comparison to pre-Grassland Bypass Project conditions (1986-1996 to 1997-2011) (GBPOC 2013). In the San Joaquin River below the Merced River, selenium concentrations decreased from an average of 4.1 µg/l during pre-project conditions (1986 to 1996) to 2 µg/l (1997 to 2011). The continued operation of the Grassland Bypass Project is expected to achieve the CVRWQCB Basin Plan objectives for the San Joaquin Valley (Reclamation & SLDMWA 2009).

Largemouth Bass were sampled during 1999, 2000, 2005, and 2007 from the San Joaquin River, lower Sacramento River, and Delta by the CVRWQCB (Foe 2010). The samples were analyzed as fillets to evaluate potential human health risks, and whole-body selenium concentrations were estimated using an equation from Saiki et al. (1991) to evaluate risks to wildlife. The data do not exceed the draft water quality criteria released by the USEPA in May 2014.

The draft discharge requirements released by the CVRWQCB in 2014 were created in an effort to meet the water quality objective for the San Joaquin River. In 2010, the CVRWQCB and SWRCB approved amendments (Resolution 2010-0046) to the Basin Plan for the Sacramento River and San Joaquin River Basins to address selenium control in the San Joaquin River basin as related to the Grassland Bypass Project (which is described below) (CVRWQCB 2010g, SWRCB 2010b).

Other relevant requirements/actions to meet the water quality objectives for the San Joaquin River, in addition to release of the draft waste discharge requirements by the CVRWQCB (2010g), include the following:

- The Basin Plan amendments (CVRWQCB 2010g, SWRCB 2010b) modify the compliance time schedule for discharges regulated under waste discharge requirements to meet the selenium objective or comply with a prohibition of discharge of agricultural subsurface drainage to Mud Slough (north), a tributary to the San Joaquin River, in Merced County. For Mud Slough (north) and the San Joaquin River from the Mud Slough confluence to the mouth of the Merced River:
  - The interim performance goal is 15 µg/l (monthly mean) by December 31, 2015 (adds to Table 6.46), and
  - The water quality objective to be achieved by December 31, 2019, is 5 µg/l (4-day average).

An extensive water quality and biological monitoring program was implemented in conjunction with the Grassland Bypass Project, and reports are issued periodically through the San Francisco Estuary Institute (e.g., SFEI 2011).

*Electrical Conductivity and Salinity*

Grasslands Marshes, North Mud Slough (downstream of San Luis Dam), Salt Slough (upstream from confluence with San Joaquin River), and San Joaquin River (Bear Creek to Vernalis) are water bodies in the Central Valley that were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by electrical conductivity (SWRCB 2011a). Salinity, which is linked to electrical conductivity, is a major concern for water quality in the San Joaquin Valley (CVRWQCB 2011). The RWQCB has adopted a TMDL for the San Joaquin River upstream of Vernalis for salt and boron.

Elevated electrical conductivity in Grasslands Marshes, North Mud Slough (downstream of San Luis Dam), Salt Slough (upstream from confluence with San Joaquin River), and San Joaquin River (Bear Creek to Vernalis) can be attributed to agriculture (SWRCB 2011x-aa,ac-af). Likewise, high salinity in the San Joaquin River near Vernalis has been linked to the discharge of water from agricultural practices (CALFED 2007). Saline water from agricultural return flow is added to the southern Delta by the San Joaquin River whereupon a portion is pumped by the export pumps back to the farms that eventually drain back to the river, exacerbating the problem of salinity control and salt buildup in the San Joaquin Valley.

To protect the beneficial uses of these water bodies, including agricultural supply, and municipal and domestic supply, particularly for San Joaquin River from Bear Creek to Mud Slough, water quality objectives were established in the SWRCB (2006a) Basin Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Table 6.18).

**Table 6.18 SWRCB Water quality objectives for electrical conductivity in the San Joaquin River (Airport Way Bridge, Vernalis)**

| Time Period | Water Quality Objective[1] |
|---|---|
| April 1 to August 31 | 0.7 mmhos (700 µS/cm) |
| September 1 to March 31 | 1.0 mmhos (1000 µS/cm) |

Source: SWRCB 2006a

1 Maximum 30-day running average of mean daily

Several samples from San Joaquin River (Bear Creek to Vernalis) between October 1995 and February 2007 exceeded the SWRCB Basin Plan's water quality objective for electrical conductivity in the San Joaquin River (SWRCB 2011 x-aa,ac-af). Samples were collected from San Joaquin River at Lander Avenue, Fremont Ford, Patterson Fishing Access, Hills Ferry Bridge, and Crows Landing. Guidelines for evaluating Grasslands Marshes, North Mud Slough, and Salt Slough are not available because the listing was made prior to 2006.

The record of monthly average electrical conductivity (EC) readings for recent years for the San Joaquin River at Vernalis is shown in Figure 6.4. Salinity in the lower San Joaquin River as observed at Vernalis often exceeds the water quality objective for individual records during summer months. The highest salt concentrations emanate from Mud and Salt sloughs, while less saline water provides dilution from the Merced River (CALFED 2007). Note the marked increase in salinity during dry months and dry years at Vernalis, ranging from midwinter lows near 100 µmhos/cm up to summer high values near 1000 µmhos/cm.

A TMDL is expected to be completed in 2019, with the exception of San Joaquin River from Tuolumne to Stanislaus River which is expected to be completed in 2021 (SWRCB 2011 x-aa,ac-af). In addition, the Board has implemented the comprehensive salt management program, known as CV-SALTS (Central Valley Salinity Alternatives for Long Term Sustainability), to develop salt control strategies for the San Joaquin and the entire Central Valley watershed (CVRWQCB 2011, 2010h). The San Joaquin River Water Quality Improvement Program (SJRIP) was designed to address issues of chronically saline water, reuse, treatment options, and the development of salt-tolerant crops for this area of the valley, as part of the Grasslands Bypass Project.

*Mercury*

Mercury is a constituent of concern for the San Joaquin River from Bear Creek to the Delta boundary, and was placed on the 303(d) list in 2010 (SWRCB 2011a). San Joaquin River from Friant Dam to Bear Creek was not included on the 303(d) list for mercury contamination.

Mercury in this reach of the San Joaquin can be attributed to resource extraction. Significant gold mining took place along the major tributaries of the San Joaquin River, including Merced River, Tuolumne River, Stanislaus River, and Cosumnes River in the San Joaquin River basin (CVRWQCB 2010a).

Mercury and enhanced mercury methylation can affect the beneficial uses of the San Joaquin River and receiving waters downstream. At the Delta boundary in Vernalis, the waterborne methylmercury concentration in the San Joaquin River from 2003 to 2006 ranged from 0.10-0.75 ng/l with an average of 0.19 ng/l (Foe et al. 2008). The average fish tissue mercury concentration in Largemouth Bass from Vernalis in 2000 was 0.68 mg/kg (wet weight) (CVRWQCB 2010a). This fish tissue concentration exceeds the USEPA wet weight methylmercury fish tissue criterion (0.3 mg/kg) for the protection of human health.

To further protect the health of humans and wildlife, the Sacramento-San Joaquin Delta TMDL specified narrative and more stringent numeric water quality objectives for the more bioavailable and more toxic form of methylmercury (CVRWQCB 2011). The TMDL for the Sacramento-San Joaquin Delta (CVRWQCB 2010a), which is applicable to the Delta, Yolo Bypass, and their waterways, includes the reach of the San Joaquin River from Bear Creek to the Delta boundary.

*Pesticides*

The San Joaquin River (all segments from Mendota Pool to Vernalis), North Mud Slough (downstream of San Luis Drain), and Salt Slough (upstream from confluence with San Joaquin River) were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by pesticides (SWRCB 2011a). North Mud Slough is listed as impaired by "pesticides"; Salt Slough by chlorpyrifos and prometryn, and San Joaquin River by OP pesticides (chlorpyrifos and diazinon), OC pesticides (DDT, DDE, Group A Pesticides, including toxaphene), alpha.-BHC, and diuron. Impairment listings vary between reaches of the San Joaquin River. Several other small tributaries to the San Joaquin River from the west are also 303(d) listed as impaired by pesticides (i.e., Mud Slough North (upstream and downstream of San Luis drain).

Pesticides in North Mud Slough, Salt Slough, and the San Joaquin River can be attributed to runoff from agriculture, with the exception of the alpha-BHC in the San Joaquin River (from Merced to Tuolumne) and toxaphene in the San Joaquin River (from Stanislaus to the Vernalis) whose sources are unknown (SWRCB 2011x-z,ac-ag).

*Boron*

The lower San Joaquin River upstream of Vernalis is listed as impaired due to elevated concentrations of boron (CVRWQCB 2002b, 2007c). A draft Amendment to the Basin Plan for the Sacramento River and San Joaquin River Basins for the control of Salt and Boron discharges into the lower San Joaquin River (resolution R5-2004-0108) (CVRWQCB 2007c) describes a pending TMDL and establishes Waste Load Allocations to meet boron water quality objectives near Vernalis (at the Airport Way Bridge).

Mean salinity in the lower San Joaquin River at Vernalis has doubled since the 1940s while boron and other trace elements have also increased to concentrations that exceed the water quality criteria of 750 μg/l. These criteria were established to be protective of sensitive crops under long-term irrigation (USEPA 1986b).

Water quality improves in the San Joaquin River downstream of confluences with the Merced, Tuolumne, and Stanislaus rivers.

Most of the boron load to the Delta comes from the lower San Joaquin River as a result of surface and subsurface agricultural discharges (CVRWQCB 2007c) on soils overlying old marine deposits and from groundwater (Hoffman 2010h, CALFED 2000). Major boron contributions come from Salt and Mud sloughs to the lower river (CVRWQCB 2002b). Point sources contribute very little of the salt and boron loads to the San Joaquin River (CVRWQCB 2007c).

Boron concentrations in surface water from two surface water sources in the lower San Joaquin River are variable, and range from 100 to over 1000 µg/l (Hoffman 2010). Effluent from subsurface drains in the New Jerusalem Drainage District have also been reported up to 4200 µg/l (Hoffman 2010). These concentrations at times exceed the water quality criteria and thresholds for sensitive crops (i.e., bean tolerance threshold is 750 to 1000 µg/l).

The collaborative effort by stakeholders and regulators is developing comprehensive management programs that will lead to attainment of water-quality objectives for salinity and boron. This program, CV-SALTS, is scheduled to be completed by 2016 and may lead to a basin plan amendment that will support the protection of beneficial uses.

*Arsenic*

The San Joaquin River from Bear Creek to Mud Slough was placed on the 303(d) list approved by the USEPA in 2010 for impairment by arsenic (SWRCB 2011a). Arsenic can cause adverse dermal, cardiovascular, respiratory, gastrointestinal, and neurological effects, and can cause cancer (ATSDR 2007). A TMDL addressing impairment due to arsenic is expected to be complete in 2021to protect the beneficial uses of this reach of the San Joaquin River, including the municipal and domestic supply (SWRCB 2011ae).

*Bacteria*

San Joaquin River (Bear Creek to Merced River; Stanislaus River to Delta Boundary) and Salt Slough (upstream from confluence with San Joaquin River) is a water body in the Central Valley that were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by *E. coli* (SWRCB 2011a).

*Invasive Species*

San Joaquin River (Friant Dam to Mendota Pool) is a water body in the Central Valley that was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by invasive species (SWRCB 2011a).

A TMDL for invasive species is expected to be completed in 2019 in an effort to meet the narrative water quality objective in San Joaquin River (Friant Dam to Mendota Pool).

#### 6.3.3.2.2 Stanislaus River

*Water Temperature*

The lower Stanislaus River was placed on the 303(d) list per the partial approval by USEPA in 2010 and the final approval in 2011 (SWRCB 2011a). The Stanislaus River supports warm and cold fresh water habitat for aquatic species such as steelhead.

According to the *Final California 2010 Integrated Report* (303(d) list/305(b) Report) Supporting Information, water temperature concerns are attributed to unknown sources (SWRCB 2011). Future climate conditions that are warmer or drier or both will further restrict the extent of suitable habitat for steelhead (NMFS 2009).

USEPA recommended water temperature criteria for different salmon and steelhead trout life stages. Data from 1991 to 2007 exceeded USEPA’s criteria and thus impairing the cold freshwater habitat. The 2009 NMFS BO also includes temperature objectives for the Stanislaus River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Mercury*

Lower Stanislaus River is a water body in the Central Valley that was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by mercury (SWRCB 2011a).

Mercury has impaired the beneficial use of the commercial or recreational collection of fish, shellfish, or organisms (SWRCB 2011aj-al). The lower Stanislaus River was evaluated prior to 2006, so the evidence for the list is not readily available. However, the total methylmercury concentration in the Stanislaus River at Caswell State Park from 2003 to 2006 was 0.12 ng/l (Foe et al. 2008). Concentrations of methylmercury in Largemouth Bass, carp, Channel Catfish, and White Catfish tissue samples from the Stanislaus River between 1999 and 2000 exceeded the USEPA methylmercury fish tissue criterion (0.3 mg/kg wet weight) for the protection of human health (Shilling 2003).

In an effort to protect the beneficial uses of these water bodies mentioned above, and including the commercial and recreational collection of fish, shellfish, or organisms beneficial use, TMDLs are expected to be completed between 2019 to 2021 to meet the water quality standards in these water bodies (CVRWQCB 2011).

*Pesticides*

Lower Stanislaus River was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by pesticides (chlorpyrifos, diazinon, Group A Pesticides) (SWRCB 2011a). OP pesticides (e.g., diazinon and chlorpyrifos) and OC pesticides (e.g., Group A Pesticides) are primarily transported to streams and rivers in runoff from agriculture (CVRWQCB 2011). Sources and descriptions of the listed pesticides are discussed further in Section 6.3.2.7.

*Other Constituents of Concern*

Lower Stanislaus River was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by unknown toxicity (SWRCB 2011a).

To protect the beneficial uses of Lower Stanislaus River, a narrative water quality objective, which addresses *E. coli*, was established in the CVRWQCB (2011) Basin Plan.

A TMDL is expected to be complete in 2021 in an effort to meet the water quality standards in the lower Stanislaus River.

#### *6.3.3.3 Sacramento-San Joaquin River Delta*

Water quality conditions in the Sacramento and San Joaquin River in the Delta are described in this subsection against criteria to protect the beneficial uses as summarized in Table 6.2. The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are summarized in Table 6.1.

##### 6.3.3.3.1 Salinity

Delta waterways were placed on the Section 303(d) List approved by the USEPA in 2010 as impaired by electrical conductivity (SWRCB 2011a). Electrical conductivity is linked to salinity and salinity is of particular concern in the tidally-influenced Delta (CVRWQCB 2011, CALFED 2007).

Electrical conductivity in Delta waterways (export area, northwestern portion, southern portion, western portion) can be attributed to runoff from agricultural practices (SWRCB 2011at-aw). Salinity in the Delta can vary significantly depending on several factors including hydrology, water operations, and Delta hydrodynamics (Jassby et al. 1995). Hydrology and upstream water operations influence the Delta inflows, which in turn influences the balance with the highly saline seawater intrusion. Various upstream watershed sources determine the quality of the Delta inflows, in addition to the in-Delta sources such as agricultural returns, natural leaching, municipal and industrial discharges that influence the Delta salinity conditions. Operation of various Delta gates and barriers, pumping rates of various diversions and volume of the open water bodies are the other key factors that influence the Delta hydrodynamics and salinity transport in the Delta.

The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

Water quality objectives for electrical conductivity were established in the SWRCB (2006a) Basin Plan to protect the beneficial uses of these Delta waterways, including agricultural supply. Objectives are specific to the western Delta, interior Delta, southern Delta and export area, as well as for inflows and outflows to the delta from other water bodies. Compliance locations in the Delta are shown in Figure 6.5.

The patterns of EC and salinity in the Delta over time and space follow predictable patterns, under the strong influence of higher saline water from the San Joaquin and less saline water from the Sacramento and Eastside streams in an ever-changing balance with tidal influence upstream from Suisun Bay and the losses from south Delta pumping. The record of monthly average EC readings for recent years at five sites throughout the Delta shows the pattern of increasing average EC in the western Delta, as shown in Figures 6.6 through 6.8. The highest salinity occurs in the late summer months when the flows from the Sacramento and San Joaquin rivers are the lowest, and sea water intrusion occurs. The lower Sacramento River at Collinsville experiences strong tidal influence during dry periods (EC above 8000 µmhos/cm) but is flushed with fresh water during winter flows. Historical salinity discharged from the CVP Jones Pumping Plant into the Delta Mendota Canal is summarized in Figure 6.9.

Salinity objectives for the southern Delta are now under review by the SWRCB (SWRCB 2008b).

#### 6.3.3.3.2 Mercury

Mercury is a constituent of concern for the Sacramento-San Joaquin River Delta, which was placed on the 303(d) list in 2010 (SWRCB 2011a). In 2008, the San Francisco Bay Mercury TMDL was approved by the USEPA and the implementation plan is expected to attain the water quality standard 20 years after the approval (SFB RWQCB 2006). In 2010, the RWQCB approved amendments to the Basin Plan for the Sacramento River and San Joaquin River Basins to include the Sacramento-San Joaquin Delta Methylmercury TMDL (CVRWQCB 2011). The TMDL was created to control methylmercury and total mercury in the Sacramento-San Joaquin River Delta Estuary, which is applicable to the Delta, Yolo Bypass, and their waterways (CVRWQCB 2010a). The waterways include the major tributaries to the Delta, the Sacramento River, eastside streams, and the San Joaquin River. Fish tissue and waterborne mercury concentration data for these water bodies are summarized in Tables 6.19 and 6.20.

**Table 6.19 Fish and Waterborne Methylmercury (as Total Mercury) Concentrations by Delta Subarea**

| | Delta Subarea[1] | | | | |
|---|---|---|---|---|---|
| | **Sacramento River** | **Mokelumne River** | **Central Delta** | **San Joaquin River** | **West Delta** |
| **Fish (Sampled in September/October 2000) (mg/kg wet weight)** | | | | | |
| Standardized 350-mm Largemouth Bass[2] | 0.72 | 1.04 | 0.19 | 0.68 | 0.31 |
| **Water (Sampled between March and October 2000) (ng/l)** | | | | | |
| Average | 0.120 | 0.140 | 0.055 | 0.147 | 0.087 |
| Median | 0.086 | 0.142 | 0.032 | 0.144 | 0.053 |
| **Water (Sampled between March 2000 and April 2004) (ng/l)** | | | | | |
| Annual Average | 0.108 | 0.166 | 0.060 | 0.160 | 0.083 |
| Annual Median | 0.101 | 0.161 | 0.051 | 0.165 | 0.061 |
| Cool Season[3] Average | 0.137 | 0.221 | 0.087 | 0.172 | 0.106 |
| Cool Season[3] Median | 0.138 | 0.246 | 0.077 | 0.175 | 0.095 |
| Warm Season[3] Average | 0.094 | 0.146 | 0.050 | 0.156 | 0.075 |
| Warm Season[3] Median | 0.089 | 0.146 | 0.040 | 0.162 | 0.055 |

Source: Adapted from CVRWQCB 2010a.

1 Location of each water and fish collection site provided on Figure 5.1 of the 2008 Draft Staff Report for the Sacramento-San Joaquin Delta Estuary TMDL for Methylmercury (CVRWQCB 2010a).

2 See CVRWQCB 2010a for the method used to calculate standard 350-mm Largemouth Bass mercury concentrations.

3 For this analysis, "cool season" is defined as November through February and "warm season" is defined as March through October.

**Table 6.20 Historical Methylmercury Concentrations in the Five Delta Source Waters for the Period 2000-2008**

| Source Water | Sacramento River | | San Joaquin River | | San Francisco Bay | | East Side Tributaries | | Agriculture in the Delta | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** |
| Mean[1] (ng/L) | 0.10 | 0.05 | 0.15 | 0.03 | 0.032 | - | 0.22 | 0.08 | 0.51 | - |
| Minimum (ng/L) | 0.06 | 0.02 | 0.09 | 0.01 | - | - | 0.02 | 0.02 | 0.02 | - |
| Maximum (ng/L) | 0.16 | 0.12 | 0.26 | 0.08 | - | - | 0.32 | 0.41 | 5.44 | - |
| 75th Percentile (ng/L) | 0.13 | 0.08 | 0.18 | 0.06 | - | - | 0.2 | 0.15 | 0.53 | - |
| 99th Percentile (ng/L) | 0.16 | 0.12 | 0.26 | 0.08 | - | - | 0.31 | 0.39 | 4.81 | - |
| Data Source | CEDEN 2014 (Irrigated Lands Regulatory Program) | | Central Valley Water Board 2010a | | SFEI 2014b | - | Central Valley Water Board 2010a | | Heim et al. 2009 | - |
| Station(s) | Sacramento River at Freeport | | San Joaquin River at Vernalis | | Suisun Bay | | Mokelumne and Calaveras Rivers | | Delta locations | |
| Date Range | 12/2006-08/2007 | | 2000-2001; 2003-2004 | 2000-2002 | 2008 | - | 2000-2001; 2003-2004 | 2000-2002 | 10/2005-03/2008 | - |

| Source Water | Sacramento River | | San Joaquin River | | San Francisco Bay | | East Side Tributaries | | Agriculture in the Delta | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** |
| ND Replaced with RL | No | | Not Applicable | Yes | - | | Yes | | Not Applicable | |
| Data Omitted | No | | None | | - | | None | | None | |
| No. of Data Points | 8 | 8 | 49 | 25 | - | - | 27 | 9 | 183 | - |

Source: Adapted from DWR, Reclamation, USFWS and NMFS 2013.

1 Geometric mean.

2 Total recoverable concentration of analyte.

3 Dissolved concentration of analyte.

For the protection of the beneficial uses of the Sacramento – San Joaquin Delta, water quality objectives were specified in the San Francisco Bay Mercury TMDL (Table 6.21) and the Sacramento-San Joaquin Delta Methylmercury TMDL (Table 6.22).

**Table 6.21 Water Quality Objectives for Total Mercury in the Delta within the San Francisco Bay Region[1]**

| | |
|---|---|
| For the protection of human health | 0.2 mg/kg wet weight mercury in fish tissue[2] |
| For the protection of aquatic organisms and wildlife | 0.03 mg Hg/kg in fish[3] |
| 1-hour average | 2.1 µg/l, in water |

Source: SFB RWQCB 2013

1 Water quality objectives are applicable to Sacramento/San Joaquin River Delta (within the San Francisco Bay region as specified in the SFB RWQCB Basin Plan, 2013), Suisun Bay, Carquinez Strait, and San Pablo Bay.

2 measured in the edible portion of trophic level 3 and trophic level 4 fish

3 measured in whole fish 3-5 cm in length

**Table 6.22 Water Quality Objectives for total mercury in the Delta within the Central Valley**

| Water body | Wet Weight Methylmercury Concentration of Fish Tissue (mg/kg wet weight) | |
|---|---|---|
| | Trophic Level 3 Fish | Trophic Level 4 Fish |
| Cache Creek, North Fork Cache Creek, and Bear Creek | 0.12 | 0.23 |
| Harley Gulch | 0.05[1] | – |
| Sacramento-San Joaquin Delta[2] and Yolo Bypass | 0.08[3], 0.03[4] | 0.24[3], 0.03[4] |

Source: CVRWQCB 2011

1 Applies to whole fish of trophic levels 2 and 3.

2 Applies to the 146 Sacramento-San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins.

3 Applies to fish of total length 150-500 mm.

4 Applies to whole fish less than 50 mm in length.

Methylation processes in the Delta are enhanced by environmental characteristics such as the source of inorganic mercury, nutrient enrichment, dissolved oxygen in the water column, sediment organic content and grain size, water residence time and sediment accumulation, periodic drying and wetting, and fish species and age structure (Alpers et al. 2008). The mercury-laden sediment that accumulates in the Delta as a result of waterborne loading is subject to methylation (Heim et al. 2007). Waterborne methylmercury in the Delta may be a more significant factor to bioaccumulation in fish than mercury-laden sediment that is subject to methylation (Melwani et al. 2009). Another factor affecting bioaccumulation in fish may be dissolved organic carbon (DOC). Laboratory studies have shown mercury uptake is much higher in water with lower DOC (as might be expected from the tributaries versus the interior Delta) (Pickhardt et al. 2006).

Mercury exposure and methylation can affect the beneficial uses of the Sacramento-San Joaquin Delta, and receiving waters downstream such as the Suisun Bay, Carquinez Strait, San Pablo Bay, and San Francisco Bay. To protect the beneficial uses of the water body a narrative water quality objective was specified, in addition to numeric water quality objectives, stating that surface waters are to "…be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses to human, plant, animal, and aquatic life" (CVRWQCB 2011).

In an effort to meet the water quality objectives, the CVRWQCB plans to continue monitoring metals in the Delta and control mass emissions from inactive or abandoned mines and other significant sources (CVRWQCB 2011). The ongoing interest in controlling mercury in fish in the Delta has spawned the Mercury Exposure Reduction Program (MERP), developed by the CVRWQCB, with the goal of pooling the resources of mercury dischargers to develop reduction programs and a better understanding of mercury bioaccumulation in Delta fish (MERP 2012). The MERP is designed to build on previous CALFED efforts. MERP was included as part of an amendment to the Sacramento River and San Joaquin River Basins Basin Plan in 2011 (CVRWQCB 2011), and is applicable to people eating one meal of trophic level 3 or 4 fish per week (32 g/day) from the Delta and Yolo Bypass, as well as their waterways. The two-phase program was put into effect October 20, 2011 and will be completed in 2030. Phase 1 consists of implementing programs to minimize pollution, implementing interim mass limits for point sources, and controlling potentially methylated sediment-bound mercury in the Delta and Yolo Bypass. Phase 1 also includes developing a program to control mercury in tributaries upstream. Plans for Phase 2 include implementing control programs and monitoring compliance. In addition to the Delta Control Mercury Program, the CVRWQCB designated load and waste load allocations for point sources within and to the Delta as specified in the Basin Plan.

#### 6.3.3.3.3 Selenium

Selenium is a constituent of concern for the Sacramento-San Joaquin River Delta and the Delta was placed on the 303(d) list in 2010 (SWRCB 2011a). Selenium criteria were promulgated for all San Francisco Bay and Delta waters in the NTR (SFB RWQCB 2011a). Although the entire San Francisco Bay is listed as impaired by selenium, the TMDL for the San Francisco Bay focuses on the North San Francisco Bay (North Bay, defined to include a portion of the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central Bay) because sources there are substantially different from sources in the South San Francisco Bay (South Bay) (Lucas and Stewart 2007). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and the Delta. The NTR values are 5.0 µg/l (4-day average) and 20 µg/l (1-hour average).

Selenium concentrations in whole-body fish and in bird eggs are most useful for evaluating risks to fish and bird wildlife receptors (Skorupa and Ohlendorf 1991; DOI 1998; Ohlendorf 2003). Analyses of dietary items (such as benthic [sediment-associated] or water-column invertebrates) can be used for evaluating risks through dietary exposure, although with less certainty than when using concentrations measured in fish or wildlife receptors. The USEPA (2014b) released draft water quality criteria for public comment in May 2014 for selenium in fish tissue; they include 15.2 mg/kg in egg/ovary, 8.1 mg/kg whole body, or 11.8 mg/kg muscle (skinless, boneless fillet).

A large number of fish tissue samples were collected from the Sacramento and San Joaquin River watersheds and the Delta between 2000 and 2007 (Foe 2010). As part of the Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (SWRCB 2008a), archived Largemouth Bass samples were analyzed for selenium to investigate possible sources of selenium being bioaccumulated in bass in the Delta and whether selenium concentrations in bass were above recommended criteria for the protection of human and wildlife health (Foe 2010). Results of this study are the most relevant biota data from the Delta, and they are summarized in Table 6.23 to compare to tissue guidelines.

**Table 6.23 Selenium Concentrations in Largemouth Bass**

| Site | Number of Samples | Selenium Concentrations in Fish Fillets (mg/kg, wet weight) | | | Selenium Concentrations in Whole-Body Fish (mg/kg, dry weight) | | | Years |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Mean | Min. | Max. | Mean | – |
| Sacramento River at Veterans Bridge | 3 | 0.40 | 0.81 | 0.56 | 1.7 | 2.9 | 2.2 | 2005 |
| Sacramento River at River Mile 44[a] | 9 | 0.27 | 0.72 | 0.46 | 1.2 | 2.7 | 1.9 | 2000, 2005, 2007 |
| Sacramento River near Rio Vista | 9 | 0.30 | 0.80 | 0.44 | 1.3 | 3.2 | 1.9 | 2000, 2005, 2007 |
| San Joaquin River at Freemont Ford | 3 | 0.35 | 0.46 | 0.48 | 1.46 | 2.44 | 1.9 | 2005 |
| San Joaquin River at Vernalis | 8 | 0.15 | 0.63 | 0.40 | 0.77 | 2.5 | 1.7 | 2000, 2005, 2007 |
| Old River near Tracy | 3 | 0.45 | 0.69 | 0.55 | 2.0 | 2.9 | 2.4 | 2005 |
| San Joaquin River at Potato Slough | 9 | 0.22 | 0.89 | 0.38 | 1.1 | 3.5 | 1.6 | 2000, 2005, 2007 |
| Middle River at Bullfrog | 6 | 0.37 | 0.58 | 0.47 | 1.6 | 2.3 | 2.0 | 2005, 2007 |

| Site | Number of Samples | Selenium Concentrations in Fish Fillets (mg/kg, wet weight) | | | Selenium Concentrations in Whole-Body Fish (mg/kg, dry weight) | | | Years |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Mean | Min. | Max. | Mean | – |
| Franks Tract | 8 | 0.15 | 0.70 | 0.37 | 0.79 | 3.0 | 1.7 | 2000, 2005, 2007 |
| Big Break | 9 | 0.15 | 0.82 | 0.38 | 0.81 | 3.1 | 1.6 | 2000, 2005, 2007 |
| Discovery Bay | 3 | 0.32 | 0.41 | 0.37 | 1.5 | 1.7 | 1.6 | 2005 |
| Whiskey Slough | 2 | 0.35 | 0.47 | 0.41 | 1.6 | 1.9 | 1.7 | 2005 |

Source: Foe 2010

Notes: Means are geometric means.

Max. = maximum, mg/kg = milligrams per kilogram, Min. = minimum.

a. Near Clarksburg.

Average selenium concentrations varied slightly in Largemouth Bass caught in the Sacramento River between Veterans Bridge and Rio Vista in 2005, as well as on the San Joaquin River between Fremont Ford and Vernalis (Foe 2010). These concentrations also varied slightly among years (2000, 2005, and 2007) in the Sacramento River at Rio Vista and in the San Joaquin River at Vernalis. The lack of a significant difference in bioavailable selenium between the two river systems was unexpected because the San Joaquin River is considered a significant source of selenium to the Delta. Selenium concentrations in the Largemouth Bass were compared to criteria recommended for the protection of human health (based on fillets; 2 mg/kg, wet weight) and fish and wildlife health (based on whole-body fish; concern threshold of 4–9 mg/kg, dry weight) (Foe 2010). Geometric means and maximum concentrations (Table 6.23) did not exceed the draft criteria.

Sporadic sampling of selenium has been conducted at a few locations in the Delta. Five major sources, shown in Table 6.24, are Sacramento River, Yolo Bypass, Eastside Delta Tributaries, San Joaquin River, and Martinez/Suisun Bay. Total selenium concentrations in Sacramento and San Joaquin river surface waters just upstream of Mallard Island (near the western limit of the Delta [Regional Monitoring Program stations BG20 and BG30, respectively]) are considered more representative of generalized Delta concentrations than of the individual rivers (SWRCB 2008a). Total and dissolved selenium concentrations were somewhat lower at those locations during low flow in a dry year (<0.1 µg/l in August 2001) than during high flow (>0.1 µg/l in February 2001) (SWRCB 2008a). Cutter and Cutter (2004) reported similar flow-related patterns for those locations. The maximum selenium concentration found in the Delta was 2 µg/l at an Old/Middle River location in the south subarea of the Delta. Except for that location, the available data show geometric mean concentrations well below 1 µg/l.

**Table 6.24 Selenium Concentrations in Water at Inflow Sources to the Delta**

| Source Water[1] | Sacramento River | San Joaquin River | San Francisco Bay | East Side Tributaries[3] | Agriculture in the Delta |
|---|---|---|---|---|---|
| Mean[2] (ng/L) | 0.10 | 0.54 | 0.09 | 0.1 | 0.11 |
| Minimum (ng/L) | 0.04 | 0.07 | 0.03 | 0.1 | 0.11 |
| Maximum (ng/L) | 0.23 | 1.50 | 0.45 | 0.1 | 0.11 |
| 75th Percentile (ng/L) | 0.11 | 0.76 | 0.12 | 0.1 | 0.11 |
| 99th Percentile (ng/L) | 0.23 | 1.50 | 0.44 | 0.1 | 0.11 |
| Data Source | USGS Website 2014b | USGS Website 2014c | SFEI 2014b | None | Lucas and Stewart 2007 |
| Station(s) | Sacramento River at Freeport | San Joaquin River at Vernalis | Central-West; San Joaquin River Near Mallard Island | None | Mildred Island, Center |
| Date Range | 11/2007-07/2014 | 11/2007-08/2014 | 02/2000-08/2013 | None | 2000, 2003-2004 |
| ND Replaced with RL | Not Applicable | Not Applicable | Yes | Not Applicable | No |
| Data Omitted | None | None | - | Not Applicable | No |
| No. of Data Points | 88 | 93 | 14 | None | 1 |

Sources: Adapted from DWR, Reclamation, USFWS and NMFS 2013; U.S. Geological Survey 2014b,c; San Francisco Estuary Institute 2014b; Lucas and Stewart 2007

1 Dissolved selenium concentration.

2 Geometric mean.

3 Dissolved selenium concentration in Mokelumne, Calaveras, and Cosumnes Rivers is assumed to be 0.1 µg/L because of lack of available data and lack of sources that would be expected to result in concentrations greater than 0.1 µg/L

In efforts to address the selenium in the Delta and water bodies downstream, the SFB RWQCB is conducting a new TMDL project to address selenium toxicity in the North Bay (SFB RWQCB 2011, 2013). The North Bay selenium TMDL will identify and characterize selenium sources to the North Bay and the processes that control the uptake of selenium by fish and wildlife. The TMDL will quantify selenium loads, develop and assign waste load and load allocations among sources, and include an implementation plan designed to achieve the TMDL and protect beneficial uses.

USEPA's Action Plan for Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Estuary (USEPA 2012a) identifies selenium as one of seven priority items for action. The plan indicated that USEPA will draft new site-specific numeric selenium criteria by December 2012 to protect aquatic and terrestrial species dependent on the aquatic habitats of the Bay Delta Estuary. More stringent selenium water quality criteria will require actions that decrease allowable concentrations of selenium in surface waters of the Bay Delta Estuary and may set allowable levels of selenium in the tissue of fish and wildlife. Following the development of the Bay Delta selenium criteria, USEPA plans to develop site-specific criteria for other parts of California, including the San Joaquin Valley watershed (USEPA 2012a). USEPA also is engaged in other efforts to minimize selenium discharges to the San Joaquin River and the Bay Delta Estuary, including the Grasslands Bypass Project and the North San Francisco Bay TMDL.

#### 6.3.3.3.4 PCBs

The Sacramento-San Joaquin River Delta was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a). A TMDL for PCBs in the Sacramento River from Knights Landing to the Delta is expected to be completed in 2021 to protect the beneficial uses of the Sacramento River and other water bodies downstream (SWRCB 2011ax).

#### 6.3.3.3.5 Pesticides

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) were placed on the Section 303(d) List approved by the USEPA in 2010 as impaired by pesticides (chlorpyrifos, DDT, Diazinon, Group A Pesticides, Chlordane, Dieldrin, Dioxin, and Furan and Dioxin compounds) (SWRCB 2011a).

Samples were collected from Sacramento River at Rio Vista, near Hood along the Sacramento/Yolo County line, San Joaquin River at Highway 4 and Antioch, 1 1/2 miles upstream from the Mossdale launch ramp, and other locations north portion of the Delta waterways (SWRCB 2011at-bb).

In an effort to meet the water quality standards in Sacramento-San Joaquin River Delta, TMDLs are expected to be complete in 2019 with the exception of the TMDL for chlorpyrifos and diazinon. A Delta Diazinon and Chlorpyrifos TMDL Project was approved in 2007.

#### 6.3.3.3.6 Nutrients

The Sacramento-San Joaquin River Delta was not placed on the 303(d) list approved by USEPA in 2010 as impaired by nutrients (SWRCB 2011a). However, nutrients are a cause of concern in the Delta (e.g., CVRWQCB 2010j) and have been the subject of discussion. A decline in pelagic fish species in the Delta, known as the pelagic organism decline (POD), including the endangered California Delta smelt, may be related to bottom-up effects from nutrients among other drivers (Baxter et. al. 2010; Sommer et al. 2007). However, unlike most waterbodies where nutrients cause too much primary production, the problem affecting beneficial uses in parts of the Delta is too little primary production to support fish populations. Nutrient effects are also dependent on flow and other factors (e.g., temperature, turbidity, and invasive species) that are potentially associated with the POD. Specific hypotheses for an association between nutrients and the POD are that ammonium (a dominant form of nitrogen in the Delta and Suisun Bay, inhibits the uptake of nitrate which is a better fuel for algae blooms (Dugdale et al. 2007) and that changes in nutrient forms and rations have caused a shift in the food web (Glibert et al. 2011). Alternatively, causes of the POD may be related to reduced phosphorus that has become a limiting factor for primary production (Van Nieuwenhuyse 2007), or that invasive clam consumption of algae have made this food source unavailable to zooplankton and fish since their introduction in the mid-1980s (Lucas and Thompson 2012; Kimmerer et al. 1994).

The Delta is a major source of anthropogenic ammonium loading to the Suisun Bay, which exchanges nutrients with Suisun Marsh, an estuarine habitat impaired by nutrients (Senn et al. 2014, Tetra Tech Inc. and WWR 2013). Primary sources of nutrients are erosion, agricultural runoff, urban runoff, and treated effluent. The Sacramento Regional Wastewater Treatment Plant (SRWTP) is the largest major point source of ammonium in the Delta, contributing 90 percent of ammonium in the river from 1986 to 2005 (Jassby 2008). Nitrogen inputs to the Delta will change as SRWTP’s current NPDES permit (NO. CA0077682) includes effluent limits for nitrogen that require the addition of nitrification and denitrification treatment by 2020. Another source of ammonium loading has already changed as the Stockton Regional Wastewater Control Facility, which discharges to the San Joaquin River began implementing nitrification and denitrification treatment in 2007 (SWRCB 2012b).

Nutrients, primarily nitrogen and phosphorous, may trigger excessive growth of algae or toxic blue-green cyanobacteria. However, within the Delta, it is generally recognized that nutrients are too high in concentration to be limiting (as compared to light, for example) (Jassby et al. 2002). The secondary effects of nutrient enrichment and oxygen depletion are most often found in the central and southern Delta near Stockton rather than the Sacramento River.

#### 6.3.3.3.7 Dissolved Oxygen

The Stockton Ship Channel in the Delta waterways was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by dissolved oxygen (SWRCB 2011a).

Low dissolved oxygen is of concern in the central and southern Delta because of enhanced treated effluent loading from Stockton, agricultural runoff, and reduced flushing of dead-end channels. Middle River, Old River, and the Stockton Deep Water Ship Channel are listed as impaired due to dissolved oxygen depletion, with dissolved oxygen concentrations criteria set at 6 mg/L minimum for the San Joaquin River between Turner Cut and Stockton between September 1 and November 30 (SWRCB 2011a, SWRCB 2006a). Loading from the Stockton Regional Wastewater Control Facility had the greatest effect in reducing DO, with hydrologic flushing (as related to upstream river flows, upstream discharges of materials that increase biological oxygen demand), geometrical cross-sections of the channels, temperature, and phytoplankton being less important (Jassby and Niewenhuyse 2005). Following recent upgrades to the Stockton Regional Wastewater Control Facility in 2006, less oxygen demand constituents have been discharged into the channels.

A TMDL addressing impairment due to dissolved oxygen was approved by the USEPA in 2007 to meet the water quality standards in the Stockton Ship Channel.

#### 6.3.3.3.8 Organics and Pathogens

The Stockton Ship Channel in the Delta waterways was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by organic enrichment and pathogens (SWRCB 2011a).

The Delta as a source of drinking water is impaired through the presence of disinfection byproducts from treated wastewater effluent and the interactions with bromide and dissolved organic carbon, which may produce potentially harmful disinfection byproducts such as the carcinogenic trihalomethanes and haloacetic acid (Healey et al. 2008). Bromide and organic carbon are natural chemical constituents of the estuarine ecosystem but they exacerbate drinking water quality impairment through discharges, agriculture drainage, or water management, when combined with disinfectants during water treatment processes. Changes to flow or use patterns or discharges to the Delta must be examined for their potential effects to concentrations of these disinfection byproduct precursors and compounds.

Pathogens are another potential concern impairing the Delta for drinking water use. Giardia and Cryptosporidium are common protozoans found in urban runoff and sometimes found to be in exceedance of drinking water standards in the Delta (SWRCB 2007). A TMDL addressing impairment due to pathogens was approved by the USEPA in 2008 to meet the water quality standards in the Stockton Ship Channel.

#### 6.3.3.3.9 Invasive Species

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by invasive species (SWRCB 2011a).

A TMDL addressing impairment due to invasive species is expected to be completed in 2019 in an effort to meet the water quality standards in Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel).

#### 6.3.3.3.10 Unknown Toxicity

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by unknown toxicity (SWRCB 2011a).

A TMDL is expected to be completed in 2019 to protect the beneficial uses of Sacramento-San Joaquin River Delta and its waterways, including impaired warm fresh water habitat.

### *6.3.3.4 Suisun Bay and Suisun Marsh*

Suisun Bay and Suisun Marsh are located in transition zones between upstream fresh water inputs and tidal saline flux from San Francisco Bay. Beneficial uses of these areas are summarized in Table 6.2. Constituents of concern are summarized in Table 6.1.

Historically, the chlorophyll maxima were found to coincide with the mixing (entrapment) zone but recent alterations by invasive species of benthic grazing clams has greatly altered the Suisun Bay food web and these historical patterns (Kimmerer 2004; Jassby et al. 2002). Although turbidity remains high and limiting to primary productivity in Suisun Bay, there has been a long term trend toward increased water clarity. Suisun Bay has low retention time, low salinity (average of 5.8 ppt), low nutrients, and high particulate matter and light attenuation (Cloern and Jassby 2012).

#### 6.3.3.4.1 Salinity

The Suisun Marsh Wetlands was placed on the 303(d) list approved by the USEPA in 2010 for impairment by salinity. The wetlands are also impaired by TDS and chlorides (SWRCB 2011a).

In an effort to protect the beneficial uses, including estuarine habitat, narrative and numeric objectives were specified by the SWRCB in Decision 1641. The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

The salinity objective in Suisun Bay, X2, which is the location, as measured in kilometers upstream from the Golden Gate bridge, of the 2 ppt isohaline (2.64

mS/cm) was established as part of the Water Quality Control Plan of 1995 (SWRCB 1995). X2 is a constantly fluctuating position in the continuum between the Delta fresh water (salinity less than 2 ppt) upstream and San Francisco Bay tidal influence, downstream (salinity greater than 2 ppt).

#### 6.3.3.4.2 Mercury

Mercury is a constituent of concern for Suisun Bay and Suisun Marsh, which were placed on the 303(d) list in 2010 (SWRCB 2011a). For the Suisun Bay, a TMDL was specified in the San Francisco Bay Mercury TMDL (SFB RWQCB 2013), which was approved by the USEPA in February 2008 and the implementation plan is expected to attain the water quality standard 20 years after the approval. For the Suisun Marsh, a TMDL was specified in the Sacramento-San Joaquin Delta Methylmercury TMDL (CVRWQCB 2010a) and was completed in September 2012 (SFB RWQCB 2012a).

Water quality objectives for Suisun Bay are specified in the San Francisco Bay Mercury TMDL (SFB RWQCB 2013). Suisun Marsh standards, as specified in Suisun Marsh TMDL, are shown in Table 6.25 (SFB RWQCB 2012a). There are future plans to adopt the Suisun Bay standards for the Suisun Marsh as well as implementation plans to improve the water quality in Suisun Marsh.

**Table 6.25 Water Quality Objectives for Total Mercury in Suisun Marsh**

| | | |
|---|---|---|
| For the Protection of Marine and Freshwater Aquatic Life | 4-day average (adverse effects from acute toxicity[1]) | 0.25 µg/l |
| | 1-hour average (adverse effects from chronic toxicity) | 2.1 µg/l |

Source: SFB RWQCB 2012a

1 Applicable to marine aquatic life, where salinity is greater than 10 parts per thousand. The same objectives apply to freshwater aquatic life because the marine objective is more stringent.

#### 6.3.3.4.3 Selenium

Although the Suisun Marsh Wetlands is not identified as an impaired water body for selenium contamination on the 303(d) list in 2010, selenium is identified as a cause for impairment for the adjacent water body, Suisun Bay (SWRCB 2011a).

The impairment of Suisun Bay by selenium can be attributed to exotic species as well as discharge from industrial point sources and natural sources (SWRCB 2011bd). *Corbula (Potamocorbula) amurensis*, a species of clam that is an important food source for sturgeon and certain ducks, is a bioaccumulator for selenium (Beckon and Maurer 2008). This exotic species was first discovered in Suisun Bay in 1986 and became very common by 1990 from San Pablo Bay through Suisun Bay (Cohen 2011). Industrial point sources, such as oil refineries, discharge waste containing selenium to the Suisun Bay (SFB RWQCB 2011).

To best protect the most susceptible fish, white sturgeon, from selenium toxicity, a TMDL for Selenium in the North San Francisco Bay, defined to include also a portion of the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central

Bay, is being completed and a Preliminary Project Report was released in 2011 (SFB RWQCB 2011). A range of concentrations for selenium in fish tissue from 6.0 to 8.1 μg/g dry weight was proposed as a numeric target. This range is based on the minimal effects of selenium in whole-body freshwater fish and the 10 percent effect level concentration.

#### 6.3.3.4.4 Nutrients

Suisun Marsh is a water body in the San Francisco Bay that was placed on the Section 303(d) list approved by USEPA in 2010 as impaired by nutrients (SWRCB 2011a).

According to the Final California 2010 Integrated Report (303(d) list/305(b) Report) Supporting Information, nutrients in Suisun Marsh can be attributed to flow regulation/modification and urban runoff/storm sewers (SWRCB 2011bc). More specific sources of nutrients to Suisun Marsh include agricultural, urban, and livestock grazing drainage through tributaries, the Sacramento River and San Joaquin River through the Sacramento-San Joaquin River Delta, nutrient exchange with Suisun Bay, atmospheric deposition, and discharge from the Fairfield Suisun Sewer District wastewater treatment plant (Tetra Tech Inc. and WWR 2013).

Concentrations of ammonia from 2000-2011, in the receiving waters from Boynton, Peytonia, Sheldrake and Chadbourne Sloughs (0-0.4 mg/l), as well as in Suisun Slough (0-0.3mg/l), exceeded the maximum water quality objective concentration for ammonia (Tetra Tech Inc. and WWR 2013). Elevated concentrations of chlorophyll-a, in comparison to concentrations at reference sites at Mallard, suggest possible impairments by nutrients. Other possible impairments of the narrative criteria by nutrients were suggested resulting in excess algal growth in wetlands, elevated organic carbon, and impacts on dissolved oxygen and mercury methylation.

#### 6.3.3.4.5 Dissolved Oxygen

Suisun Marsh Wetlands were placed on the 303(d) list approved by the USEPA in 2010 for dissolved oxygen impairment (SWRCB 2011a). Insufficient dissolved oxygen can alter the well-being of the estuarine habitat, fish spawning, warm freshwater habitat, and wildlife habitat (SFB RWQCB 2013).

Flow regulation and modification, as well as urban runoff and storm sewers dictate the dissolved oxygen levels in the marsh (SWRCB 2011bc). Specific oxygen demanding sources that cause low dissolved oxygen levels are "grazed open areas, nutrient-enriched wastewater discharge from Fairfield-Suisun Sewer District, wastes from boats in Suisun City marina, and tidal marshes," in addition to tides, delta outflow, agricultural drainage from surrounding watersheds and urban areas, and managed wetlands (Tetra Tech, Inc. and WWR 2013). Slough size and hydrology also influenced the low dissolved oxygen conditions in Suisun Marsh Wetlands (Siegel et al. 2010).

Low dissolved oxygen levels in exceedances of water quality objectives between 2000 and 2011 in Suisun Slough, Montezuma Slough, and Goodyear Slough are presented in Table 6.26 (Tetra Tech, Inc. and WWR 2013).

**Table 6.26 Percentage of Observations Exceeding Water Quality Objectives for Dissolved Oxygen**

| Location | WQO Exceedances | |
|---|---|---|
| | **7 mg/l** | **< 80% Saturation[1]** |
| Suisun Slough | 10 – 40% | 2% |
| Montezuma Slough | < 10% | 60 – 68% |
| Goodyear, Peytonia, and Boynton Sloughs | > 50% | 73 – 94%[2] |

Source: Tetra Tech, Inc. and WWR 2013

1 3-month median above 80 percent dissolved oxygen saturation

2 Lower Goodyear Slough exceeded the 3-month media above 80 percent dissolved oxygen saturation 48.1 percent of the time

To further protect the beneficial uses of the Suisun Marsh Wetlands from low dissolved oxygen concentrations, water quality objectives more representative of natural conditions are currently being developed (Tetra Tech, Inc. and WWR 2013). A TMDL for Suisun Creek, a tributary of Suisun Marsh Wetlands that is impaired by low dissolved oxygen, is expected to be completed in 2021 (SWRCB 2011bc).

#### 6.3.3.4.6 Organics

Suisun Marsh was placed on the 303(d) list approved by USEPA in 2010 for organic enrichment (SWRCB 2011a). Organic enrichment enhances microbial production and activity, such as the methylation of mercury, and the decomposition of organic matter can cause low dissolved oxygen levels (Tetra Tech, Inc. and WWR 2013).

#### 6.3.3.4.7 Pesticides

Suisun Bay, and other water bodies in the San Francisco Bay area including Carquinez Strait and San Pablo Bay were placed on the Section 303(d) list for pesticides (chlordane, DDT, dieldrin) contamination per the list approved by USEPA in 2010 (SWRCB 2011a). However, according to the 2013 Regional Monitoring Program Report, pesticides (chlordane, DDT, and dieldrin) in the estuary are being considered for delisting (SFEI 2013).

A TMDL for the Diazinon and Pesticide-related Toxicity in Urban Creeks was added as an amendment to the Basin Plan and was approved by the USEPA in 2007 (SFB RWQCB 2005).

##### 6.3.3.4.8 PCBs

Suisun Bay, and several other water bodies within San Francisco Bay area including Carquinez Strait and San Pablo Bay, were placed on the Section 303(d) list for the contamination of PCBs per the list approved by USEPA in 2010 (SWRCB 2011a). The following is applicable to all water bodies specified in the San Francisco Bay PCBs TMDL, including Suisun Bay, Carquinez Strait, and San Pablo Bay (SFB RWQCB 2013).

A TMDL was approved by the USEPA in 2010. The TMDL allows 10 kilograms of PCBs to be discharged to San Francisco Bay per year (SFB RWQCB 2013). It is projected that this load allocation will be achieved in 20 years with implementation of plans and actions for external and internal sources, such as municipal and industrial dischargers, as stated in the San Francisco Bay TMDL.

##### 6.3.3.4.9 Other Constituents of Concern

Suisun Bay was placed on the Section 303(d) list for invasive species contamination per the list approved by USEPA in 2010 (SWRCB 2011a).

Invasive species in Suisun Bay can be attributed to ballast water, fresh or salt water placed on a ship for stability (SWRCB 2011bd). *Corbula (Potamocorbula) amurensis*, a native clam of southern China estuaries, was discovered in Suisun Bay in 1986 and was introduced to San Pablo Bay shortly after (USFWS and NSGCP 1995). This species of clam is important as a food source for sturgeon, diving ducks, etc. and consequently a bioaccumulator of selenium (USFWS 2008). Other species introduced to the Suisun Bay are reported in the *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta* (USFWS and NSGCP 1995).

Invasive species can affect the beneficial uses of Suisun Bay, as listed in Table 6.2, including estuarine habitat. For the protection of marine aquatic life, a TMDL is expected to be completed in 2019.

Other contaminants in the Suisun Bay include furan compounds and dioxin compounds. These contaminants were placed on Section 303(d) list per the list approved by USEPA in 2010 (SWRCB 2011bd).

### 6.3.4 Delta Water Quality Issues for CVP and SWP Water Users

The designated beneficial uses and constituents of concern for the study area and for each RWQCB region are described in Section 6.3.1, Beneficial Uses of Surface Waters in the Study Area. In this section, the beneficial uses of water from the Delta are generalized and categorized by purpose of use into those associated with municipal and industrial, agricultural, groundwater recharge, and recycling and blending uses.

#### *6.3.4.1 Municipal and Industrial Uses*

The Delta is a source of drinking water supply to over 25 million people, or sixty percent of the state population. The CVP and SWP water users that use water from the Delta as a source of potable water supply for municipal and industrial uses have two main water quality concerns: protection, preservation, and improvement of source water quality; and capability of treatment processes to meet stringent drinking water quality regulatory requirements. To protect public health and safety, water providers apply a multi-barrier approach: seek the highest quality source water available, protect and preserve the source water quality to ensure non-degradation, operate and periodically upgrade drinking water treatment processes, and maintain safe distribution systems.

The Delta, as a drinking water source, is compromised by high levels of naturally occurring and manmade constituents of concern. Some of the naturally occurring constituents, such as organic carbon and nutrients, are necessary components of the Delta ecosystem. Salinity, another natural constituent, is inherent with the tidal cycles of the estuary. Other anthropogenic constituents such as pathogens and contaminants are results of point and non-point source discharges into the Delta.

Water containing organic carbon reacts with chlorine, commonly used as a disinfectant in drinking water treatment processes, to form disinfection byproducts (DBP) such as trihalomethanes and haloacetic acids. Delta waters contain high levels of both dissolved organic compounds and bromide, increasing the formation of DBP. Use of chloramines for disinfection would reduce the production of DBP, but chloramination can lead to the formation of carcinogenic N-nitrosamines, including N-nitrosodimethylamine (NDMA). These interactions complicate the design of drinking water treatment processes and create the necessity to balance and trade off disinfection effectiveness with DBP creation. Balance and tradeoffs are also necessary between source water quality protection and ecosystem restoration actions that could increase the levels of organic carbon.

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) designated drinking water municipal and domestic supply beneficial use for most waters in the Central Valley, including the Delta. It includes narrative objectives for chemical constituents, taste and odor, sediment, suspended material, and toxicity, and numeric objectives for chemical constituents and salinity. The Basin Plan incorporates by reference the primary and secondary maximum contaminant levels specified in Title 22 of the California Code of Regulations for waters designated for municipal uses.

Through the triennial review process, stakeholders prioritized the need for a drinking water policy and identified a number of drinking water constituents of concern including: salt (including bromide), nutrients, organic carbon and pathogens such as *Cryptosporidium* and *Giardia*.

In 2013, the Central Valley RWQCB adopted Resolution No. R5-2013-0098, an amendment to the Basin Plan to establish a drinking water policy for surface waters of the Delta and its upstream tributaries. The amendment was approved by the SWRCB in the same year, and approved by the Office of Administrative Law and US EPA in 2014.

The Amendment modifies the water quality objectives of the Basin Plan to add a narrative water quality objective for *Crytosporidium* and *Giardia*, and clarifies that existing narrative objective for chemical constituents includes drinking water chemical constituents of concern, such as organic carbon. The Amendment also establishes a Drinking Water Policy to maintain high quality of water, anti-degradation, application of water quality objectives, implementation of toxics standards for inland surface waters, enclosed bays, and estuaries, and continued coordinated monitoring, assessment, and reporting of identified drinking water constituents of concern.

#### 6.3.4.1.1 Organic Carbon

Delta water is high in dissolved and suspended organic carbon, due to the high peat soil composition and estuarine environment. Organic carbon combines with disinfectants in drinking water treatment processes to produce DBP that are harmful to human health. In a 1998 study and a 2003 update, expert panels for the California Urban Water Agencies recommended that TOC in the Delta source water should not exceed 3.0 mg/L, in order for Delta-dependent water agencies to be able to meet treated drinking water regulatory requirements. This recommendation was based on an analysis of the various existing and planned treatment processes, residual (distribution systems) disinfection requirements, as well as the interaction among TOC and other DBP precursors.

In the 2013-14 Basin Plan amendment, indicates that the state waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses, and that this includes drinking water chemical constituents of concern, such as organic carbon.

#### 6.3.4.1.2 Bromide and Other Disinfection By-product (DBP) Precursors

Bromide is a naturally occurring constituent in waters subjected to tidal influences such as the Delta. It reacts with ozone, a disinfectant often used for inactivation or removal of *Cryptosporidium* and for controlling taste and odor issues, to form bromate which is a regulated DBP for its cancer-causing potential. The combination of TOC and bromide in Delta waters poses an especially challenging scenario for treatment processes in balancing the need for microbiological removal and minimizing the formation of organically-based brominated DBP. The 1998/2003 expert panels for California Urban Water Agencies recommended that bromide levels should not exceed 50 µg/L in order for Delta-dependent water agencies to be able to meet treated water regulatory requirements.

#### 6.3.4.1.3 Nutrients and Other Discharges

Municipal discharges and agricultural return flows into the Sacramento and San Joaquin river watersheds and the Delta contribute pollutants and constituents of concern that could potentially degrade water quality.

Nutrients such as nitrogen and phosphorus originate from natural sources and from anthropogenic sources including point and non-point source discharges. Although nutrients are necessary for a healthy ecosystem, over enrichment of nitrogen and phosphorus can contribute to eutrophication and toxicity. Eutrophication also results in elevated levels of TOC, a DBP precursor.

In August 2015, USEPA published revisions to the federal Water Quality Standards Regulations required the state to develop implementation methods to conduct analyses if ongoing or future projects would degrade high quality waters. The regulations require analysis of a range of non-degrading or less-degrading alternatives and make a finding that degradation is necessary to accommodate important social or economic development in the area where the waters are located.

The SWRCB's Policy with Respect to Maintaining High Quality of Water in California (Resolution No. 68-16) incorporates the federal antidegradation policy and restricts reductions in water quality even if beneficial uses are protected. The Drinking Water Policy in the 2013-14 Basin Plan amendment stated that drinking water constituents of concern shall continue to be considered when waste discharge facilities conduct antidegradation analyses. The 2013-14 Drinking Water Policy also requires the RWQCBs to consider the necessity for inclusion of monitoring of organic carbon, salinity, and nutrients for waste discharge permit renewals if the facilities are located near drinking water intakes, if a concentration load has significantly increased, and the importance of the data submitted by the discharger to management decisions to protect drinking water.

#### 6.3.4.1.4 Pathogens and Emerging Contaminants

Point and non-point source discharges into Delta waters have the potential to introduce and elevate the levels of pathogens and other contaminants. *Cryptosporidium* and *Giardia* are two main pathogens of concern that are the focus of drinking water regulatory requirements promulgated by USEPA. In addition, other contaminants of emerging concern, particularly pharmaceuticals and personal care products, have been widely distributed and persistent in the environment. These chemicals bio-accumulate and cause endocrine disruption.

The 2013-14 Basin Plan amendment includes a narrative water quality objective for *Cryptosporidium* and *Giardia* within the Sacramento-San Joaquin Delta and its tributaries below the first major dams. Compliance with this objective will be assessed at existing and new public water system intakes to maintain existing levels of pathogens at public water system intakes.

The Basin Plan amendment also includes support of a one-time special study to characterize ambient levels of *Cryptosporidium*, to better understand the relationship between source loading and ambient *Cryptosporidium* concentrations, and to better understand the movement of *Cryptosporidium* through the system.

#### 6.3.4.1.5 Salinity and TDS

Salinity is commonly measured in units of EC or TDS. Salinity standards, in the form of chloride objectives, have been established in the Basin Plan to protect the various beneficial uses. The most restrictive is the 150 mg/L chloride objective for Contra Costa Canal and the City of Antioch intake. The objective was originally established to protect an industrial manufacturing facility that has since closed. In terms of drinking water, bromide is the most critical component of salinity that impacts drinking water treatment processes. No standards have been set for bromide, although there is a MCL for the disinfection byproduct bromate. Secondary MCLs for TDS (500 mg/L), chloride (250 mg/L), and sulfate (250 mg/L) have been set to address cosmetic or aesthetic effects such as staining, mineral deposits, taste, odor, and color. The CV-SALTS Executive Committee is currently considering potential revisions to water quality objectives for secondary MCL, as part of the developing Salt and Nitrate Management Plan for the Central Valley.

Salinity also affects non-potable uses such as industrial processes, irrigation, groundwater recharge, and recycling. High salinity waters may render them infeasible for certain industrial processes, or reduce the efficiency by reducing the number of recirculation cycles. Impacts of salinity on irrigation, groundwater recharge, and recycling are discussed in the following subsections.

Changes in operation of the CVP and SWP could exacerbate salinity and bromide problems, through changes in allowable export pumping windows during the year and for different year types, as well as the operation of the Delta Cross-Channel gates, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

#### *6.3.4.2 Agricultural Uses*

The main water quality issues related to agricultural use of Delta exported supplies are salinity and drainage, as discussed in the following subsections.

##### 6.3.4.2.1 Salinity, Sodium, and Toxicity

Delta waters are high in salinity due to tidal influence and upstream discharges. High salinity in irrigation water inhibits water and nutrients intake by plants, resulting in yield reduction. Saline conditions could be a result of high salinity source water used for direct irrigation, or saline soil water due to saline water accumulation and poor drainage. Plant uptake of water through osmo-regulation is restricted when the soil water salinity is greater than the internal salinity of the plant. Water with a TDS above 1,500 to 2,600 mg/L (EC greater than 2.25 to 4 mmho/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance.

Irrigation water containing high levels of sodium is of special concern because of its potential to create a sodium hazard in the soil. Sodium hazard, expressed as sodium adsorption ratio, is the phenomenon when sodium is adsorbed and becomes attached to soil particles, rendering the soil hard and compact when dry and increasingly impervious to water penetration. Fine textured soils high in clay content are most vulnerable to the sodium hazard.

High salinity in irrigation water could also result in plant toxicity due to accumulation of ions in the leaves. The most common ions which cause toxicity are chloride, sodium, and boron. Boron is particularly troublesome because toxicity can occur in very low concentrations, despite the fact that boron is an essential plant nutrient. Boron can also accumulate in the soil.

Sulfate salts affect sensitive crops by limiting the uptake of calcium and increasing the adsorption of sodium and potassium, upsetting the cationic balance within the plant. High concentrations of potassium may introduce a magnesium deficiency and iron chlorosis.

Different crops have different toleration for salinity, with forage crops being the most resistant and fruit crops being the most sensitive. Crops are also most sensitive to salinity during seed germination, and more tolerant during later growth stages. Changes in salinity of Delta waters due to seasonal fluctuations or different year types may affect crops, depending on the timing within the growth cycle. To protect salt sensitive crops during the irrigation season, the EC overall objectives in the San Joaquin River and the interior southern Delta are generally at 0.7 mS/cm (700 µS/cm) during the irrigation season (April to August) and at 1.0 mS/cm for the remainder of the year.

Generally, salinity in groundwater is higher than surface water in the San Joaquin Valley. Changing from irrigating with surface water to groundwater, due to shortages of CVP and/or SWP water supplies, could exacerbate salinity issues.

#### 6.3.4.2.2 Agricultural Drainage

The Central Valley RWQCB initiated the Irrigated Lands Regulatory Program (ILRP) in 2003 to prevent agricultural runoff containing pesticides, fertilizers, salts, pathogens, and sediment from impairing surface waters. Waste discharge requirements were subsequently developed and adopted to address irrigated agricultural discharges throughout the Central Valley, in order to protect both surface water and groundwater for all beneficial uses. The waste discharge requirements replaced pre-2003 waivers and previous interim regulatory requirements under a Conditional Waiver of Waste Discharge Requirements. All commercial irrigated lands, including nurseries and managed wetlands, are required to obtain regulatory coverage by joining a coalition group, or obtaining coverage as an individual grower under general waste discharge requirements, or obtaining an individual permit.

The recently adopted waste discharge requirements have been expanded to include discharges to groundwater, in order to address the critical need to protect this drinking water source from contaminants such as nitrate that are associated with fertilizer application. The waste discharge requirements are tailored to known threats to water quality and specific geographic areas or commodities.

According to the Central Valley RWQCB, there are about 35,000 growers in the Central Valley and nearly 5 million acres of land that are part of water quality coalition groups. The coalition groups conduct water quality monitoring and analysis, perform vulnerability assessments, prepare regional plans to address water quality problems, determine the effectiveness of management actions, and perform education and outreach to growers. Coalitions are required to prepare Water Quality Management Plans anytime water quality objectives have been exceeded more than once in three years. The growers are required to implement management practices to protect surface and groundwater, especially in areas where monitoring has identified problems associated with irrigated agriculture such as the pesticides chlorpyrifos and diazinon, indicators of pathogens such as *e. coli*, or nitrates. Growers are required to conduct farm evaluations to determine the effectiveness of farm practices in protecting water quality. Nutrient management is a key element for all growers. A certified nitrogen management plan is required for growers in areas where groundwater is known to be severely impacted by nitrates, pesticides or other constituents associated with agriculture.

#### *6.3.4.3 Groundwater Recharge Uses*

In addition to direct use for municipal, industrial, and agricultural purposes, some of the CVP and SWP water from the Delta is used for groundwater recharge purposes through direct application or indirect potable recharge by blending with recycled water. The quality of the applied water could affect hydrogeological properties of the aquifer, or impair the quality of groundwater for subsequent use.

Hydrogeological properties of the aquifer could be affected by precipitation reactions between the recharge water and native soil material or groundwater, causing mechanical blockage of aquifer pores. Ion exchange reactions could adversely affect the shrink/swell properties of some clays present in an aquifer. Sodium adsorption is particularly of concern due to the high salinity of Delta water.

Chemical and microbial contaminants in the recharge water could build up in the aquifer and impair the subsequent use of the groundwater. Secondarily treated domestic wastewaters and many industrial wastewaters, urban stormwater drainage, agricultural and rural stormwater runoff, and irrigation return waters contain high concentrations of a wide variety of inorganic and organic, dissolved, particulate, and colloidal contaminants that can adversely impact groundwater and aquifer quality. Nonconventional and emergent contaminants in pharmaceuticals and body care products may not have been removed through conventional secondary treatment. Furthermore, chloramination of wastewater effluents especially during water reuse processes could create NDMA, a known carcinogen. For some CVP and SWP water users, the CVP and/or SWP water supplies are used to dilute some of these potential contamintants to protect groundwater quality.

#### *6.3.4.4 Water Recycling Use*

Salinity in Delta waters reduces the utility of the water for reuse or blending purposes by CVP and SWP water users. A higher salinity source water exacerbates the increase in salinity from use and reuse, reducing the applicability of the recycled water for non-potable purposes such as landscape and agricultural irrigation or industrial cooling and reuse. Residential use of water could add 200 to 300 mg/L of TDS to the wastewater stream. Conventional wastewater treatment processes are designed to remove suspended solids but not dissolved solids. Depending on the TDS levels of the source water, the TDS levels in recycled water could reach beyond the threshold of market acceptance for irrigation. TDS removal or demineralization would require an advanced treatment process and add to the cost of recycling.

#### *6.3.4.5 Blending Use*

Some SWP water users in Southern California rely on Delta water exported from the SWP to blend with the higher TDS water from the Colorado River. Water imported through the Colorado River Aqueduct has an average TDS of 650 mg/L, and has exceeded 900 mg/L during drought events. Delta water imported through the SWP has a lower TDS by comparison, with an average TDS of 250 to 325 mg/L. The real time TDS levels fluctuate significantly due to variations in hydrology, tidal cycles, and project operations. Article 19 of the SWP long-term water supply contracts contains a water quality objective for TDS of below 440 ppm for monthly averages, and below 220 ppm for 10-year averages. These objectives were set in the 1960s when SWP deliveries were thought to be more assured. Metropolitan Water District of Southern California has used these SWP delivered water quality objectives to set a salinity-by-blending objective of 500 mg/L for its blended supply. Reduced SWP deliveries would pose challenges in meeting this blending objective.

#### *6.3.4.6 San Luis Reservoir Low-Point Issues*

As described in Chapter 5, Surface Water Resources and Water Supplies, the San Luis Reservoir provides off-stream storage for CVP water used by Santa Clara Valley Water District and San Benito County Water District. These districts withdraw their CVP supplies from the Upper Pacheco Intake at the San Luis Reservoir. This supply is at risk when water elevations in San Luis Reservoir reach very low levels during late summer and early fall. High temperatures combined with low water levels foster algae growth to as much as 35 feet thick on the water surface. Algae captured in the intake and conveyed to the CVP water users is not suitable for municipal water treatment or agricultural drip irrigation systems. As water levels continue to drop below the level of the intake, water supply to these CVP water users ceases.

The Santa Clara Valley Water District has partnered with Reclamation and the San Luis and Delta-Mendota Water Authority to complete the San Luis Low Point Improvement Project. The project purpose is to identify a feasible alternative that will address the uncertainty of CVP delivery schedules and the water supply reliability problems associated with the low-point issues.

### 6.3.5 Drought Impacts on Water Quality

California is currently in the fourth consecutive year of a severe drought, with precipitation way below average and record high temperatures. The availability of water supplies throughout the state have declined substantially as described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts. In addition, there are chronic and significant shortages in supplies and historically low groundwater levels, as described in Chapter 7, Groundwater Resources and Groundwater Quality. Drought conditions affect many Delta water quality constituents, including changes in temperatures and dissolved oxygen conditions in the lower San Joaquin River, temperature in the Sacramento River, and salinity in the Delta.

#### 6.3.5.1 Water Quality Conditions in the Lower San Joaquin River

The San Joaquin River watershed in particular has experienced severely dry conditions, with water year 2012 classified as dry and water years 2013-2015 classified as critically dry. Lack of precipitation has resulted in historically low reservoir storage levels, creating significant concerns about low flows, high temperatures, low dissolved oxygen conditions and other factors that have significant effects on steelhead and fall-run Chinook Salmon.

As described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts, Reclamation and DWR filed a Temporary Urgency Change Petition (TUCP) with the SWRCB on January 23, 2015, seeking to make changes to their water right permits and license for the CVP and SWP. The TUCP sought changes to D-1641 requirements on flow-dependent and operational water quality objectives. The TUCP was approved in part on February 3, 2015, subject to conditions, and modified on March 5, 2015 and April 6, 2015. Reclamation submitted a request on May 21, 2015 to modify and renew the TUCP Order, which was approved on July 3, 2015 and modified on August 4, 2015 with changes effective through November 30, 2015.

The August 4, 2015 Order conditionally approved a change to Reclamation's water rights to modify the Stanislaus River dissolved oxygen requirement from 7.0 mg/L to 5.0 mg/L at and below Ripon on the Stanislaus River. It also included other conditions, including the development, coordinated implementation, evaluation, and update of operations plans that would affect flows, temperatures and dissolved oxygen conditions, to ensure that the change can be made without unreasonable effects on fish, wildlife, or other instream beneficial uses, and to ensure that the change is in the public interest.

#### 6.3.5.2 Temperature Conditions in the Lower San Joaquin River

Reclamation files an annual Sacramento River Temperature Management Plan to guide the release of water from Shasta Lake in order to maintain downstream water temperatures to protect the fisheries during the higher temperature months of summer and fall. In 2014, temperature targets were not achieved in the upper reaches of the Sacramento River late in the fall, despite Reclamation's efforts.

In early 2015, Reclamation developed a release plan in conjunction with DWR, USFWS, NMFS, CDFW, SWRCB, and others to meet the CVP authorized purposes and regulatory requirements to the extent possible. The plan was submitted and provisionally approved by the SWRCB on May 14, 2015. On May 29, 2015, Reclamation informed the SWRCB that the proposed temperature target will unlikely be met, due to faulty equipment used to obtain temperature data for modeling. The SWRCB suspended the plan in June while Reclamation developed and submitted a revised Temperature Plan on June 25, 2015. On July 1, 2015, NMFS provided conditional concurrence with the revised plan. On July 7, 2015, the SWRCB conditionally approved the June 25, 2015 plan, placing numerous monitoring, consultation, and update requirements on Reclamation, as well as correlating the Temperature Plan with conditions in the July 3, 2015 approved TUCP filed by Reclamation and DWR.

#### 6.3.5.3 Delta Salinity Conditions

As described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts, in early 2015, as a result of very low precipitation and diminished reservoir storage, DWR planned and installed an emergency drought barrier on West False River in the Delta to help repel salt water intrusion into the central Delta and to minimize the amount of upstream reservoir releases. The barrier installation was completed in early June. Removal began on September 8, 2015 and must be completed by mid-November to provide capacity for wet weather flows in the winter season and to comply with fisheries protection requirements.

In June and July 2015, some of the salinity objectives were not met, despite the drought barrier and other project operations to mitigate for the effects of the severe drought. Exceedances were reported by Reclamation and DWR at: the South Delta agricultural objective at San Joaquin River near Brandt Bridge compliance station, the two western Delta agricultural objectives of 14-day running average EC values at Sacramento River at Three Mile Slough and San Joaquin River at Jersey Point, and the 30-day running average EC value at Old River near Middle River.

Salinity in CVP and SWP water supplies has increased since the onset of the drought.

#### 6.3.5.4 Municipal and Industrial Water Users Responses to Drought-related Water Quality Impacts

With low surface water runoff, increased temperature, and concentrated nutrient levels due to the drought, algae growth in surface water proliferated, leading to increased turbidity, taste and odor issues, as well as increased potential for algal cyanotoxins from the blue-green algae, *Microcystis*. Urban water agencies that have alternative supply sources use blending, coupled with changes in treatment processes such as increased use of ozone, to address the taste and odor issues. Some of the larger urban agencies are participating in studies to investigate alternative treatment processes to address algal toxin issues. Other studies raised concern with respect to changes in pH due to low flows and their effects on toxicity and bioaccumulation of ionizable contaminants. The Metropolitan Water District of Southern California announced plans to apply copper sulfate to treat algae at Lake Skinner, Lake Mathews, and Diamond Valley Lake in accordance with its NPDES permit.

Many urban water agencies accelerated their investments in recycled water development during the current drought. Most notably, a lot of these investments are focused on advanced treatment processes for indirect, as well as direct, potable reuse. For example, the Santa Clara Valley Water District began operations of the 8 million gallon/day Silicon Valley Advanced Water Purification Center in 2014, to test and demonstrate its advanced treatment processes in producing highly purified recycled water that meets drinking water standards. Advanced treated recycled water has historically been used to blend with tertiary-treated recycled water to reduce the level of total dissolved solids for expanded industrial and irrigation use, thereby offsetting potable demand during droughts.

## 6.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in surface water quality; results of the impact analysis; potential mitigation measures; and cumulative effects.

### 6.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in surface water quality conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could result in changes to surface water quality due to changes in river flows and surface water deliveries. Based on the discussion above, the following water quality changes are further analyzed in the Evaluation of Alternatives section.

As described in Section 6.3 Affected Environment, there are numerous constituents of concern that have been identified in the study area. These components are not all critical in each region and may not be all affected by changes in CVP and SWP operations considered in the alternatives of this EIS. The groups of constituents that could be affected by implementation of the alternatives has been identified through consideration of constituents of concern described in Section 6.3, Affected Environment, and the anticipated implementation of TMDLs by 2030. These constituents were grouped into major categories, as shown in Table 6.27. The constituents that already have approved TMDLs in certain regions are not further analyzed for those regions, as it is expected that the TMDL will be implemented by 2030. A complete list of TMDLs and the anticipated completion dates is provided in Table 6.1.

**Table 6.27 List of Surface Water Quality Constituents Considered for this Analysis**

| Constituent/Parameter Group | Individual Constituents/Parameters |
|---|---|
| Water Temperature | Water Temperature |
| Salinity Indicators | EC, TDS, Chloride, Bromide, Delta X2 |
| Nutrients | Nitrate, phosphorus |
| Mercury | Mercury, methylmercury |
| Selenium | Selenium |
| Dissolved Oxygen | Dissolved Oxygen |
| Other Constituents | Pesticides, PCBs, DOC/TOC, Boron, Trace Metals, Pathogens, TSS, Turbidity, Unknown Toxicity |

Each constituent group is further discussed below, to determine whether changes would occur due to implementation of the alternatives.

#### 6.4.1.1 Changes in Water Temperature

Changes in CVP and SWP operations would change water temperatures in rivers downstream of CVP and SWP reservoirs. Changes in water temperatures are presented in Appendix 6B, Surface Water Temperature Modeling. However, the effects of change in temperature are related to the changes on aquatic habitat. Therefore, analysis of changes in temperature is presented in Chapter 9, Fish and Aquatic Resources.

#### 6.4.1.2 Changes in Salinity

Changes in salinity due to changes in CVP and SWP operations would be focused in the Delta. Salinity indicators generally considered in this analysis include electrical conductivity, total dissolved solids, chloride, bromide, and X2.

The DSM2, a one-dimensional hydrodynamic and water quality simulation model, is used to evaluate changes in salinity (as represented by EC) in the Delta and at the CVP/SWP export locations. CalSim II outputs are used to evaluate changes in location of X2 in the Delta.

#### 6.4.1.3 Changes in Mercury/Methylmercury Concentrations

Changes in CVP and SWP operations under the alternatives could affect mercury concentrations in the Delta and Suisun Marsh. The changes in CVP and SWP operations would not affect mercury concentrations in the tributaries to the Sacramento and San Joaquin rivers.

A modeling framework is used to evaluate changes in methylmercury concentrations in the Delta reaches and qualitatively estimate mercury concentration changes at the San Luis Reservoir and O'Neill Forebay.

The methylmercury impacts analysis uses CalSim II, DSM2, and the Central Valley Regional Water Quality Control Board Total Maximum Daily Load model (RWQCB model) to assess and quantify effects of the alternatives on the long-term operations and the environment, as described in Appendix 6C, Methylmercury Model Documentation.

The QUAL module of DSM2 is used to simulate source water finger printing which can determine the relative contributions of water sources to the volume at any specified location. DSM2 water quality and volumetric fingerprinting results are used to assess changes in concentration of methylmercury in Delta waters. CalSim II, DSM2 (water), and the RWQCB model (fish tissue) are used in sequence to estimate the effects of CVP and SWP operations on water and fish tissue quality in the Delta.

#### 6.4.1.4 Changes in Selenium Concentrations

Changes in CVP and SWP operations under the alternatives could affect selenium concentrations in the San Joaquin River, Delta, and Suisun Marsh. Selenium also is of a concern in the Southern California Region because the use of water supplies from both the Delta and the Colorado River.

A suite of modeling tools is used to evaluate changes in selenium concentrations in the Delta reaches and in the San Francisco Bay, based on the western Delta model outputs. The selenium impacts analysis uses CalSim II, DSM2, and Delta-specific selenium bioaccumulation modeling to assess and quantify effects of the alternatives on the long-term operations and the environment. Appendix 6D, Selenium Model Documentation, provides information about the development and calibration of a Delta-wide bioaccumulation model for selenium in fish, use of outputs from that model to estimate bioaccumulation in bird eggs and fish fillets, and modeling of selenium bioaccumulation in sturgeon living in the western Delta using inputs from other models. Modeling assumptions for the selenium analysis are also provided in that appendix.

The selenium impact analysis focuses on evaluation of changes to selenium concentrations in tissues that affect the health of fish as well as wildlife and humans consuming fish in the Delta.

CalSim II, DSM2, and bioaccumulation modeling are used in sequence to estimate the effects of CVP and SWP operations on water quality relative to selenium in the Delta. The DSM2-QUAL module simulates one-dimensional source tracking in the Delta. Results from DSM2 are multiplied by source concentrations to determine annual average waterborne selenium concentrations in the Delta for all year types. Output from the DSM2-QUAL model (expressed as percent inflow from different sources) is used in combination with the available measured waterborne selenium concentrations to model concentrations of selenium at locations throughout the Delta. These modeled waterborne selenium concentrations are used in the relationship model to estimate bioaccumulation of selenium in whole-body fish and in bird eggs.

#### *6.4.1.5 Changes in Nutrient Concentrations*

Nutrients generally considered in this analysis include nitrate and phosphorus. The two main anthropogenic sources of these constituents are urban point sources (wastewater effluent), and agricultural non-point sources (agricultural runoff and return flows of fertilizers mixed in irrigation water). By 2030, wastewater treatment plants that discharge into the Sacramento and San Joaquin rivers watersheds and the Delta that are currently implementing nutrient removal projects will have completed those projects. Agricultural non-point source discharges are regulated under the Long-Term Irrigated Lands Regulatory Program (ILRP) Waste Discharge Requirements, which mandate monitoring of nutrients in the major agricultural reaches and the implementation of Best Management Practices to reduce nutrient discharges to streams, and controlling fertilizer application and management. Since nutrient loadings would be managed through regulatory processes by 2030, it is anticipated that nutrient conditions would be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes in nutrients are not evaluated in this EIS.

#### 6.4.1.6 Changes in Dissolved Oxygen Concentrations

Dissolved oxygen has been found to be a parameter of concern primarily in the lower Klamath River, Sacramento-San Joaquin River Delta, and the Suisun Marsh. By 2030, it is anticipated that TMDLs would be implemented to address the dissolved oxygen issues. Since dissolved oxygen conditions would be managed through regulatory processes by 2030, it is anticipated that dissolved oxygen conditions would similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes in dissolved oxygen are not evaluated in this EIS.

#### 6.4.1.7 Changes in Other Constituents

Conditions for other water quality constituents are expected to be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison because critical factors that affect the sources, transport mechanisms or chemical transformations are not expected to be affected by changes in CVP and SWP operations. Therefore, changes in the other constituents are not analyzed in this EIS.

#### 6.4.1.8 Effects Related to Water Transfers

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); crop idling; or substituting crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur in drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the reduced CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future water quality conditions related to water transfer activities is difficult because of the wide variability in sources of transfer water, conveyance, and recipients involved in each specific water transfer action. Use of the transfer water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

## 6.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. Changes to water quality that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section and included in all alternatives. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

### *6.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

#### 6.4.2.1.1 Effects due to Climate Change and Sea Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack runoff in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies, including water supplies released to maintain freshwater conditions in the western Delta and at the CVP and SWP Delta intakes. Ambient temperatures are also expected to increase. Therefore, water temperatures in the CVP and SWP reservoirs and in the rivers downstream of the reservoirs are expected to increase by 2030 under the No Action Alternative as compared to recent historical conditions.

#### 6.4.2.1.2 Effects due to Reasonable and Foreseeable Projects and Programs

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change water quality, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that could affect surface water quality in beneficial and adverse manners, including restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.

The reasonable and foreseeable projects also would include issuance and implementation of TMDL programs and other programs to improve water quality, including those that address salinity, mercury, and selenium.

*Potential Changes in Salinity Indicators*

In the Central Valley, changes in salinity under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions are anticipated primarily to occur in the Delta. The salinity in the Delta is anticipated to increase with projected sea level rise; and therefore, the region of the Delta influenced by daily tidal fluctuations will increase, and the increased tidal mixing may result in salt transport further upstream. The average water depth in the Delta will increase, allowing for increased gravitational circulation and upstream transport of salinity further into the Delta. The increased salinity potentially will decrease the flexibility to meet regulatory requirements at compliance locations, municipal and industrial water intakes, and export facilities.

*Potential Changes in Mercury Concentrations*

In the Central Valley, mercury concentrations in the Sacramento River watershed would be similar under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions. Programs would be implemented to reduce the sources of mercury into water bodies by 2030; however, the results of those programs are not anticipated to change mercury concentrations prior to 2030.

Changes in mercury in the Yolo Bypass are also anticipated under the No Action Alternative and the Second Basis of Comparison as floodplain restoration is implemented, as compared to recent historical conditions.

Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions. Phase 1 of the Delta Mercury Program mandated by the CVRWQCB is currently being completed to protect people eating one meal per week of larger fish from the Delta, including Largemouth Bass. This program also would reduce wildlife exposure to excess mercury. Phase 1 is focused on studies and pilot projects to develop and evaluate management practices to control methylmercury from mercury sources in the Delta and Yolo Bypass; and to reduce total mercury loading to the San Francisco Bay. Following completion of Phase 1 in 2019, Phase 2 will be implemented through 2030. Phase 2 will focus on methylmercury control programs and reduction programs for total inorganic mercury. Due to the length of these studies and limited time for implementation of recommendations, it is not anticipated that changes in methylmercury or total mercury concentrations in fish tissue would be reduced by 2030 under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions.

The No Action Alternative and the Second Basis of Comparison include the same projected tidal wetland and floodplain restoration within or adjacent to the Delta. These projects considered in the No Action Alternative and the Second Basis of Comparison have undergone environmental compliance and include methods to reduce mercury loading. For example, in Suisun Marsh, tidal wetland restoration activities will include cooperation with regional monitoring and research efforts, and sediment and fish monitoring. The collected information would be used adaptively to correct long-term construction and management plans and activities associated with tidal wetland restoration (Reclamation et al. 2011).

*Potential Changes in Selenium Concentrations*

Selenium is a constituent of concern in the San Joaquin Valley and the Delta, and TMDLs have been adopted for the San Joaquin River from Mud Slough to Merced River, Grasslands Marshes, Agatha Canal, and Mud Slough. It is assumed that water quality concerns for selenium in those reaches will be addressed before 2030. TMDLs are anticipated prior to 2030 for Panoche Creek and Mendota Pool. However, it is assumed that these TMDLs for water quality issues related to selenium may not be fully implemented by 2030.

It is expected that a TMDL may be developed separately for the Delta. To increase the database for evaluation of constituents of concern in the Delta, a large number of fish tissue samples were collected from the Sacramento and San Joaquin River watersheds and the Delta between 2000 and 2007 for selenium analysis. As part of the Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (State Water Resources Control Board 2008b), archived Largemouth Bass samples were analyzed for selenium to determine the primary source of the selenium being bioaccumulated in bass in the Delta and whether selenium concentrations in bass were above recommended criteria for the protection of human and wildlife health (Foe 2010). There were no differences in selenium concentrations in Largemouth Bass caught in the Sacramento River at Rio Vista and in the San Joaquin River at Vernalis in 2000, 2005, and 2007. However, because the TMDL is not yet under development, it is assumed that it would not be in place by 2030 under the No Action Alternative and the Second Basis of Comparison.

Reclamation is actively engaged with the Grassland Area Farmers who discharge subsurface agricultural drainage waters through the Grassland Bypass Project, which is a significant source of selenium to the San Joaquin River and to the Delta. Reclamation and the Grassland Area Farmers are continuing to reduce the amount of agricultural drainage water produced in the Grassland Drainage Area, preventing the discharge of this water into local Grassland wetland water supply channels, and improving the quality of water in the San Joaquin River. The Grassland Bypass Project is based upon an agreement between Reclamation and the San Luis and Delta-Mendota Water Authority to use a 28-mile segment of the San Luis Drain to convey agricultural subsurface drainage water from the Grassland Drainage Area to Mud Slough (North), a tributary of the San Joaquin River. An extensive monitoring program (e.g., San Francisco Estuary Institute [SFEI] 2013) continues to document the effectiveness of actions such as source control and other measures being taken by the Grassland Area Farmers. These actions by the Grassland Area Farmers are described in Chapter 2 of SFEI (2013). Briefly, these activities have included the Grassland Bypass Project and the San Joaquin River Improvement Project, formation of a regional drainage entity, newsletters and other communication with the farmers, a monitoring program, using State Revolving Fund loans for improved irrigation systems, installing and using drainage recycling systems to mix subsurface drainage water with irrigation supplies under strict limits, tiered water pricing and a tradable loads programs.

## 6.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

### *6.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 6.4.3.1.1 Potential Changes in Salinity Indicators

Salinity in the Sacramento River at Emmaton would be lower in September through January, higher in June, and similar in all other months over long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.4.

Salinity in the San Joaquin River at Vernalis would be lower in April and October, and higher in all other months under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.4.

Salinity in the San Joaquin River at Jersey Point would be lower in September through January, higher in June, and similar in all other months, for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.4.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be substantially lower in September through January, moderately lower February through May, higher in June, and similar in all other months, for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.6.4, 6E.4.4, and 6E.2.4.

Salinity at the CVP Contra Costa Canal and Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be lower in September through January, and higher in all other months for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6.E.11.4, 6E.7.4, and 6E.8.4. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be lower in September through January, and higher in all other months for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.12.4 and 6E.13.4. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

Another indication of salinity is the measurement of X2. X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under the No Action Alternative, Delta outflow would increase and X2 would move towards the west as compared to the Second Basis of Comparison, as shown in Table C.16.4 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower in September through May, and similar in all other months in long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison.

#### 6.4.3.1.2 Potential Changes in Mercury Concentrations

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.28 and 6.29 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.28 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Delta Location | No Action Alternative (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 0.1% |
| San Joaquin River at Turner Cut | 0.89 | 0.87 | 3% |
| San Joaquin River at San Andreas Landing | 0.59 | 0.58 | 3% |
| San Joaquin River at Jersey Point | 0.57 | 0.54 | 5% |
| Victoria Canal | 0.85 | 0.82 | 4% |
| Sacramento River at Emmaton | 0.50 | 0.49 | 2% |
| San Joaquin River at Antioch | 0.50 | 0.47 | 7% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.35 | 0.32 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 1% |
| CVP Contra Costa Pumping Plant Intake | 0.73 | 0.68 | 6% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.75 | 5% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.79 | 3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.29 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Delta Location | No Action Alternative (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.06 | 1.06 | 0.3% |
| San Joaquin River at Turner Cut | 0.84 | 0.81 | 4% |
| San Joaquin River at San Andreas Landing | 0.54 | 0.53 | 3% |
| San Joaquin River at Jersey Point | 0.52 | 0.50 | 4% |
| Victoria Canal | 0.82 | 0.76 | 7% |
| Sacramento River at Emmaton | 0.48 | 0.47 | 2% |
| San Joaquin River at Antioch | 0.43 | 0.41 | 5% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.26 | 5% |
| SWP Barker Slough Pumping Plant Intake | 0.59 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.67 | 0.62 | 8% |
| SWP Banks Pumping Plant Intake | 0.75 | 0.69 | 8% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.77 | 7% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

#### 6.4.3.1.3 Potential Changes in Selenium Concentrations

It is anticipated that the selenium loadings would be similar under the No Action Alternative and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under No Action Alternative and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under No Action Alternative would be identical to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 μg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 μg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar (within 5 percent change) under the No Action Alternative and the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant intake would be similar under the No Action Alternative and Second Basis of Comparison, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under the No Action Alternative would be slightly higher than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under the No Action Alternative would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.13, Exceedance Quotients (EQs) computed with respect to the applicable benchmarks show that selenium concentrations in biota under the No Action Alternative would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both the No Action Alternative and the Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

#### 6.4.3.1.4 Effects Related to Cross Delta Water Transfers

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to water quality were identified as:

- Potential for sediment and other constituents to be transported from crop idled lands into adjacent water bodies.
- Water transfer practices could change reservoir storage or stream flow patterns in a manner that would affect water quality, including upstream temperatures and Delta water quality.
- Use of transferred water could increase drainage flows in the purchaser's service areas.

The analysis indicated that these potential impacts would not be substantial because the amount of land subject to crop changes in the seller's and purchaser's service areas would be within the historical range of irrigated lands and crop idled lands. The groundwater substitution practices would be implemented with monitoring and mitigation programs to avoid long-term adverse impacts, including impacts to water quality. The water transfers would not be allowed to occur if the program harmed other water users or the environment, including changes to water quality in the rivers or the Delta. Therefore, water quality conditions would be similar with and without the water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### *6.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because water quality factors under Alternative 1 are identical to water quality factors under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 6.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in September through January, lower in June, and similar in all other months over long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.1.

Salinity in the San Joaquin River at Vernalis would be higher in April and October, lower in May through June, lower in November through February and similar in March and July through September and higher in all other months under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.1.

Salinity in the San Joaquin River at Jersey Point would be higher in September through January, lower in June, and similar in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.1.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be higher in September through January, moderately higher February through May, lower in June, and similar in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.1, 6E.4.1, and 6E.2.1.

Salinity at the CVP Contra Costa Canal and Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be higher in September through January, and lower in all other months for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.1, 6E.7.1, and 6E.8.1. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be higher in September through January, and lower in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.12.1 and 6E.13.1. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 1, Delta outflow would decrease and X2 would move towards the east as compared to the No Action Alternative, as shown in Table C.16.1 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be higher in September through May, and similar in all other months in long-term average conditions under Alternative 1 as compared to the No Action Alternative.

*Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.30 and 6.31 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.30 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Delta Location | Alternative 1 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 0.99 | 1.00 | 0% |
| San Joaquin River at Turner Cut | 0.87 | 0.89 | -3% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.59 | -3% |
| San Joaquin River at Jersey Point | 0.54 | 0.57 | -4% |
| Victoria Canal | 0.82 | 0.85 | -4% |
| Sacramento River at Emmaton | 0.49 | 0.50 | -2% |
| San Joaquin River at Antioch | 0.47 | 0.50 | -6% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.32 | 0.35 | -6% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.68 | 0.73 | -6% |
| SWP Banks Pumping Plant Intake | 0.75 | 0.79 | -5% |
| CVP Jones Pumping Plant Intake | 0.79 | 0.83 | -4% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.31 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 1 as Compared to the No Action Alternative**

| Delta Location | Alternative 1 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.06 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.81 | 0.84 | -4% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.54 | -3% |
| San Joaquin River at Jersey Point | 0.50 | 0.52 | -4% |
| Victoria Canal | 0.76 | 0.82 | -6% |
| Sacramento River at Emmaton | 0.47 | 0.48 | -2% |
| San Joaquin River at Antioch | 0.41 | 0.43 | -5% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.26 | 0.28 | -5% |
| SWP Barker Slough Pumping Plant Intake | 0.57 | 0.59 | -2% |
| CVP Contra Costa Pumping Plant Intake | 0.62 | 0.67 | -7% |
| SWP Banks Pumping Plant Intake | 0.69 | 0.75 | -8% |
| CVP Jones Pumping Plant Intake | 0.77 | 0.82 | -6% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 1 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 1 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 1 would be identical to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 1 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant intake would be similar under Alternative 1 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under Alternative 1 would be lower than under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 1 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.13, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 1 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 1 and the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 1 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

##### 6.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *6.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 6.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to surface water quality under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 6.4.3.1, No Action Alternative.

#### *6.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and Alternative 1 with modified Old and Middle River flow criteria. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 6.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in September through January, lower in June, and similar in all other months over long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.2.

Salinity in the San Joaquin River at Vernalis would be higher in February through July and in October, lower in November through December, and similar in other months under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.2.

Salinity in the San Joaquin River at Jersey Point would be higher in September through January, lower in June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.2.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be higher in September through December, moderately higher January and April, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.2, 6E.4.2, and 6E.2.2.

Salinity at the CVP Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be higher in September through January, and lower or similar in all other months for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.7.2 and Table 6E.8.2. Salinity at the CVP Contra Costa Canal Pumping Plant and at the Contra Costa Water District Old River and Middle River intakes would be higher in September through January, lower in February through June, and similar in July and August for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.2, 6E.12.2, and 6E.13.2. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 3, Delta outflow would decrease and X2 would move towards the east as compared to the No Action Alternative, as shown in Table C.16.2 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be higher in September through December and in April and May, and similar in all other months in long-term average conditions under Alternative 3 as compared to the No Action Alternative.

*Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.32 and 6.33 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.32 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Delta Location | Alternative 3 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 1.00 | 1% |
| San Joaquin River at Turner Cut | 0,88 | 0.89 | -2% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.59 | -3% |
| San Joaquin River at Jersey Point | 0.55 | 0.57 | -4% |
| Victoria Canal | 0.83 | 0.85 | -2% |
| Sacramento River at Emmaton | 0.49 | 0.50 | -2% |
| San Joaquin River at Antioch | 0.48 | 0.50 | -6% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.33 | 0.35 | -6% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.69 | 0.73 | -5% |
| SWP Banks Pumping Plant Intake | 0.77 | 0.79 | -3% |
| CVP Jones Pumping Plant Intake | 0.81 | 0.83 | -3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.33 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 3 as Compared to the No Action Alternative**

| Delta Location | Alternative 3 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.07 | 1.06 | 1% |
| San Joaquin River at Turner Cut | 0.82 | 0.84 | -3% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.54 | -2% |
| San Joaquin River at Jersey Point | 0.51 | 0.52 | -2% |
| Victoria Canal | 0.79 | 0.82 | -3% |
| Sacramento River at Emmaton | 0.47 | 0.48 | -1% |
| San Joaquin River at Antioch | 0.42 | 0.43 | -3% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.27 | 0.28 | -3% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.59 | -1% |
| CVP Contra Costa Pumping Plant Intake | 0.64 | 0.67 | -4% |
| SWP Banks Pumping Plant Intake | 0.72 | 0.75 | -4% |
| CVP Jones Pumping Plant Intake | 0.80 | 0.82 | -3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 3 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 3 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 3 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.9. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 3 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant intake would be similar under Alternative 3 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under Alternative 3 would be lower than under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 3 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.14, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 3 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 3 and the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 3 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

#### 6.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in October through November and June, lower in December through March and July through September, and similar in April and May over long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.5.

Salinity in the San Joaquin River at Vernalis would be higher in November through March and May through June, and similar in all other months under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.5.

Salinity in the San Joaquin River at Jersey Point would be higher in October through November and June through August, lower in December through March and September, and similar in April and May for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.5.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be lower in December through April and July through September, higher in May and June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.6.5, 6E.4.5, and 6E.2.5.

Salinity at the CVP Contra Costa Canal intake would be lower in December through February, as summarized in Appendix 6E, Table 6E.11.5. Salinity at Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be higher in January through May, lower in June, and similar in all other months for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.7.5 and Table 6E.8.5. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be higher in January through April, lower in May and June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.12.5 and 6E.13.5. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 3, Delta outflow generally would increase and X2 would move towards the west as compared to the Second Basis of Comparison, as shown in Table C.16.5 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower (towards the west) in December through April and July through September, higher in May and June (towards the east), and similar in all other months in long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison.

*Potential Changes in Mercury Concentrations*

Changes in flows in the rivers result in similar changes to erosional inputs and resuspension of both inorganic and methylmercury fractions. Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.34 and 6.35 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.34 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 3 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 1% |
| San Joaquin River at Turner Cut | 0,88 | 0.87 | 1% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.58 | 0% |
| San Joaquin River at Jersey Point | 0.55 | 0.54 | 1% |
| Victoria Canal | 0.83 | 0.82 | 2% |
| Sacramento River at Emmaton | 0.49 | 0.49 | 0% |
| San Joaquin River at Antioch | 0.48 | 0.47 | 1% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.33 | 0.32 | 1% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.69 | 0.68 | 1% |
| SWP Banks Pumping Plant Intake | 0.77 | 0.75 | 2% |
| CVP Jones Pumping Plant Intake | 0.81 | 0.79 | 2% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.35 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 3 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.07 | 1.06 | 1% |
| San Joaquin River at Turner Cut | 0.82 | 0.81 | 1% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.53 | 1% |
| San Joaquin River at Jersey Point | 0.51 | 0.50 | 2% |
| Victoria Canal | 0.79 | 0.76 | 3% |
| Sacramento River at Emmaton | 0.47 | 0.47 | 0% |
| San Joaquin River at Antioch | 0.42 | 0.41 | 2% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.27 | 0.26 | 2% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.64 | 0.62 | 4% |
| SWP Banks Pumping Plant Intake | 0.72 | 0.69 | 4% |
| CVP Jones Pumping Plant Intake | 0.80 | 0.77 | 4% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 3 and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 3 and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 3 would be identical to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar under Alternative 3 and the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant and Banks Pumping Plant intakes would be similar under Alternative 3 and Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9. Selenium at the Jones Pumping Plant intake under Alternative 3 would be slightly higher than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 3 would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.11. As shown in Appendix 6D, Table 6D.14, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 3 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both Alternative 3 and Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under

Alternative 3 and the Second Basis of Comparison, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

### *6.4.3.5 Alternative 4*

Water quality under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

#### 6.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in water quality under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 12.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

### *6.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 6.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be lower in May through September, and similar in all other months over long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.3.

Salinity in the San Joaquin River at Vernalis would be lower in April and May, and similar in all other months under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.3.

Salinity in the San Joaquin River at Jersey Point would be lower in December through February, higher in June through August, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.3.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be lower in April through June, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.3, 6E.4.3, and 6E.2.3.

Salinity at the Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be lower in May and slightly higher in June through September, and similar in all other months for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.7.3 and Table 6E.8.3. Salinity at the CVP Contra Costa Canal intake and at the Contra Costa Water District Old River and Middle River intakes also would be higher in April through September, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.3, 6E.12.3, and 6E.13.3. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 5, Delta outflow would increase and X2 would move towards the west as compared to the No Action Alternative, as shown in Table C.16.3 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower (towards the west) in April and May, and similar in all other months in long-term average conditions under Alternative 5 as compared to the No Action Alternative.

*Potential Changes in Mercury Concentrations*

Changes in flows in the rivers result in similar changes in erosional inputs and resuspension of both inorganic and methylmercury fractions. Changes in mercury from the rivers results in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.36 and 6.37 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.36 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Delta Location | Alternative 5 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 1.00 | 0% |
| San Joaquin River at Turner Cut | 0.89 | 0.89 | 0% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.59 | 1% |
| San Joaquin River at Jersey Point | 0.57 | 0.57 | 1% |
| Victoria Canal | 0.85 | 0.85 | 0% |
| Sacramento River at Emmaton | 0.50 | 0.50 | 0% |
| San Joaquin River at Antioch | 0.51 | 0.50 | 1% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.35 | 0.35 | 1% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.74 | 0.73 | 2% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.79 | 0% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.83 | 0% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.37 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 5 as Compared to the No Action Alternative**

| Delta Location | Alternative 5 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.05 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.85 | 0.84 | 1% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.54 | 2% |
| San Joaquin River at Jersey Point | 0.53 | 0.52 | 2% |
| Victoria Canal | 0.82 | 0.82 | 0% |
| Sacramento River at Emmaton | 0.49 | 0.48 | 1% |
| San Joaquin River at Antioch | 0.44 | 0.43 | 2% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.28 | 0% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.59 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.70 | 0.67 | 5% |
| SWP Banks Pumping Plant Intake | 0.74 | 0.75 | -1% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.82 | 1% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 5 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 5 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 5 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 5 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant and Banks Pumping Plant intakes would be higher under Alternative 5 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones Pumping Plant intake under Alternative 5 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 5 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.12. As shown in Appendix 6D, Table 6D.15, Exceedance Quotients (EQs) computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 5 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be higher under Alternative 5 than under the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 5 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

#### 6.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be lower in September through January, higher in June, and similar in all other months over long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.6.

Salinity in the San Joaquin River at Vernalis would be lower in April through May and October, higher in November through March, and similar in all other months under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.6.

Salinity in the San Joaquin River at Jersey Point would be lower in September through January, higher in July and August, and similar in all other months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.6.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be lower in all months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.6.6, 6E.4.6, and 6E.2.6.

Salinity at Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be lower in September through January, and higher in all other months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.7.6 and Table 6E.8.6. Salinity at the CVP Contra Costa Canal intake and the Contra Costa Water District Old River and Middle River intakes also would be lower in September through January and higher in February through August for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.11.6, 6E.12.6, and 6E.13.6. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 5, Delta outflow generally would increase and X2 would move towards the west, especially in September through May, as compared to the Second Basis of Comparison, as shown in in Table C.16.6 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results.

*Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.38 and 6.39 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.38 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 5 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 0% |
| San Joaquin River at Turner Cut | 0.89 | 0.87 | 3% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.58 | 4% |
| San Joaquin River at Jersey Point | 0.57 | 0.54 | 5% |
| Victoria Canal | 0.85 | 0.82 | 4% |
| Sacramento River at Emmaton | 0.50 | 0.49 | 3% |
| San Joaquin River at Antioch | 0.51 | 0.47 | 7% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.35 | 0.32 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 1% |
| CVP Contra Costa Pumping Plant Intake | 0.74 | 0.68 | 8% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.75 | 5% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.79 | 5% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.39 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 5 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.05 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.85 | 0.81 | 4% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.53 | 4% |
| San Joaquin River at Jersey Point | 0.53 | 0.50 | 5% |
| Victoria Canal | 0.82 | 0.76 | 7% |
| Sacramento River at Emmaton | 0.49 | 0.47 | 3% |
| San Joaquin River at Antioch | 0.44 | 0.41 | 7% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.26 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.70 | 0.62 | 13% |
| SWP Banks Pumping Plant Intake | 0.74 | 0.69 | 7% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.77 | 7% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 5 and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

In the Delta, selenium concentrations are related to the movement of flows from the San Joaquin River and the accumulation in certain areas of the Delta due to tidal flow patterns.

Selenium in the water column at various locations in the Delta under Alternative 5 and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 5 would be similar to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar under Alternative 5 and the Second Basis of Comparison. There would be small increases in selenium along the Sacramento River at Emmaton under Alternative 5 as compared to the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant, Jones Pumping Plant, and Banks Pumping Plant intakes would be higher under Alternative 5 than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 5 would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.12. As shown in Appendix 6D, Table 6D.13, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 5 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be higher under Alternative 5 than the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both Alternative 5 and Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

##### *6.4.3.7 Summary of Environmental Consequences*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 6.40 and 6.41.

It should be noted that since concentrations of nutrients, dissolved oxygen, and other constiuents of current concern (except salinity, mercury, and selenium) would be managed through regulatory processes by 2030, it is assumed that concentrations of these constituents would be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison, as described in Section 6.4.1., Potential Mechanisms of Change and Analytical Methods.

Environmental effects associated with changes in water temperatures are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources. Therefore, the, potential impacts of the action alternatives related to changes in water temperature, including changes resulting from including reasonably and foreseeable actions are presented in Chapter 9.

**Table 6.40 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Salinity increases near Emmaton in almost all months (5 to 377 percent), particularly in September, October and November of wet and above normal years; decreases in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity increases near Antioch (5 to 265 percent) in almost all months except it decreases in June of wet, above normal, and below normal years ( 7 to 14 percent) and when it is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity increases near CVP and SWP intakes (6 to 36 percent) in October, November, and December (and January for only SWP), decreases (5 to 22 percent) in February through June, and is similar in other months.<br>Salinity increases near Contra Costa Water District intakes (8 to 65 percent) in October through January and September of wet and above normal years, decreases (5 to 32 percent) March through May and June of wet, above normal, and below normal years, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity increases (5 to 96 percent) near Port Chicago October through February, April, March of below normal, dry, and critically dry years, and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in most of the Delta; and a 6 percent decrease near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes and near Emmaton. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 2 | Water quality conditions would be the same as under the No Action Alternative. | None needed |
| Alternative 3 | Salinity increases near Emmaton (7 to 378 percent) October through January and September of wet and above normal years, in September, October and November of wet and above normal years; decreases (7 and 8 percent) in June of above normal years and September of below normal years, and is similar in all other months.<br>Salinity increases near Antioch (6 to 262 percent) in almost all months except it is similar in March, July, August, below normal, dry, and critically dry years of September, and wet, above normal, and dry years of February.<br>Salinity increases near CVP intakes (6 to 29 percent) in October, November, and December, decreases (5 to 13 percent) in June, and is similar in other months.<br>Salinity increases near SWP intakes (5 to 41 percent) in October, November, December, and January, decreases (5 to 19 percent) in April through June, and is similar in other months.<br>Salinity increases near Contra Costa Water District intakes (6 to 76 percent) in October through December, January of above normal, below normal, and dry years, and September of wet and above normal years; decreases (5 to 34 percent) April through June; and is similar in other months.<br>Salinity increases (6 to 95 percent) near Port Chicago October through January, April, and May, June and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in most of the Delta; and a 6 percent decrease near San Joaquin River at Antioch and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Salinity near Emmaton is similar in all months except it increases (6 and 8 percent) January and February and decreases (6 to 15 percent) in April through June of critically dry years.<br>Salinity decreases (9 to 20 percent) near Antioch in April and May of below normal, dry, and critically dry years and June of critically dry years; increases (7 percent) in February of critically dry years; and is similar in all other months.<br>Salinity is similar near CVP and SWP intakes in most months, and increases (8 to 12 percent) in June of dry and critically dry years.<br>Salinity increases near Contra Costa Water District intakes (6 to 40 percent) in April, May, and June of below normal, dry, and critical years; and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity near Port Chicago is similar in all months except it decreases (5 to 8 percent) in April and May of dry and critical years.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | |

Notes:

1 In general, D-1641 Delta salinity standards are met in all alternatives except for few dry and critical years where there is no stored fresh water available for release The differences in salinity between alternatives mostly point to results of other operations beyond meeting the D-1641 salinity standards; such as whether or not reservoirs are releasing to meet 2008 USFWS Biological Opinion Action 4 (Fall X2), Delta Cross Channel operations, or whether or not south Delta exports are allowed in a particular month. As a result, changes in salinity for each location in Delta shows wide month to month variation between alternatives. Please refer to Appendix 6E for detailed comparison of salinity between the alternatives.

2 Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 6.41 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Salinity decreases near Emmaton in almost all months (5 to 79 percent), particularly in September, October and November of wet and above normal years; increases (9 to 21 percent) in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity decreases near Antioch (5 to 73 percent) in almost all months except it increases (7 to 16 percent) in June of wet, above normal, and below normal years; and is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity decreases near CVP and SWP intakes (6 to 28 percent) in October, November, and December (and January for only SWP), increases (5 to 23 percent) in February through June, and is similar in other months.<br>Salinity decreases near Contra Costa Water District intakes (7 to 42 percent) in October through January and September of wet and above normal years, increases (5 to 47 percent) March through May and June of wet, above normal, and below normal years, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (6 to 49 percent) near Port Chicago October through May, and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
| --- | --- | --- |
| Alternative 1 | No effects on public health issues. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Salinity increases near Emmaton (5 to 35 percent) in June except for critically dry years; decreases (5 to 24 percent) in December and January of above normal years, January through March and July through September of below normal years, January, February, and July of dry years, and March of critically dry years; and it is similar in all other months.<br>Salinity increases near Antioch (8 to 20 percent) in June except critically dry years and in May of wet years; decreases (7 to 40 percent) in January through April, and is similar in all other months.<br>Salinity is similar near CVP and SWP intakes except for increase (5 to 23 percent) mostly in February through May of dry and critically dry years.<br>Salinity increases near Contra Costa Water District intakes (5 to 16 percent) in March and April of dry and critically dry years; decreases (5 to 23 percent) in December, January and February of dry and critically dry years; and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (5 to 25 percent) near Port Chicago January through March; increases (7 to 9 percent) in June of wet, above normal, and below normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Not considered for this comparison. |
| Alternative 4 | No effects on water quality issues. | Not considered for this comparison. |
| Alternative 5 | Salinity decreases near Emmaton in almost all months (5 to 79 percent), particularly in September, October and November of wet and above normal | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | years; increases (7 to 21 percent) in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity decreases near Antioch (5 to 73 percent) in almost all months except it increases (7 to 14 percent) in June of wet, above normal, and below normal years; and is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity decreases near CVP and SWP intakes (5 to 28 percent) in October, November, and December (and January for only SWP), increases (5 to 26 percent) in February through June, and is similar in other months.<br>Salinity decreases near Contra Costa Water District intakes (7 to 41 percent) in October through January and September of wet and above normal years, increases (5 to 63 percent) March through June, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (5 to 49 percent) near Port Chicago October through May, and September of wet and above normal years; and is similar in other months. Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | |

Notes:

1 In general, D-1641 Delta salinity standards are met in all alternatives except for few dry and critical years where there is no stored fresh water available for release The differences in salinity between alternatives mostly point to results of other operations beyond meeting the D-1641 salinity standards; such as whether or not reservoirs are releasing to meet 2008 USFWS Biological Opinion Action 4 (Fall X2), Delta Cross Channel operations, or whether or not south Delta exports are allowed in a particular month. As a result, changes in salinity for each location in Delta shows wide month to

month variation between alternatives. Please refer to Appendix 6E for detailed comparison of salinity between the alternatives.

2 Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

#### *6.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Environmental effects associated with changes in water temperatures are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources. Therefore, mitigation measures related to changes in temperatures as compared to the No Action Alternative conditions are presented in Chapter 9.

##### 6.4.3.8.1 Salinity Water Quality Conditions

Implementation of Alternatives 1 through 5 would not result in adverse impacts to mercury and selenium concentrations as compared to the No Action Alternative. Therefore, no mitigation measures are required for these constituents.

Implementation of Alternatives 1, 3, and 4 would result in adverse impacts to salinity concentrations as compared to the No Action Alternative. A potential mitigation measure to reduce these effects would be:

- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes.

Under the No Action Alternative and Alternatives 1 through 5, it is anticipated that the ongoing real-time decision making meetings between Reclamation, DWR, USFWS, and NMFS would continue in a manner similar to that described in Section 3A.3 of Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Under this mitigation measure, a specific agenda item would be added to the groups' actions to reduce salinity impacts on the beneficial uses in the Delta. Potential changes could be to modify intake operations in accordance with real-time flows, observations related to fish presence, and real-time water quality observations.

#### *6.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Water Quality are summarized in Table 6.42.

**Table 6.42 Summary of Cumulative Effects on Water Quality of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g.,Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities | These effects would be the same in all alternatives.<br>Climate change and sea level rise area anticipated to increase salinity in the Delta and expand the region of the Delta influenced by tidal fluctuations.<br>Water quality programs to reduce nutrient loadings from wastewater treatment plant effluent and other point source discharges under the TMDLs would be fully implemented by 2020; and it is anticipated that nutrient concentrations would be reduced by 2030.<br>Programs to meet TMDLs related to dissolved oxygen, pesticides, mercury, selenium, and other constituents of concern are anticipated to be fully defined and implemented in the early 2020s to reduce, but not necessarily meet TMDL objectives, by 2030. These programs include projects to reduce effects of agricultural drainage.<br>Tidal restoration programs would change salinity gradients in the Delta, including increased salinity in the western and central Delta, depending upon the location of the tidal restoration lands. Estuarine tidal restoration could reduce constituents from runoff of adjacent upland areas, depending upon the location of the restored lands. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | (projects with completed environmental documents) | |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- EcoRestore<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- *Westlands Water District v. United States Settlement*<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same in all alternatives.</u><br><br>Some of the future reasonably foreseeable actions are anticipated to reduce water quality issues, including Bay-Delta Water Quality Control Plan Update, FERC Relicensing Projects, agricultural drainage programs, and San Luis Reservoir Low Point Improvement Project.<br>Future reasonably foreseeable actions related to tidal restoration projects could increase salinity and mercury water quality issues. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative would result in increased salinity in the western and central Delta due to climate change and sea level rise.<br>Numerous projects would be implemented by 2030 to reduce water quality issues related to nutrients, agricultural drainage, and other discharges of constituents of concern by 2030.<br>Depending upon the location of tidal restoration lands, salinity in the No Action Alternative could increase in the western and interior Delta. |
| Alternatives 1 and 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would increase salinity in the western and interior Delta as compared to the No Action Alternative with these added actions. Other water quality conditions under Alterantives 1 through 4 with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br><br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in the same conditions as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br><br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would increase salinity in the western and interior Delta as compared to the No Action Alternative with the added actions. Other water quality conditions under Alterantive 3 with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br><br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar salinity conditions as compared to the No Action Alternative with the added actions. Other water quality conditions under Alterantive 5 with with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |

## 6.5 References

Alpers C, Eagles-Smith C, Foe C, Klasing S, Marvin-DiPasquale M, Slotton D, and Winham-Myers L. 2008. Mercury conceptual model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Anderson, B., J. Hunt, D. Markiewicz, K. Larsen. 2011. *Toxicity in California Waters*. Surface Water Ambient Monitoring Program. California State Water Resources Control board. Sacramento, California.

ATSDR (Agency for Toxic Substances and Disease Registry). 2000. *Toxicological Profile for Polychlorinated Biphenyls (PCBs).* U.S. Department of Health and Human Services. Public Health Service. November.

ATSDR (Agency for Toxic Substances and Disease Registry). 2003. *Toxicological Profile for Selenium.* U.S. Department of Health and Human Services. Public Health Service. September.

ATSDR (Agency for Toxic Substances and Disease Registry). 2005. Toxicological Profile for Alpha, Beta-, Gamma-, and Delta-hexachlorocyclohexane. U.S. Department of Health and Human Services Public Health Service Agency for Toxic Substances and Disease Registry. August. http://www.atsdr.cdc.gov/toxprofiles/tp43.pdf

ATSDR (Agency for Toxic Substances and Disease Registry). 2007. *Public Health Statement: Arsenic*. CAS#: 7440-38-2. U.S. Division of Toxicology and Environmental Medicine. August.

ATSDR (Agency for Toxic Substances and Disease Registry). 2010. Agency for Toxic Substances and Disease Registry ToxFAQs: Toxaphene, CAS # 8001-35-2. September. http://www.atsdr.cdc.gov/tfacts94.pdf

ATSDR (Agency for Toxic Substances and Disease Registry). 2013a. *Minimal Risk Levels (MRLs) (List)*. U.S. Department of Health and Human Services. Public Health Service. July.

ATSDR (Agency for Toxic Substances and Disease Registry). 2013b. *Minimal Risk Levels for Hazardous Substances (MRLs) Narrative*. U.S. Department of Health and Human Services. Public Health Service. September.

Baginska, B. 2011. Total Maximum Daily Load Selenium North San Francisco Bay Preliminary Project Report. San Francisco Bay Regional Water Quality Control Board. Oakland, CA.

Ballard, A., R. Breuer, F. Brewster, C. Dahm, C. Irvine, K. Larsen, A. Mueller-Solger, and A. Vargas. 1 2009. *Background/Summary of Ammonia Investigations in the Sacramento-San Joaquin Delta and* 2 *Suisun Bay*. August 2, 2014. http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/ambient_am4 monia_concentrations/02mar09_ammonia_invest_summ.pdf

Baxter, R, R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, Anke Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. 2008. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Interagency Ecological Program for the San Francisco Estuary, January. http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf

Beckon, W.N., and T.C. Maurer. 2008. *Species at Risk from Selenium Exposure in the San Francisco Estuary*. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Division. Sacramento, California.

Brodberg, R.K., and G.A. Pollock. 1999. Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public health designed screening study. Sacramento, CA: Office of Environmental Health Hazard Assessment

CALFED (CALFED Bay-Delta Program). 2000. *CALFED Bay-Delta Program Final Programmatic Environmental Impact Statement/Environmental Impact Report*. Prepared by the CALFED Bay-Delta Program for the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Natural Resources Conservation Service, U.S. Army Corps of Engineers, and California Resources Agency.

CALFED (CALFED Bay-Delta Program). 2007. *Conceptual Model for Salinity in the Central Valley and Sacramento–San Joaquin Delta*. Prepared for Central Valley Drinking Water Policy Workgroup. CALFED Bay-Delta Program, Sacramento, California. July.

CEDEN (California Environmental Data Exchange Network). 2014. Advanced Query Tool. Site accessed September 30, 2014. http://ceden.waterboards.ca.gov/AdvancedQueryTool

City of Woodland. 2005. *Yolo Bypass Water Quality Management Plan Report*. Prepared under CALFED Watershed Grant for the City of Woodland. Prepared by Larry Walker Associates.

Cloern, J., D. Jassby, J. Carstensen, W. Bennett, W. Kimmerer, R. Mac Nally, D. Schoellhamer, and M. Winder. 2012. Perils of correlating CUSUM-transformed variables to infer ecological relationships (Breton et al. 2006, Glibert 2010). *Limnology and Oceanography* 57(2): 665-668.

Cohen, A.N. 2011. The Exotics Guide: Non-native Marine Species of the North American Pacific Coast. Center for Research on Aquatic Bioinvasions, Richmond, CA, and San Francisco Estuary Institute, Oakland, CA. Revised September 2011. http://www.exoticsguide.org

Colusa Basin Drain Steering Committee. 2005. *Colusa Basin Drain Study. Phase I: Characterization of Colusa Basin Drain Water Quality and Flow.* May.

Colusa County RCD (Colusa County Resource Conservation District). 2008. *Colusa Basin Watershed Assessment. Final.* Chapter 12 – Water Quality. December.

Cutter, G.A., and L.S. Cutter. 2004. Selenium Biogeochemistry in the San Francisco Bay Estuary: Changes in Water Column Behavior. *Estuarine Coastal and Shelf Science* Volume 61:463–476.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2001. Total Maximum Daily Load for Selenium in the Lower San Joaquin River. Sacramento, CA.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2002a. *Upper Sacramento River TMDL for Cadmium, Copper & Zinc.* Final Report. April 2002.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2002b. Staff Report of the California Environmental Protection Agency, Regional Water Quality Control Board Central Valley Region. Total Maximum

Daily Load for Salinity and Boron in the Lower San Joaquin River. January. http://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/vernalis_salt_boron/saltandborontmdljan2002.pdf

CVRWQCB (Central Valley Regional Water Quality Control Board). 2003. *Bay Protection Program Toxic Hot Spot Cleanup Plans for Diazinon in Orchard Dormant Spray; Diazinon and Chlorpyrifos in Urban Stormwater; Chlorpyrifos in Irrigation Return Flow: Revised Report.* March.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2004. *Water Quality Control Plan for the Tulare Lake Basin*. Second edition. Revised January 2004 (with approved amendments). California Regional Water Quality Control Board Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2005. Amendments to the Water Quality Control Plan For the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River. Final Staff Report, October.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2006a. Sacramento and San Joaquin River Watersheds Pesticide Basin Plan Amendment Fact Sheet. October.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2006b. Amendments to the Water Quality Control Plan For the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Sacramento-San Joaquin Delta. Final Basin Plan Amendment Staff Report, June.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2007a. *Basin Plan Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Sacramento and Feather Rivers. May 2007 Final Staff Report.* California Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2007b. 2007 Review of Monitoring Data Irrigated Lands Conditional Waiver Program. 13 July. Revised Draft. http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_5/2007/ref2436.zip

CVRWQCB (Central Valley Regional Water Quality Control Board). 2007c. *Amending the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the control of Salt and Boron discharges into the Lower San Joaquin River* (resolution R5-2004-0108) *Final Staff Report.* California Regional Water Quality Control Board, Central Valley Region http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdl_report?p_tmdl_id=32019&p_report_type=

CVRWQCB (Central Valley Regional Water Quality Control Board). 2007d. *Tulare Lake Basin Annual Report: Fiscal Years 2002/2003 and 2003/2004*. June.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2009. *San Joaquin River Selenium TMDL*. Site accessed on April 7, 2009. http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_se/

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010a. *Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury*. Staff Report. April 2010a. California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010b. *Supplemental Information for the Stakeholder Meeting for a Proposed Basin Plan Amendment to Address Organochlorine Pesticides in Several Central Valley Water bodies*. June.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010c. *Supplemental Information on Source Analysis for the 19 August Stakeholder Meeting for a Proposed Basin Plan Amendment to Address Organochlorine Pesticides in Several Central Valley Water bodies*. August.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010d. *SWAMP Safe-To-Swim Study, June 2009*. December. California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010e. *SWAMP Safe-To-Swim Study, Sample Sites for the Lower American River Watershed (Sacramento County)*. June. California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010f. *SWAMP Safe-To-Swim Study, Sample Sites for the Lower American River Watershed (Sacramento County)*. August-September. California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010g. *Resolution No. R5-2010-0046 Amending the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Selenium in the Lower San Joaquin River Basin*. Adopted May 27.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010h. *CV-SALTS Salt and Nitrate Pilot Implementation Study Report*. Submitted by Larry Walker Associates. February.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010i. *Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury*. Staff Report. April 2010. California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2010j. Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta. Prepared by Chris Foe, Adam Ballard, and Stephanie Fong. Rancho Cordova, California. July 2010.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2011. *Water Quality Control Plan (Basin Plan) for the Sacramento River Basin and the San Joaquin River Basin*. Fourth Edition Revised October 2011 (with Approved Amendments). California Regional Water Quality Control Board, Central Valley Region.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2012a. *Central Valley Drinking Water Policy Workgroup*. Work Group Synthesis Report. Central Valley Regional Water Quality Control Board. February 21, 2012.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2012b. *Central Valley Diuron Total Maximum Daily Load and Basin Plan Amendment, Informational Document*. Central Valley Regional Water Quality Control Board. October 30, 2012.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2014a. *(Draft) Waste Discharge Requirements General Order for San Luis & Delta-Mendota Water Authority and United States Department of the Interior Bureau of Reclamation Surface Water Discharges from the Grasslands Bypass Project Fresno and Merced Counties*. Order R5-2014-XXXX. May 2014. California Regional Water Quality Control Board, Central Valley Region.

CVRWQCB. 2014b. Amendments to the water quality control plan for the Sacramento River and San Joaquin River Basins for the control of diazinon and chlorpyrifos discharges. McClure, D., Fojut, T., J. Grover, and Z. Lu. Regional Water Quality Control Board Central Valley Region. Public Review Draft Staff Report. January.

Davis, D.E., C.E. Hanson, and R.B. Hansen. 2008b. Constructed wetland habitat for American Avocet and Black-necked Stilt foraging and nesting. *J. Wildlife Management* 72(1): 143 – 151.

Davis, J.A., D. Yee, J.N. Collins, S.E. Schwarzbach, and S.N. Luoma. 2003. Potential for increased mercury accumulation in the estuary food web. *San Francisco Estuary and Watershed Science* 1.1 (2003): 1-36.

deVlaming, V. 2008. Organochlorine Pesticides and Polychlorinated Biphenyls (PCB) Concentrations in Muscle Tissue of Fish Collected from the San Joaquin River and Sacramento River Watersheds and Delta During 200.

Prepared for: Central Valley Regional Water Quality Control Board. March.

DOI (U.S. Department of the Interior). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment, Selenium*. National Irrigation Water Quality Program Information Report No. 3. DOI, Denver, Colorado.

DOI (U.S. Department of the Interior) and DFG (California Department of Fish and Game). 2012. *Klamath Facilities Removal Final EIS/EIR.*

Department of Pesticide Regulation (DPR). 2006. Amendment to the California Code of Regulations; CFR (3)6.1.1.1. Dormant Insecticide Contamination Prevention. http://www.cdpr.ca.gov/docs/emon/dormspray/dpr05-004/text.pdf

Dubrovsky, K. M., C. R. Kratzer, L. R. Brown, J. M. Gronberg, and K. R. Burrow. 1998. *Water Quality in the San Joaquin-Tulare Basins, California, 1992–1995*. U.S. Geological Survey Circular 1159.

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue, A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal and Shelf Science 73, 17–29.

DWR (California Department of Water Resources). 2005. *California Detailed Analysis Units.* October. GIS Layer accessed August 14, 2013. http://www.waterplan.water.ca.gov/maps/index.cfm

DWR (California Department of Water Resources). 2007. *Oroville Facilities Relicensing FERC Project No. 2100*. Draft EIR. May, 2007.

DWR (California Department of Water Resources). 2013. The Suisun Marsh - Physical Facilities constructed by DWR and USBR. Site accessed on March 26, 2013. http://www.water.ca.gov/suisun/facilities.cfm#roaringRiver.

DWR (California Department of Water Resources). 2013b. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR (California Department of Water Resources). 2014a. California Data Exchange Center – Water Quality Information (Trinity River at Douglas City). Site accessed on May 8, 2014. http://cdec.water.ca.gov/wquality/DGC_032011.html

DWR (California Department of Water Resources). 2014b. California Data Exchange Center – Water Quality Information (Trinity River Above North Forth Trinity River Near Helena). Site accessed on May 8, 2014. http://cdec.water.ca.gov/wquality/NFH_092012.html

DWR (California Department of Water Resources). 2014c. California Data Exchange Center – Water Quality Information (Trinity River Near

Weitchpec). Site accessed on May 8, 2014. http://cdec.water.ca.gov/wquality/DGC_032011.html

DWR (California Department of Water Resources). 2014d. Water Data Library. Site accessed on September 30, 2014. http://www.water.ca.gov/waterdatalibrary/.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper), Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

ESJWQC (East San Joaquin Water Quality Coalition) and Westside Coalition (Westside San Joaquin River Watershed Coalition). 2013. *San Joaquin River Chlorpyrifos and Diazinon 2012 Water Year Annual Monitoring Report*. May.

Enright, C., and S. D. Culberson. 2009. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 7(2).

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Foe, C., S. Louie, and D. Bosworth. 2008. Methylmercury Concentrations and Loads in the Central Valley and Freshwater Delta. Final Report submitted to the CALFED Bay-Delta Program for the project "Transport, Cycling and Fate of Mercury and Monomethylmercury in the San Francisco Delta and Tributaries" Task 2. Central Valley Regional Water Quality Control Board. Available at: http://mercury.mlml.calstate.edu/reports/reports/

Foe, C. 2010. *Selenium Concentrations in Largemouth Bass in the Sacramento–San Joaquin Delta*. Central Valley Regional Water Quality Control Board, Sacramento, California. June.

Fojut, T., A. Palumbo, and R. Tjeerdema. 2012. Aquatic Life Water Quality Criteria Derived via the UC Davis Method: III. Diuron. Rev. Env. Contam. Toxicol. 216:105-141.

Gao, S., E. Christen, and A.L. Toto. 2008. *Agricultural Evaporation Basins*. Revised final version of chapter dated 10-1-08 for American Society of Civil Engineers Salinity Manual No. 71 revision, Chapter 24. Received from A.L. Toto 2/17/2011

GBPOC (Grassland Bypass Project Oversight Committee). 2013. *Grassland Bypass Project Annual Report 2010-2011.* Contribution No. 697. San Francisco Estuary Institute. Richmond, CA.

Glibert, Patricia M., D. Fullerton, J.M. Burkholder, J.C. Cornwell and T.M. Kana. 2011. Ecological stoichiometry, biogeochemical cycling, invasive species and aquatic food webs: San Francisco Estuary and comparative systems. Reviews in Fisheries Science. 19(4): 358-417. http://dx.doi.org/10.1080/10641262.2011.611916

Gordus, A. G. 1999. Selenium concentrations in eggs of American Avocets and Black-necked Stilts at an evaporation basin and fresh water wetland in California. *J. Wildlife Management* 62(2): 497 – 501.

Greenfield BK, Davis JA, Fairey R, Roberts C, Crane D, Ichikawa G. 2005. Seasonal, inter annual, and long-term variation in sport fish contamination, San Francisco Bay. Sci. Total Environ. 336:25-43.

Healey, M. C., M. D. Dettinger, and R. B. Norgaard, eds. 2008. *The State of Bay-Delta Science, 2008*. CALFED Science Program: Sacramento, CA, 174 pp.

Heim, W. A., K. H. Coale, M. Stephenson, K. Choe, G. A. Gill, and C. Foe. 2007. Spatial and Habitat-Based Variations in Total and Methyl Mercury Concentrations in Surficial Sediments in the San Francisco Bay-Delta. *Environmental Science and Technology*. Volume 41:3501–3507.

Heim, W.A., S. Deverel, T. Ingrum, W. Piekarski, M. Stephenson. 2009. Final Report: Assessment of Methlymercury Contributions from Sacramento-San Joaquin Delta Farmed Lands. August 2009.

Hoffman. 2010. Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta Final Report. Prepared for the California Environmental Protection Agency State Water Resources Control Board Division of Water Rights. January.

Hoopa Valley TEPA (Hoopa Valley Tribal Environmental Protection Agency). 2008. *Hoopa Valley Indian Reservation Water Quality Control Plan.* Approved September 22, 2002. Amendments Approved February 14, 2008.

Jabusch, T. and C. Foe. 2010. *Ammonia in the Delta: State of the Science, Implications for Management*. Pulse of the Delta, Draft Articles. November 29.

Janz, D.M., D.K. DeForest, M.L. Brooks, P.M. Chapman, G. Gilron, D. Hoff, W.A. Hopkins, D.O. McIntyre, C.A. Mebane, V.P. Palace, J.P. Skorupa, and M. Wayland. 2010. *Selenium Toxicity to Aquatic Organisms.* Ecological Assessment of Selenium in the Aquatic Environment. Edited by P.M. Chapman, W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, and D.P. Shaw. Pensacola: Society of Environmental Toxicology and Chemistry. 141-231.

Jassby. 2008. Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance. *San Francisco Estuary and Watershed Science* Volume 6(1): Article 2.

Jassby, A.D. and W.J. Kimmerer. S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, T.J. Vendlinski. 1995. *Isohaline Position as a Habitat Indicator for Estuarine Populations*. Ecological Applications. 5(1): 272-289. February 1995.

Jassby, A., J. Cloern, and B. Cole. 2002. Annual Primary Production: Patterns and Mechanisms of Change in a Nutrient-Rich Tidal Ecosystem. *Limnology and Oceanography* Volume 47:698–712.

Jassby, A. and E. Van Nieuwenhuyse. 2005. Low Dissolved Oxygen in an Estuarine Channel (San Joaquin River, California): Mechanisms and Models Based on Long-Term Time Series. *San Francisco Estuary and Watershed Science* Volume 3(2).

Kimmerer. 2004. Open water processes of the San Francisco estuary: from physical forcing to biological responses. *San Francisco Estuary and Watershed Science*.

Kimmerer, W., E. Gartside and J. J. Orsi. 1994. Predation by an introduced clam as the likely cause of substantial declines in zooplankton of San Francisco Bay, Marine Ecology Progress Series, 113, 81-94.

Klamath River Basin Fisheries Task Force. 1991. Long Range Plan For The Klamath River Basin Conservation Area Fishery Restoration Program. January 1991.

Lee, G.F. and A. Jones-Lee. 2007. Update of Organochlorine (OCl) “Legacy” Pesticide and PCB Concentrations in Delta and Central Valley Fish. Report of G. Fred Lee & Associates, El Macero, California. http://www.gfredlee.com/SurfaceWQ/UpdateLegacyPestCVFish.pdf

Lost Hills Water District. 2007. *Lost Hills Water District 2007 Biannual Wildlife Monitoring Report*. Draft Report Prepared by H.T. Harvey & Associates for Lost Hills Water District. File No. 981-34. 20 December 2007.

Lost Hills Water District. 2008. *Lost Hills Water District 2007 to 2008 Biannual Wildlife Monitoring Report*. Prepared by H.T. Harvey & Associates for Lost Hills Water District. File No. 981-38A. 30 May 2008.

Lucas, L., and R. Stewart. 2007. *Transport, Transformation, and Effects of Selenium and Carbon in the Delta of the Sacramento–San Joaquin Rivers: Implications for Ecosystem Restoration*. Ecosystem Restoration Program Project No. ERP-01-C07. U.S. Geological Survey, Menlo Park, California.

Lucas, L. and J.K. Thompson. 2012. Changing restoration rules: Exotic bivalves interact with residence time and depth to control phytoplankton productivity. Ecosphere. 3(12):117. http://www.esajournals.org/doi/abs/10.1890/ES12-00251.1

Markiewicz, D., M. Stillway, S. Teh. 2012. *Toxicity in California Waters: Central Valley Region*. Surface Water Ambient Monitoring Program. California State Water Resources Control board. Sacramento, California.

May, J.T.; R.L. Hothem; J.J. Rytuba; W.G. Duffy; C.N. Alpers; R.P. Ashley; M.P. Hunerlach2004. Mercury concentrations in sediment, water, and aquatic biota from the Trinity River Safe Eating Guidelines for Fish from Selected Water Bodies in the Trinity River Watershed (Trinity County) 27 Watershed, 2000-2003. Abstract; Annual Meeting and Symposium, 2004, California-Nevada Chapter of the American Fisheries Society.

MacCoy, D. E., and J. L. Domagalski. 1999. *Trace Elements and Organic Compounds in Streambed Sediment and Aquatic Biota from the Sacramento River Basin, California, October and November 1995.* U.S. Geological Survey Water-Resources Investigations Report 99-4151. Prepared in cooperation with the National Water-Quality Investigation Program. Sacramento, California.

MacDonald, D.D., C.G. Ingersoll, T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39, 20–31.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42,156 p. Site accessed September 11, 2014. http://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/vsp_2000.pdf

Melwani, A. R., S. N. Bezalel, J. A. Hunt, J. L. Grevier, G. Ichikawa, W. Heim, A. Bonnema, C. Foe, D. G. Slotton, and J. A. Davis. 2009. Spatial trends and impairment assessment of mercury in sport fish in the Sacramento-San Joaquin Delta watershed. *Environ. Pollut*. 157 (11): 3137 – 3149.

NCRWQCB (North Coast Regional Water Quality Control Board). 2004. Total Maximum Daily Load Implementation Policy Statement for Sediment-Impaired Receiving Waters in the North Coast Region. Resolution No. R1-2004-0087. November 2004.

NCRWQCB (North Coast Regional Water Quality Control Board). 2008. *Regional Water Board Staff Work Plan to Control Excess Sediment in Sediment-Impaired Watersheds.* April 2008.

NCRWQCB (North Coast Regional Water Quality Control Board). 2010. *Final Staff Report for the Klamath River Total Maximum Daily Loads (TMDLs) Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California; the Proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California; and the Klamath River and Lost River Implementation Plans.* March 2010.

NCRWQCB (North Coast Regional Water Quality Control Board). 2011. Water Quality Control Plan for the North Coast Region. May 2011. Santa Rosa, CA.

NMFS (National Marine Fisheries Service). 2009. *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project.* Southwest Region. June.

NMFS (National Marine Fisheries Service). 2009b. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Southwest Regional Office. Sacramento, California. October 2009.

NOAA (National Oceanic and Atmospheric Administration). 2008a. Dissolved Oxygen. NOAA Ocean Service Education: Estuaries Site accessed on August 21, 2014. http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10d_disolvedox.html

NOAA (National Oceanic and Atmospheric Administration). 2008b. Salinity. NOAA Ocean Service Education: Estuaries Site accessed on August 21, 2014. http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10c_salinity.html

NOAA (National Oceanic and Atmospheric Administration). 2014. What is nutrient pollution? Site accessed on July 30, 2014. http://oceanservice.noaa.gov/facts/nutpollution.html

Nordstrom, D.K. and C.N. Alpers. 1999. Negative pH, efflorescent mineralogy, and consequences for environmental restoration at the Iron Mountain Mines Superfund site, California. Paper presented at the National Academy of Sciences colloquium, Geology, Mineralogy, and Human Welfare, November 8-9, 1998, Irvine, California. 3455-3462 Site accessed on August 29, 2014 PNAS Online, http://www.pnas.org/cgi/content/abstract/96/7/3455

OEHHA (California Office of Environmental Health Hazard Assessment). 2007. *Health Advisory: Draft Safe Eating Guidelines for Fish and Shellfish from the San Joaquin River and South Delta (Contra Costa, San Joaquin, Stanislaus, Merced, Madera, and Fresno Counties)*. March.

OEHHA (Office of Environmental Health Hazard Assessment). 2008. *Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene*. Sacramento, California. June.

OEHHA (Office of Environmental Health Hazard Assessment). 2010. *Public Health Goal for Selenium in Drinking Water.* December.

Ohlendorf, H.M. 2003. *Ecotoxicology of Selenium*. Handbook of Ecotoxicology, Second Edition. Edited by D.J. Hoffman, B.A. Rattner, G.A. Burton Jr., and J.C. Cairns Jr. Lewis Publishers, Boca Raton, Florida. 465–500.

Palumbo, A.J., T.L. Fojut, P.L. Tenbrook, and R.S. Tjeerdema, 2010. Water Quality Criteria Report for Diazinon. Phase III: Application of Pesticide Water Quality Criteria Methodology Report Prepared by U.C. Davis Department of Environmental Toxicology for the Central Valley Regional Water Quality Control Board

Pickhardt, C., M. Stepanova, N.S. Fisher. 2006. Contrasting uptake routes and tissue distributions of inorganic and methylmercury in mosquitofish (*Gambusia affinis*) and redear sunfish (*Lepomis microlophus*). Environmental Toxicology and Chemistry, 25.8 (2006): 2132-2142.

Presser, T.S. 1994. *Geologic Origin and Pathways of Selenium from the California Coast Ranges to the West-Central San Joaquin Valley.* Selenium in the Environment. Edited by W.T. Frankenburger, Jr. and S. Benson. New York: Marcel Dekker, Inc. 139-155.

Presser, T.S., and D.Z. Piper. 1998. *Mass Balance Approach to Selenium Cycling Through the San Joaquin Valley: From Source to River to Bay.* Environmental Chemistry of Selenium. Edited by W. T. Frankenberger, Jr. and Richard A. Engberg. New York: Marcel Dekker, Inc. 153-182.

Presser, T.S., and H.M. Ohlendorf. 1987. Biogeochemical Cycling of Selenium in the San Joaquin Valley, California, USA. *Environmental Management*. Volume 11, Number 6: 805-821.

Presser, T.S., and S.N. Luoma. 2006. *Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension*. Professional Paper 1646. U.S. Geological Survey, Reston, Virginia.

Presser, T.S., and S.N. Luoma. 2013. Ecosystem-scale Selenium Model for the San Francisco Bay-Delta Regional Ecosystem Restoration Implementation Plan. *San Francisco Estuary and Watershed Science*. Volume 11, Issue 1:1-39.

Reclamation (U.S. Bureau of Reclamation). 2006. *San Luis Drainage Feature Re-evaluation Final Environmental Impact Statement, Section 5*. Mid-Pacific Region, Sacramento, California.

Reclamation (U.S. Bureau of Reclamation). 2008. *Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project*. Mid-Pacific Region. Sacramento, California.

Reclamation (U.S. Bureau of Reclamation). 2013a. *Shasta Lake Water Resources Investigation Environmental Impact Statement/Report*. June 2013.

Reclamation (U.S. Bureau of Reclamation). 2013b. Sacramento River Temperature Report. Central Valley Operations Office. Mid-Pacific Region. Site accessed March 26, 2013. http://www.usbr.gov/mp/cvo/temp.html

Reclamation (U.S. Bureau of Reclamation). 2013c. Central Valley Project. Site accessed March 20, 2013. http://www.usbr.gov/projects/Project.jsp?proj_Name=Central+Valley+Project

Reclamation (U.S. Bureau of Reclamation). 2013d. Delta Division Project. Site accessed March 26, 2013. http://www.usbr.gov/projects/Project.jsp?proj_Name=Central+Valley+Project

Reclamation (U.S. Bureau of Reclamation). 2013e. *2000 – 2012 Water Quality Reports; Data provided by Stacey Smith, Central Valley Operations Office, Sacramento California*. February 12, 2013.

Reclamation (Bureau of Reclamation). 2013f. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation & SLDMWA (U.S. Bureau of Reclamation and San Luis Delta-Mendota Water Authority). 2009. Grassland Bypass Project 2010-2019 Environmental Impact Statement and Environmental Impact Report. State Clearinghouse No. 2007121110.

Reclamation et al. (U.S. Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game). 2003. Environmental Water Account Draft Environmental Impact Statement / Environmental Impact Report.

Reclamation et al.(U.S. Bureau of Reclamation, U.S Bureau of Reclamation, Mid-Pacific Region, U.S. Army Corps of Engineers, Sacramento District, California Department of Water Resources, State of California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental*

*Impact Statement/Environmental Impact Report.* Folsom, California. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

[see DWR et al. 2013]Saiki, M.K., M.R. Jennings, and S.K. Hamilton. 1991. *Preliminary Assessment of Selenium in Agricultural Drainage on Fish in the San Joaquin Valley*. The Economics and Management of Water and Drainage in Agriculture. Edited by A. Dinar and D. Zilberman. Kluwer Academic Publishers, Boston. 369-385.

Schemel, L. E., T. R. Sommer, A. B. Muller-Solger, and W. C. Harrell. 2004. Hydrological variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, USA. Hydrobiologia 513:129-139.

Senn, D., Novick, E. 2014. Suisun Bay Ammonia Synthesis Report. San Francisco Estuary Institute. Contribution No. 706. Richmond, California. Site accessed on August 4, 2014. http://www.sfei.org/sites/default/files/SuisunSynthesisI_Final_March2014_0.pdf

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2005. Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks Water Quality. Attainment Strategy and Total Maximum Daily Load (TMDL). Proposed Basin Plan Amendment and Staff Report. November 2005.

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2006. Mercury in the San Francisco Bay. Basin Plan Amendment and Staff Report for Revised Total Maximum Daily Load (TMDL) and Proposed Mercury Water Quality Objectives. August 1, 2006.

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2011. *Total Maximum Daily Load Selenium in North San Francisco Bay*. Preliminary Project Report. Prepared by Barbara Baginska. January.

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2012a. Suisun Marsh TMDL for Methylmercury, Dissolved Oxygen and Nutrient Biostimulation. Prepared by Barbara Baginska. September 2012.

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2012b. San Francisco Bay Nutrient Management Strategy. Prepared by Barbara Baginska. November.

SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2013. *San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)*. California Regional Water Quality Control Board, San Francisco Bay Region.

[same as SFBRWQCB 2005 – accessed 2014]
SFEI (San Francisco Estuary Institute). 2011. *Grassland Bypass Project Annual Report 2006–2007*. Prepared by the San Francisco Estuary Institute for the Grassland Bypass Project Oversight Committee.

SFEI (San Francisco Estuary Institute). 2012. 2010 Annual Monitoring Results. The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). Contribution #661. San Francisco Estuary Institute, Richmond, CA.

SFEI (San Francisco Estuary Institute). 2013. The Pulse of the Bay: Contaminants of Emerging Concern. SFEI Contribution 701. San Francisco Estuary Institute, Richmond, CA.

SFEI (San Francisco Estuary Institute). 2014a. 2012 Annual Monitoring Results. The Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP). Contribution #710. San Francisco Estuary Institute, Richmond, CA.

SFEI (San Francisco Estuary Institute). 2014b. Contaminant Data Display Download. San Francisco Estuary Institute, Richmond, CA. Site accessed September 30, 2014. http://www.sfei.org/tools/wqt

Shilling, F. 2003. Background Information for a Central Valley Fish Consumption Study: Geographic Information System and Relational Database for Fish Tissue Mercury and Creel Survey Data. Prepared for the Delta Tributaries Mercury Council and the Sacramento River Watershed Program. Department of Environmental Science & Policy, University of California, Davis.

Sickman, J. O., M. J. Zanoli, and H. L. Mann. 2007. *Effects of urbanization on organic carbon loads in the Sacramento River, California*. Wat. Res. Res. 43: W11422, doi:10.1029/2007WR005954.

Siegel, S., P. Bachand, D. Gillenwater, C. Chappell, B. Wickland, O. Rocha, M. Stephenson, W. Heim, C. Enright, P. Moyle, P. Crain, B. Downingand B. Bergamaschi. 2011. Final Evaluation Memorandum, Strategies for Resolving Low Dissolved Oxygen and Methylmercury Events in Northern Suisun Marsh. Prepared for the State Water Resources Control Board, Sacramento, CA. Project #06-283-552-0.

Siepmann, S., and B. Finlayson. 2000. Water quality criteria for diazinon and chlorpyrifos. Administrative Report 00-3. Rancho Cordova, CA: Pesticide Investigations Unit, Office of Spills and Response. CA Department of Fish and Game.

Singer, M.B., R. Aalto, L.A. James, N.E. Kilham, J.L. Higson & S. Ghoshal. *Enduring Legacy of a Toxic Fan via Episodic Redistribution of California Gold Mining Debris*. 2013.

Skorupa, J. P. 1998. *Selenium Poisoning of Fish and Wildlife in Nature: Lessons from Twelve Real-World Examples*. Environmental Chemistry of

Selenium. Edited by W. T. Frankenberger, Jr., and R. A. Engberg, 315–354. New York: Marcel Dekker.

Skorupa, J. P., and H. M. Ohlendorf. 1991. *Contaminants in Drainage Water and Avian Risk Thresholds*. The Economics and Management of Water and Drainage in Agriculture. Edited by A. Dinar and D. Zilberman, 345–368. Kluwer Academic Publishers, Norwell, Massachusetts.

Slotton, D.G., S.M. Ayers, and R.D. Weyand. 2007. *CBDA Biosentinel Mercury Monitoring Program. Second Year Draft Data Report. February through December, 2006*. Department of Environmental Science and Policy, University of California, Davis.

Sommer, T. B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. *Fisheries* 26 (8): 6 – 16.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries. 32(6):270-277.

SRWP (Sacramento River Watershed Program). 2014. Sacramento River Basin. Site accessed on July 14, 2014. http://www.sacriver.org/aboutwatershed/roadmap/sacramento-river-basin

Stewart, A.R., S.N. Luoma, C.E. Schlekat, M.A. Doblin, and K.A. Hieb. 2004. Food Web Pathway Determines How Selenium Affects Aquatic Ecosystems: A San Francisco Bay Case Study. *Environmental Science and Technology*. Volume 38:4519-4526.

SWRCB (State Water Resources Control Board). 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. May. Sacramento, CA.

SWRCB (State Water Resources Control Board). 1998. *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California*.

SWRCB (State Water Resources Control Board). 2000. *Water Rights Decision 1641, revised. Order WR 2000-02*. March 15, 2002.

SWRCB (State Water Resources Control Board). 2001. California ocean plan; water quality control plan, ocean waters of California. Sacramento, California.

SWRCB (State Water Resources Control Board). 2006a. *Draft Informational Document: Public Scoping Meeting for Proposed Methylmercury Objectives for Inland Surface Waters, Enclosed Bays, and Estuaries in California.* December 2006.

SWRCB (State Water Resources Control Board). 2006b. *Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary*.

SWRCB (State Water Resources Control Board). 2007. *Conceptual Model for Pathogens and Pathogen Indicators in the Central Valley and Sacramento–San Joaquin Delta*. Prepared for the Central Valley Drinking Water Policy Group. Prepared by Tetra Tech.

SWRCB (State Water Resources Control Board). 2008a. *Technical Memorandum 2: North San Francisco Bay Selenium Data Summary and Source Analysis*. Prepared for San Francisco Bay Regional Water Quality Control Board by Tetra Tech. Lafayette, California.

SWRCB (State Water Resources Control Board). 2008b. *Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. Central Valley Regional Water Quality Control Board, and San Francisco Bay Regional Water Quality Control Board).

SWRCB (State Water Resources Control Board). 2010a. Staff Report for 2010 Integrated Report Clean Water Act Sections 303(d) and 305(b). April 19.

SWRCB (State Water Resources Control Board). 2010b. *Resolution No. 2010-0046 Approving Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) to Address Selenium Control in the San Joaquin River Basin*. Adopted October 5.

SWRCB (State Water Resources Control Board). 2011a. Final California 2010 Integrated Report (303(d) List/305(b) Report) Supporting Information. Site accessed July 7, 2015. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/table_of_contents.shtml

SWRCB (State Water Resources Control Board). 2011b. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Trinity Lake (was Claire Engle Lake). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00179.shtml#5525

SWRCB (State Water Resources Control Board). 2011c. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Trinity River HU, Lower Trinity HA. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00543.shtml#6924

SWRCB (State Water Resources Control Board). 2011d. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Trinity River HU, Middle HA. Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00545.shtml#6926

SWRCB (State Water Resources Control Board). 2011e. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information.

Trinity River HU, South Fork HA. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00544.shtml#6925

SWRCB (State Water Resources Control Board). 2011f. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Trinity River HU, Upper HA. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00546.shtml#6716

SWRCB (State Water Resources Control Board). 2011g. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Trinity River HU, Upper HA, Trinity River, East Fork. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00547.shtml#6833

SWRCB (State Water Resources Control Board). 2011h. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Klamath River HU, Lower HA, Klamath Glen HAS. Site accessed January 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00533.shtml#6118

SWRCB (State Water Resources Control Board). 2011i. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Shasta Lake. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02260.shtml#12120

SWRCB (State Water Resources Control Board). 2011j. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Whiskeytown Lake (areas near Oak Bottom, Brandy Creek Campgrounds and Whiskeytown). Site accessed February 17, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00339.shtml#11507

SWRCB (State Water Resources Control Board). 2011k. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Clear Creek (below Whiskeytown Lake, Shasta County). Site accessed November 14, 2013. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01140.shtml#12958

SWRCB (State Water Resources Control Board). 2011l. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sacramento River (Cottonwood Creek to Red Bluff). Site accessed February 17, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01125.shtml#7156

SWRCB (State Water Resources Control Board). 2011m. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Spring Creek, Lower (Iron Mountain Mine to Keswick Reservoir). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01227.shtml#7508

SWRCB (State Water Resources Control Board). 2011n. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Keswick Reservoir (portion downstream from Spring Creek). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00338.shtml#6970

SWRCB (State Water Resources Control Board). 2011o. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sacramento River (Red Bluff to Knights Landing). Site accessed February 17, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01209.shtml#7157

SWRCB (State Water Resources Control Board). 2011p. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sacramento River (Keswick Dam to Cottonwood Creek). Site accessed November 19, 2013. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01137.shtml#7158

SWRCB (State Water Resources Control Board). 2011q. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sacramento River (Knights Landing to the Delta). Site accessed November 19, 2013. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01144.shtml#7160

SWRCB (State Water Resources Control Board). 2011r. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Colusa Basin Drain. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01211.shtml#14304

SWRCB (State Water Resources Control Board). 2011s. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Knights Landing Ridge Cut (Yolo County). Site accessed October 1, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02044.shtml#12809

SWRCB (State Water Resources Control Board). 2011t. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento

River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01204.shtml#4172

SWRCB (State Water Resources Control Board). 2011u. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. American River, Lower (Nimbus Dam to confluence with Sacramento River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01196.shtml#6501

SWRCB (State Water Resources Control Board). 2011v. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Yuba River, Lower. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01159.shtml#11444

SWRCB (State Water Resources Control Board). 2011w. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Tule Canal (Yolo County). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02089.shtml#11625

SWRCB (State Water Resources Control Board). 2011x. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Merced River to Tuolumne River). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01304.shtml#8139

SWRCB (State Water Resources Control Board). 2011y. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Tuolumne River to Stanislaus River). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01261.shtml#9262

SWRCB (State Water Resources Control Board). 2011z. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Mud Slough to Merced River). Site accessed August 3, 2015. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01269.shtml#6963

SWRCB (State Water Resources Control Board). 2011aa. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Grasslands Marshes. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01657.shtml#7554

SWRCB (State Water Resources Control Board). 2011ab. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information.

Agatha Canal (Merced County). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02243.shtml#15933

SWRCB (State Water Resources Control Board). 2011ac. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Mud Slough, North (downstream of San Luis Drain). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02101.shtml#12605

SWRCB (State Water Resources Control Board). 2011ad. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Salt Slough (upstream from confluence with San Joaquin River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01287.shtml#12350

SWRCB (State Water Resources Control Board). 2011ae. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Bear Creek to Mud Slough). Site accessed September 19, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01268.shtml#7914

SWRCB (State Water Resources Control Board). 2011af. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Stanislaus River to Delta Boundary). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01306.shtml#12238

SWRCB (State Water Resources Control Board). 2011ag. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Mendota Pool to Bear Creek). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01266.shtml#7018

SWRCB (State Water Resources Control Board). 2011ah. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Joaquin River (Friant Dam to Mendota Pool). Site accessed September 23, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01308.shtml#6783

SWRCB (State Water Resources Control Board). 2011ai. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Panoche Creek (Silver Creek to Belmont Avenue). Site accessed September 10,

2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01331.shtml#13587

SWRCB (State Water Resources Control Board). 2011aj. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Merced River, Lower (McSwain Reservoir to San Joaquin River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01265.shtml#13836

SWRCB (State Water Resources Control Board). 2011ak. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01263.shtml#4914

SWRCB (State Water Resources Control Board). 2011al. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Stanislaus River, Lower. Site accessed December 2, 2013. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01260.shtml#11952

SWRCB (State Water Resources Control Board). 2011am. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Mokelumne River, Lower (in Delta Waterways, eastern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01297.shtml#7425

SWRCB (State Water Resources Control Board). 2011an. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Calaveras River, Lower (from Stockton Diverting Canal to the San Joaquin River; partly in Delta Waterways, eastern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01300.shtml#6031

SWRCB (State Water Resources Control Board). 2011ao. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Cosumnes River, Lower (below Michigan Bar; partly in Delta Waterways, eastern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02233.shtml#16125

SWRCB (State Water Resources Control Board). 2011ap. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Kings River, Lower (Pine Flat Reservoir to Island Weir). Site accessed September 10,

2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02179.shtml#15765

SWRCB (State Water Resources Control Board). 2011aq. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Kings River, Lower (Island Weir to Stinson and Empire Weirs). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01311.shtml#9243

SWRCB (State Water Resources Control Board). 2011ar. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Kaweah River (below Terminus Dam, Tulare County). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02042.shtml#12860

SWRCB (State Water Resources Control Board). 2011as. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Kaweah River, Lower (includes St Johns River). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01326.shtml#11963

SWRCB (State Water Resources Control Board). 2011at. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (export area). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00141.shtml#6342

SWRCB (State Water Resources Control Board). 2011au. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (northwestern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00137.shtml#6523

SWRCB (State Water Resources Control Board). 2011av. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (southern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00140.shtml#5958

SWRCB (State Water Resources Control Board). 2011aw. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (western portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00136.shtml#7414

SWRCB (State Water Resources Control Board). 2011ax. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sacramento San Joaquin Delta. Site accessed September 10,

2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00116.shtml#5981

SWRCB (State Water Resources Control Board). 2011ay. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (central portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00142.shtml#6168

SWRCB (State Water Resources Control Board). 2011az. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (eastern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00135.shtml#5901

SWRCB (State Water Resources Control Board). 2011ba. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (northern portion). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00138.shtml#14610

SWRCB (State Water Resources Control Board). 2011bb. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Delta Waterways (Stockton Ship Channel). Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00139.shtml#6410

SWRCB (State Water Resources Control Board). 2011bc. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Suisun Marsh Wetlands. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01653.shtml#6221

SWRCB (State Water Resources Control Board). 2011bd. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Suisun Bay. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00014.shtml#6045

SWRCB (State Water Resources Control Board). 2011be. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Carquinez Strait. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00117.shtml#6668

SWRCB (State Water Resources Control Board). 2011bf. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Pablo Bay. Site accessed September 10, 2014. http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00013.shtml#6141

SWRCB (State Water Resources Control Board). 2012a. SWRCB Direct Sacramento County Sanitation District to Upgrade Sewage Treatment to Protect Human Health and Aquatic Life District must Comply with Regional Water Board Permit. Media Release. December 2012. Site accessed on May 8, 2014. http://www.swrcb.ca.gov/press_room/press_releases/2012/pr120412r5_scsd.pdf

SWRCB (State Water Resources Control Board). 2012b. *Total Maximum Daily Load Progress Report: Stockton Ship Channel Low Dissolved Oxygen TMDL*. September 2012. Site accessed on August 28, 2014. http://www.waterboards.ca.gov/about_us/performance_report_1112/plan_assess/docs/fy1112/11112_r5_stocktonshipchannel_do.pdf

SWRCB (State Water Resources Control Board). 2012c. *Delta Mercury Control Program Mercury Exposure Reduction Program Strategy 15 November 2012 Final Document. Delta Mercury Control Program. Final Document*. November 15.

SWRCB (State Water Resources Control Board). 2014a. *Statewide Mercury Program.* Addressing Mercury in California's Waters. Site accessed April 16, 2014. http://www.waterboards.ca.gov/water_issues/programs/mercury/index.shtml.

SWRCB (State Water Resources Control Board). 2014b. Central Valley Pesticide TMDL and Basin Plan Amendment – Sediment Quality Criteria Derivation. Site accessed June 26, 2014. http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/central_valley_pesticides/sediment_quality_criteria_method_development/index.shtml

[duplicate SFBRWQCB 2005]

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Tenbrook, P.L., A.J. Palumbo, T.J. Fojut, P. Hann, J. Karkoski, R.S. Tjeerdema. 2010. The University of California-Davis methodology for deriving aquatic life pesticide water quality criteria. Rev. Environ. Contamin. Toxicol. 209:1-155.

Tetra Tech, Inc. and WR and TMDL Center. 2009. Appendix D: Klamath River Model Scenarios Summary. December. Site accessed on September 11, 2014. http://www.deq.state.or.us/wq/tmdls/docs/klamathbasin/uklost/KlamathLostAppendixD.pdf

Tetra Tech, Inc. and WWR (Tetra Tech, Inc. and Wetlands and Water Resources). 2013. *Suisun Marsh Conceptual Model/Impairment Assessment Report for Organic Enrichment, Dissolved Oxygen, Mercury, Salinity, and Nutrients*. November 26, 2013. Site accessed on August 1,

2014. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/suisunmarsh/SM_CMIA%20ReportNov-2013.pdf

Toto, A. 2011. Information on selenium concentrations in evaporation basins received by Harry Ohlendorf, CH2M HILL Task Manager, on February 17, 2011, via phone conversation from Anthony Toto, Water Resources Control Engineer, California Regional Water Quality Control Board, Fresno, California.

TRRP (Trinity River Restoration Program) and NCRWQCB (North Coast Regional Water Quality Control Board). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites.* Volume III: Environmental Assessment/Draft Environmental Impact Report. June 2009.

USDAFS (U.S. Department of Agriculture Forest Service). 2014. Shasta-Trinity National Forest: South Fork Trinity River. Accessed July 14, 2014. http://www.fs.usda.gov/recarea/stnf/recreation/fishing/recarea/?recid=75236&actid=43

USEPA (U.S. Environmental Protection Agency). 1984. Ambient Water Quality Criteria for Mercury. Office of Research and Development Environmental Research Laboratories. Duluth, Minnesota and Narragansett, Rhode Island.

USEPA (U.S. Environmental Protection Agency). 1986. Ambient Water Quality Criteria for Dissolved Oxygen. Office of Water Regulation and Standards Criteria and Standards Division. EPA 400/5-86-006.

USEPA (U.S. Environmental Protection Agency). 1986b. Quality Criteria for Water. Office of Water Regulation and Standards. EPA 440/5-86-001.

USEPA (U.S. Environmental Protection Agency). 1986c. Ambient Water Quality Criteria for Bacteria. Office of Water Regulation and Standards Criteria and Standards Division. EPA 440/5-84-002. January 1986.

USEPA (U.S. Environmental Protection Agency). 1997. Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003. Office of Water 4503F. November 1997. Site accessed on July 25, 2014. http://www.epa.gov/owow/monitoring/volunteer/stream/stream.pdf

USEPA (United States Environmental Protection Agency). 1998. National Strategy for the Development of Regional Nutrient Criteria. EPA 822-R-98-002. Office of Water 4304. June.

USEPA (U.S. Environmental Protection Agency). 2000a. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule. Federal Register 65:97 18 May 2000. p. 31711-31719.

USEPA (U.S. Environmental Protection Agency). 2000b. Ambient Water Quality Criteria Recommendations. Information Supporting the Development or

State and Tribal Nutrient Criteria. River and Streams in Nutrient Ecoregion III. Office of Water. EPA-822-B-00-016.

USEPA (U.S. Environmental Protection Agency). 2000c. Ambient Water Quality Criteria Recommendations. Information Supporting the Development or State and Tribal Nutrient Criteria. River and Streams in Nutrient Ecoregion II. Office of Water. EPA-822-B-00-015.

USEPA (U.S. Environmental Protection Agency). 2000d. Ambient Water Quality Criteria Recommendations. Information Supporting the Development or State and Tribal Nutrient Criteria. Lakes and Reservoirs in Nutrient Ecoregion II. Office of Water. EPA-822-B-00-007.

USEPA (U.S. Environmental Protection Agency). 2001a. *Water Quality Criterion for the Protection of Human Health: Methylmercury*. Final. Office of Water. USEPA-823-F-01-011. June.

USEPA (U.S. Environmental Protection Agency). 2001b. *Mercury Update: Impact on Fish Advisories*. Fact Sheet. Office of Science and Technology, Office of Water. USEPA-823-R-01-001. January.

USEPA (U.S. Environmental Protection Agency). 2001c. Ambient Water Quality Criteria Recommendations. Information Supporting the Development or State and Tribal Nutrient Criteria. River and Streams in Nutrient Ecoregion I. Office of Water. EPA-822-B-01-012.

USEPA (U.S. Environmental Protection Agency). 2001d. Ambient Water Quality Criteria Recommendations. Information Supporting the Development or State and Tribal Nutrient Criteria. Lakes and Reservoirs in Nutrient Ecoregion III. Office of Water. EPA-822-B-01-008.

USEPA (U.S. Environmental Protection Agency). 2001e. *Trinity River Total Maximum Daily Load for Sediment.* Region IX. December 20, 2001.

USEPA (U.S. Environmental Protection Agency). 2002a. *Interim Reregistration Eligibility Decision for Chlorpyrifos.* February.

USEPA (U.S. Environmental Protection Agency). 2002b. *Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity.* Office of Pesticide Programs U.S. Environmental Protection Agency. Washington, D.C. January 2002.

USEPA (U.S. Environmental Protection Agency). 2002c. *National Recommended Water Quality Criteria: 2002, Human Health Criteria Calculation Matrix*. Office of Water. EPA-822-R-02-012. Washington, D.C. November 2002.

USEPA (U.S. Environmental Protection Agency). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B03-001. Region 10 Office of Water. April 2003.

USEPA (U.S. Environmental Protection Agency). 2004. *Interim Reregistration Eligibility Decision: Diazinon.* May.

USEPA (U.S. Environmental Protection Agency). 2005. *Pesticide News Story: Chlorpyrifos Pre-Construction Termiticide Products Phase Out on December 31, 2005.* September. Site accessed on November 5, 2013. http://www.epa.gov/oppfead1/cb/csb_page/updates/chlorpy-phasout.htm

_USEPA (U.S. Environmental Protection Agency). 2006. An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the 14 United States for the Years 1987, 1995, and 2000. National Center for Environmental Assessment, 15 EPA/600/P-03/002F. Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 2007. *Cancellation of Certain Agricultural Uses of Diazinon.* January.

USEPA (U.S. Environmental Protection Agency). 2008a. Problem Formulation for the Environmental Fate and Ecological Risk, Endangered Species and Drinking Water Assessments in Support of the Registration Review of Diazinon. Diazinon (CAS 333-41-5). March.

USEPA (U.S. Environmental Protection Agency). 2008b. *Fecal Coliform and E.Coli*. Site accessed on August 10, 2014. http://www.epa.gov/katrina/fecal.html

USEPA (U.S. Environmental Protection Agency). 2009a. *National Primary Drinking Water Regulations*. EPA 816-F-09-004. May.

USEPA (U.S. Environmental Protection Agency). 2009b. *National Recommended Water Quality Criteria*. Office of Water, Office of Science and Technology. 4304T.

USEPA (U.S. Environmental Protection Agency). 2011. Persistent Bioaccumulative and Toxic (PBT) Chemical Program: DDT. Site accessed November 11, 2013. http://www.epa.gov/pbt/pubs/ddt.htm

USEPA (U.S. Environmental Protection Agency). 2012a. *Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: EPA's Action Plan*. August.

USEPA (U.S. Environmental Protection Agency). 2012b. CADDIS Volume 2: Sources, Stressors & Responses: pH. January.

USEPA (U.S. Environmental Protection Agency). 2013a. Final Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater 2013. EPA-HQ-OW-2009-0921; FRL-9810-4. Federal Register. 78:163. August 22.

USEPA (U.S. Environmental Protection Agency). 2013b. Iron Mountain Mine. Pacific Southwest, Region 9: Superfund. Last updated November 25, 2013.

USEPA (U.S. Environmental Protection Agency). 2014a. National Recommended Water Quality Criteria. Site accessed August 1, 2014. http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

USEPA (U.S. Environmental Protection Agency. 2014b. External Peer Review Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2014. Federal Register Vol. 79 No. 93 (14 May 2014): 27601-27604.

USEPA (United States Environmental Protection Agency). 2014c. State Development of Numeric Criteria for Nitrogen and Phosphorus Pollution: State/Territory Details. Site accessed on July 29, 2014. http://cfpub.epa.gov/wqsits/nnc-development/

USEPA. 2014. Update of Human Health Ambient Water Quality Criteria: alpha-BHC 319-84-6 Draft. Office of Science and Technology Office of Water U.S. Environmental Protection Agency Washington, DC 20460. EPA 820-D-14-006. May.

USEPA (U.S. Environmental Protection Agency) and SFB RWQCB (San Francisco Bay Regional Water Quality Control Board). 2013. Best Management Practice Recommendations Suisun Marsh TMDL Development. Prepared by Dan Gillenwater, et al. January 25, 2013. San Francisco, California and Oakland California.

USFWS (U.S. Fish and Wildlife Service). 2008. Species at Risk from Selenium Exposure in the San Francisco Bay Estuary. Sacramento, CA.

USFWS (U.S. Fish and Wildlife Service). 2011. San Pablo Bay National Wildlife Refuge Final Comprehensive Conservation Plan. Newark, CA.

USFWS (U.S. Fish and Wildlife Service). 2013. Evaporation Ponds. Site accessed March 20, 2013. http://www.fws.gov/sacramento/ec/Investigations-And_Prevention/Evaporation-Pond/ec_invest-prevent_evaporation-pond.htm

USFWS and NSGCP (U.S. Fish and Wildlife Service and the National Sea Grant College Program). 1995. Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasion of the San Francisco Bay and Delta. Prepared by Andrew N. Cohen and James T. Carlton. Site accessed August 1, 2014 https://nas.er.usgs.gov/Publications/SFBay/sfinvade.html

USGS (U.S. Geological Survey). 2002. *Hydrology and Chemistry of Flood waters in the Yolo Bypass, Sacramento River System, California, During 2000.* Water Resources Investigations Report 02-4202. September.

USGS (U.S. Geological Survey). 2014. Water properties: Dissolved oxygen. The USGS Water Science School. Site accessed August 21, 2014. http://water.usgs.gov/edu/dissolvedoxygen.html

Van Nieuwenhuyse. 2007. Response of summer chlorophyll concentration to reduced total phosphorus concentration in the Rhine River (Netherlands) and the Sacramento – San Joaquin Delta (California, USA). Canadian Journal of Fisheries and Aquatic Sciences. 64:1529-1542.

Wallace, Roberts, and Todd, LLC; LSA Associates; Geotechnical Consultants, Inc.; Psomas; Concept Marine Inc. 2003. Draft Resource Inventory for Folsom Lake State Recreation Area. Prepared for: CDPR and Reclamation.

Westlake Farms, Inc. 2007. *Westlake Farms, Inc. 2007 Biannual Wildlife Monitoring Report*. Prepared by H.T. Harvey & Associates for Westlake Farms, Inc. File No. 749-34B. 20 December 2007.

Westlake Farms, Inc. 2008. *Westlake Farms, Inc. 2007 to 2008 Biannual Wildlife Monitoring Report*. Prepared by H.T. Harvey & Associates for Westlake Farms, Inc. File No. 749-35A. 30 May 2008.

Weston, D., and M. Lydy. 2010. Urban and Agricultural Sources of Pyrethroid Insecticides to the Sacramento–San Joaquin Delta of California. Environmental Science and Technology. Volume 44(5):1833–1840.

Wiener, J. G., C. C. Gilmour, and D. P. Krabbenhoft. 2003. *Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration*. Final Report to the California Bay-Delta Authority.

**Chapter 6**

# Surface Water Quality Figures

The following figures are included in Chapter 6, Surface Water Quality.

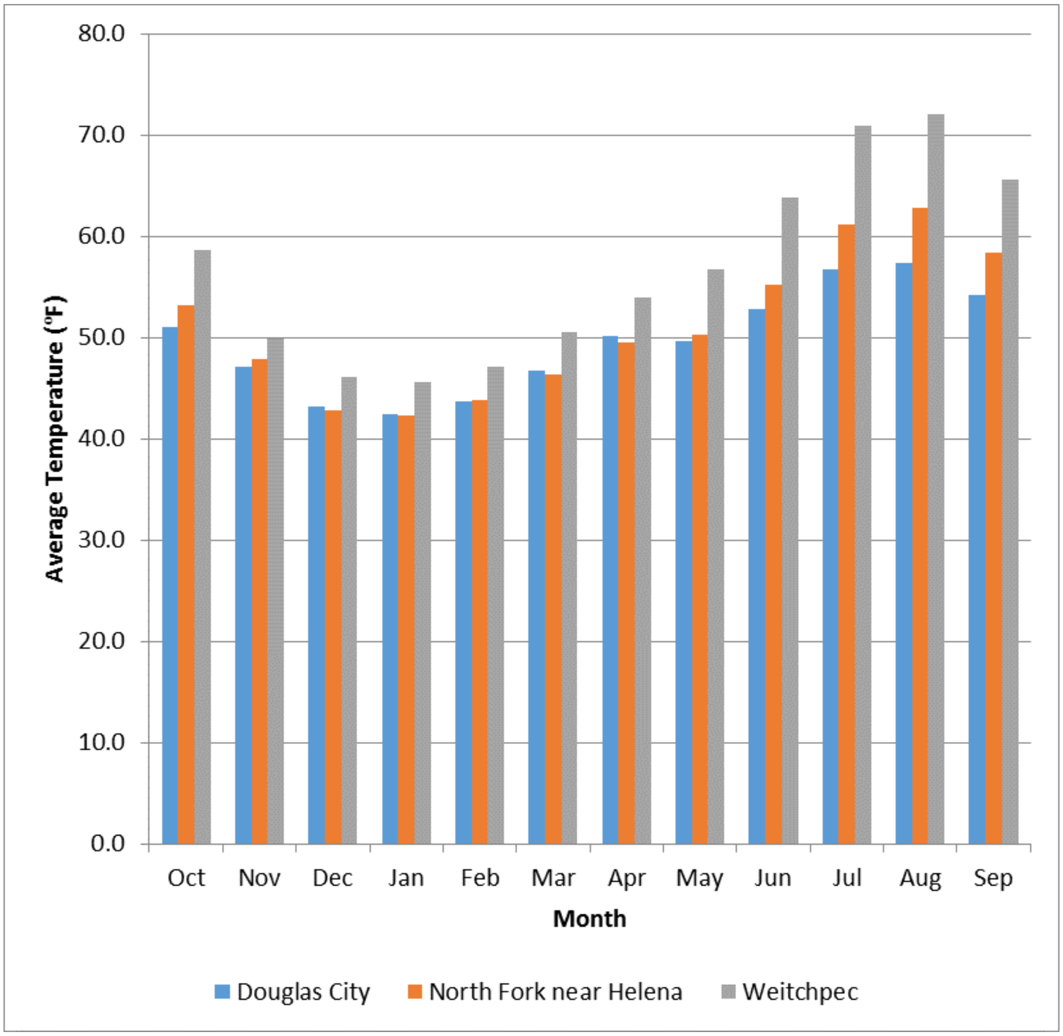



**Figure 6.1 Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations (2001-2012)**

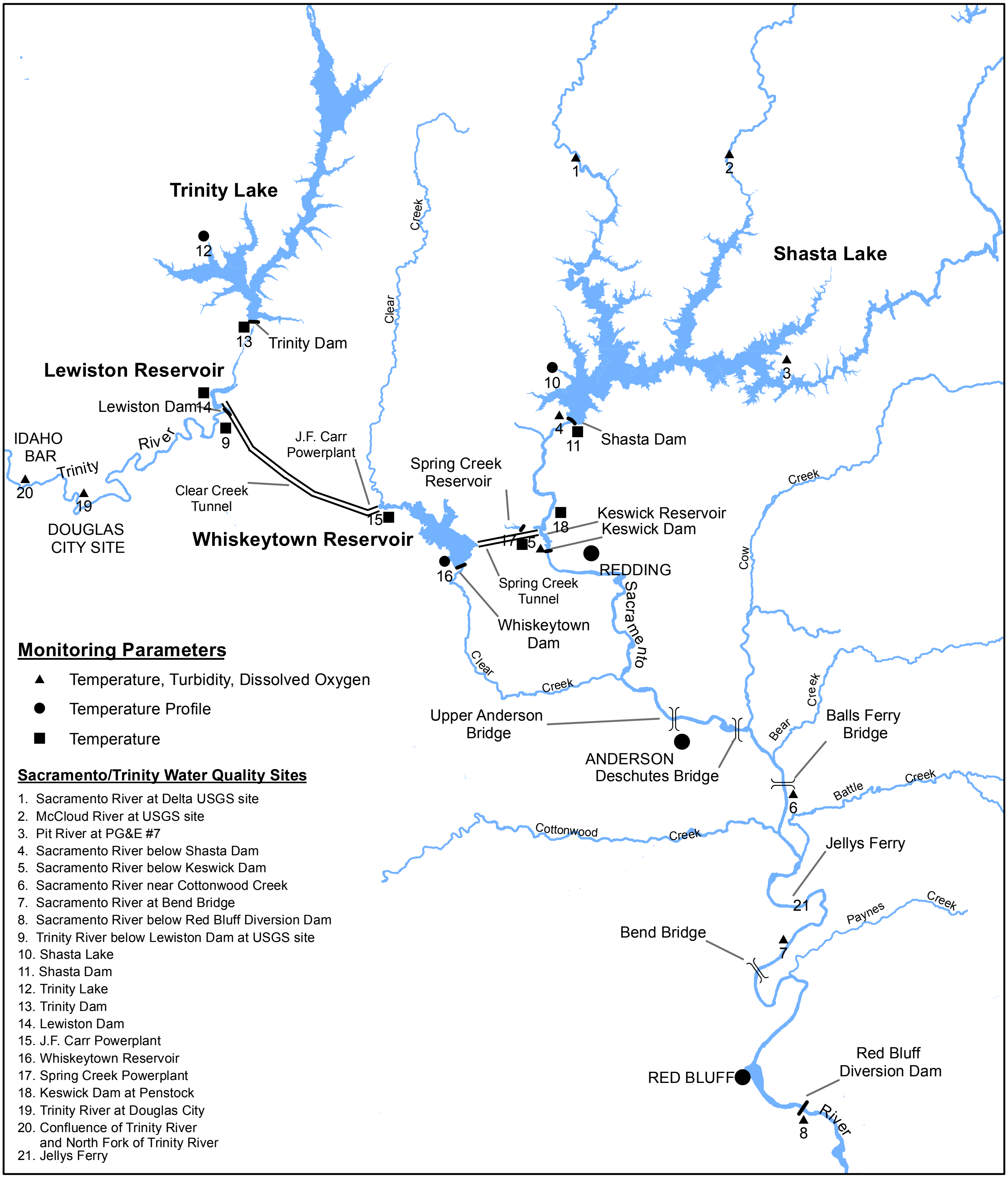



**Figure 6.2 Water Quality Compliance Stations Along Trinity River and Upper Sacramento River**

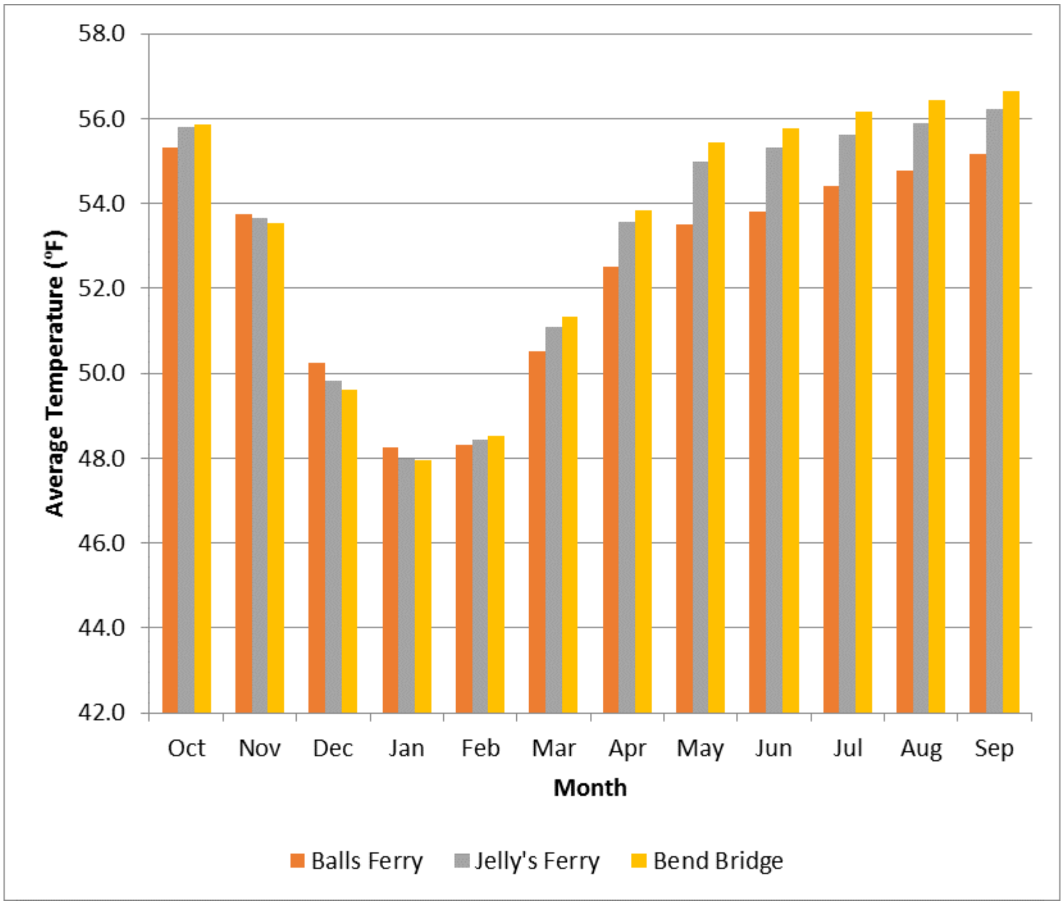



**Figure 6.3 Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations (2001-2012)**

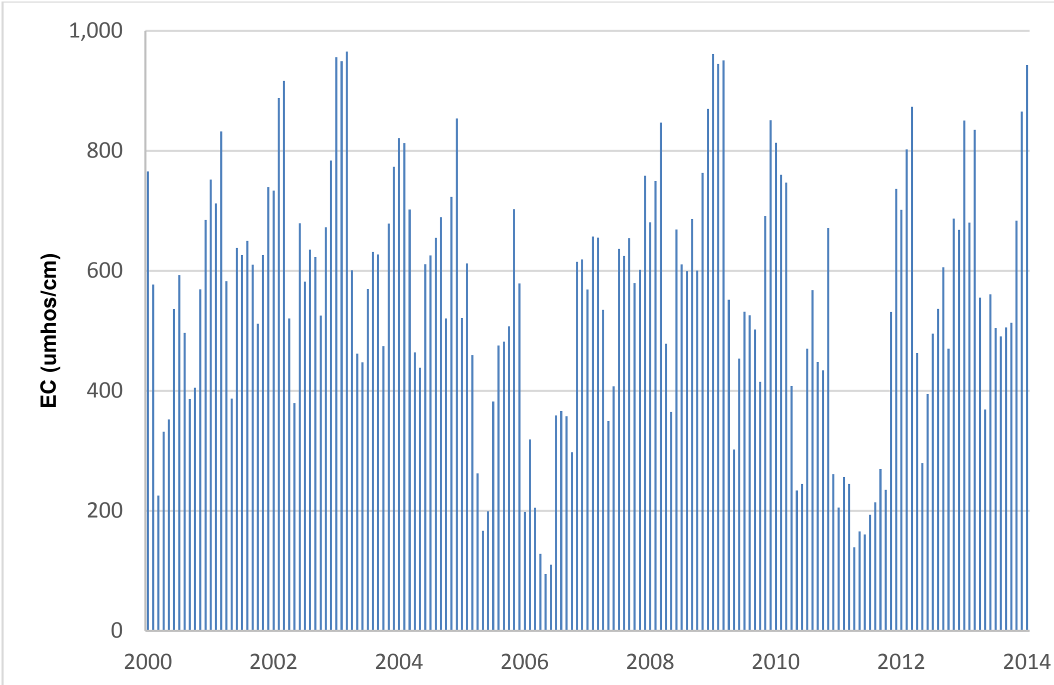



**Figure 6.4 Monthly Average Specific Conductance in San Joaquin River at Vernalis (Reclamation 2013e)**

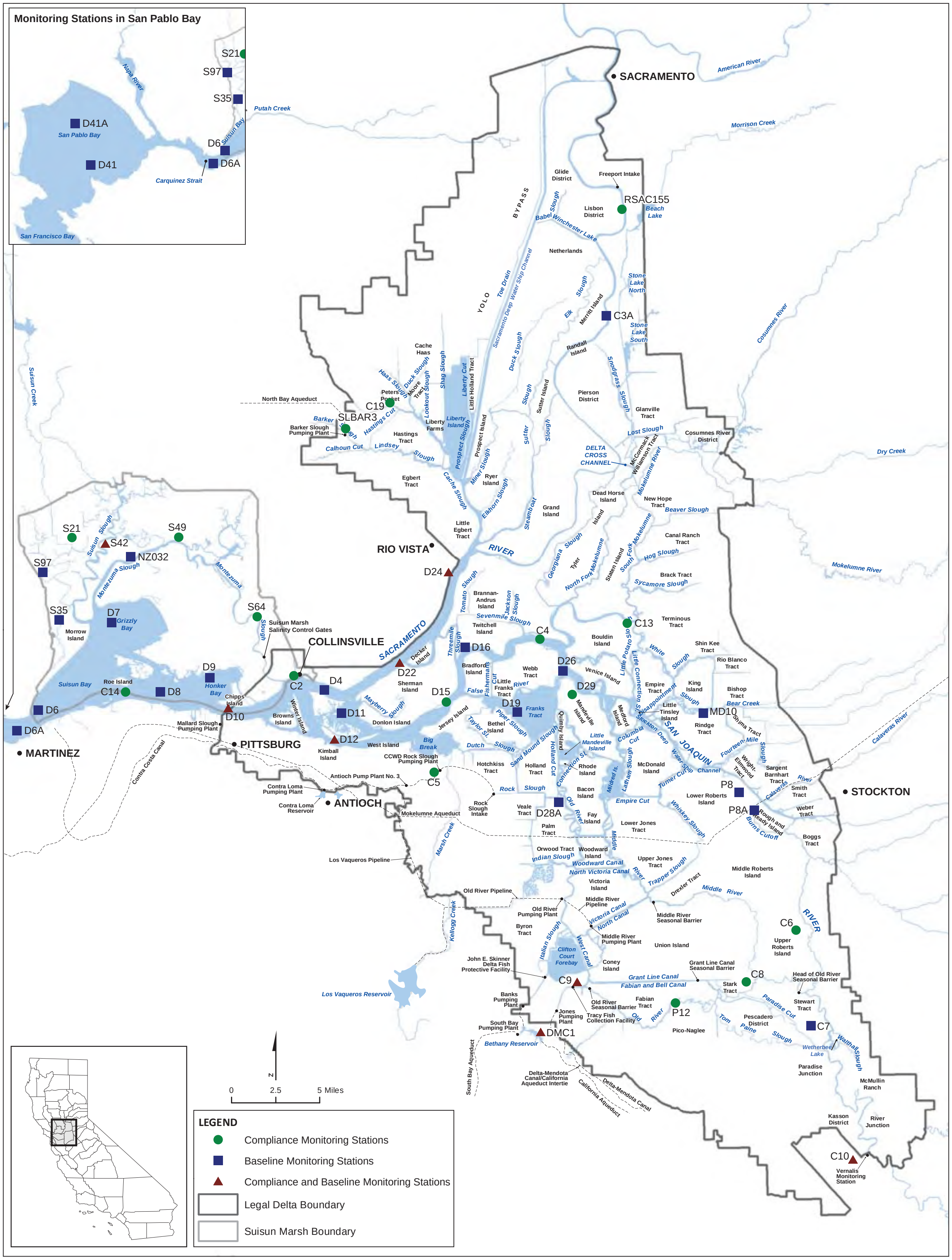



**Figure 6.5. Water Quality Compliance Stations in the Delta**

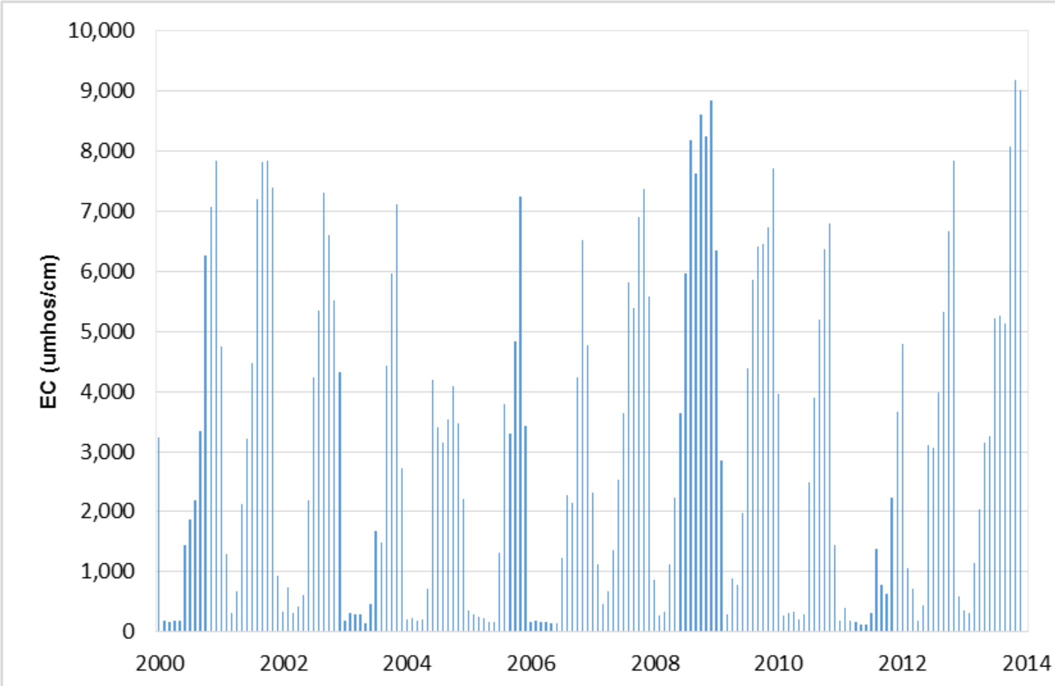



**Figure 6.6 Monthly Average Specific Conductance in Sacramento River at Collinsville (Reclamation 2013e)**

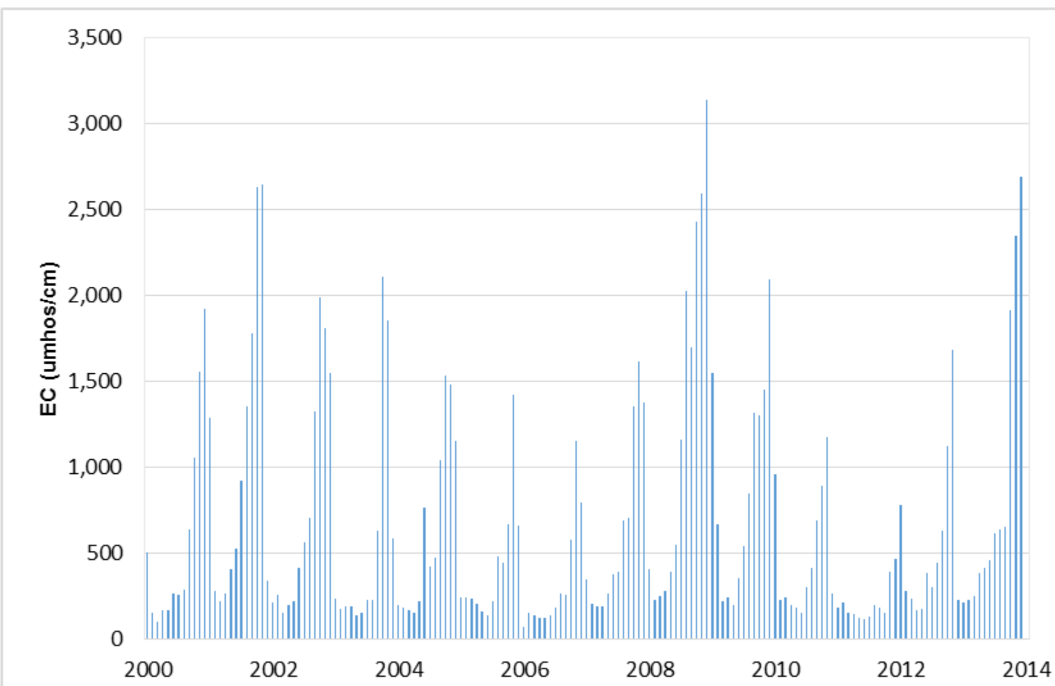



**Figure 6.7 Monthly Average Specific Conductance in Sacramento River at Emmaton (Reclamation 2013e)**

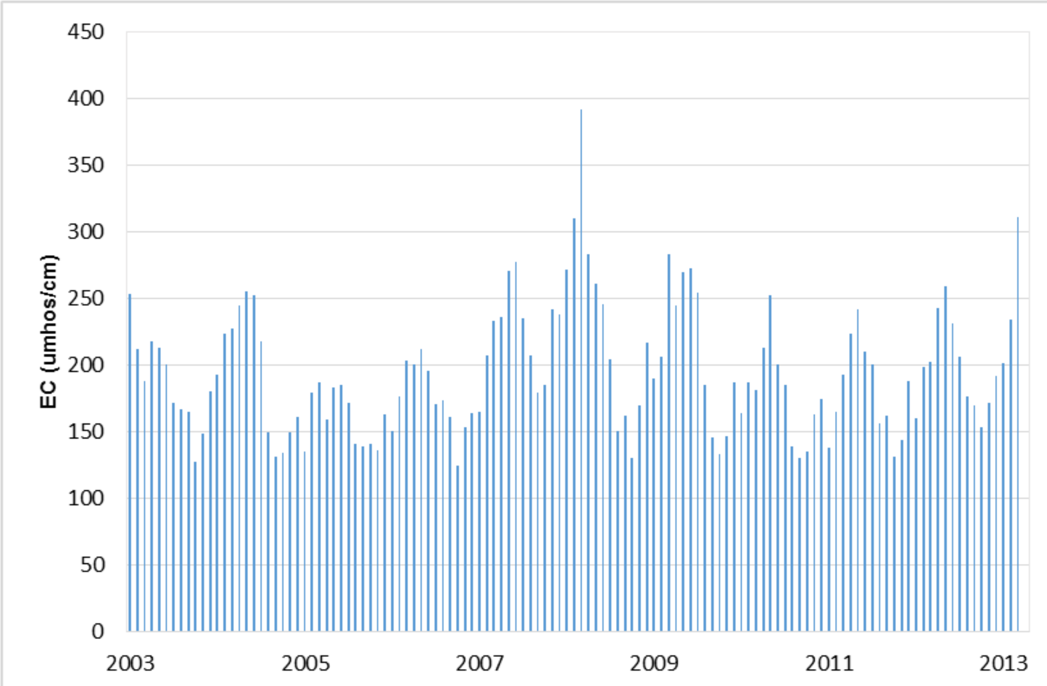



**Figure 6.8 Monthly Average Specific Conductance in Sacramento River at Rio Vista (Reclamation 2013e)**

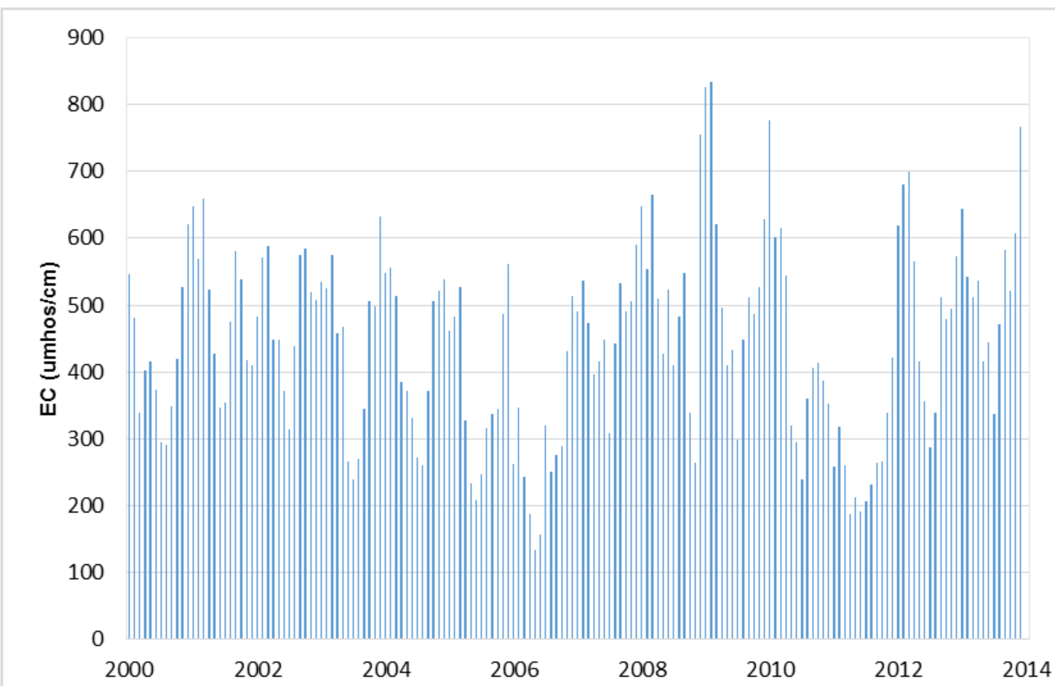



**Figure 6.9 Monthly Average Specific Conductance at Delta Mendota Canal Intake (Reclamation 2013e)**

Chapter 7

# Groundwater Resources and Groundwater Quality

## 7.1 Introduction

This chapter describes groundwater resources and groundwater quality in the study area, and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect groundwater resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 7.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect groundwater resources in the areas along the rivers impacted by changes in the operations of CVP or SWP reservoirs and in the vicinity of and lands served by CVP and SWP water supplies. Groundwater basins that may be affected by implementation of the alternatives are in the Trinity River Region, Central Valley Region, San Francisco Bay Area Region, Central Coast Region, and Southern California Region.

Actions located on public agency lands or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

Several of the state policies and regulations described in Chapter 4 have resulted in specific institutional and operational conditions in California groundwater basins, including the basin adjudication process, California Statewide Groundwater Elevation Monitoring Program (CASGEM), California Sustainable Groundwater Management Act (SGMA), and local groundwater management ordinances, as summarized below.

### 7.2.1 Groundwater Basin Adjudication

Basin adjudications are determined through court decisions or pre-court mediation on litigation that determines the groundwater rights of all the groundwater users overlying the basins. The court identifies the extractors or well owners and the amount of groundwater those well owners are allowed to extract, and appoints a Watermaster whose role is to ensure that the basin is managed in accordance with the court's decree. The Watermaster must report periodically to the court. There are currently 23 adjudicated groundwater basins in California, most of which are located in Southern California. Table 7.1 lists the adjudicated groundwater basins located in the study area.

**Table 7.1 Adjudicated Groundwater Basins in the Study Area**

| Basin Name | Date of Final Court Decision | County |
|---|---|---|
| Antelope Valley Groundwater Basin | Under way | Kern and Los Angeles |
| Beaumont – Upper Santa Ana Groundwater Basin | 2004 | Riverside |
| Brite Groundwater Basin | 1970 | Kern |
| Central Subbasin of the Coastal Plain of Los Angeles Basin | 1965 | Los Angeles |
| Chino Subbasin of the Upper Santa Ana Valley Basin | 1978 | Riverside and San Bernardino |
| Cucamonga Subbasin of the Upper Santa Ana Valley Basin | 1978 | San Bernardino |
| Cummings Valley Groundwater Basin | 1972 | Kern |
| Goleta Groundwater Basin | 1989 | Santa Barbara |
| San Jacinto Groundwater Basin | 2013 | Riverside |
| Los Osos Valley Groundwater Basin | Under way | San Luis Obispo |
| Mojave Basin Area (Lower Mojave River Valley, Middle Mojave River Valley, Upper Mojave River Valley, El Mirage Valley, and Lucerne Valley groundwater basins) | 1996 | San Bernardino |
| San Gabriel Valley Groundwater Basin – excluding Raymond Groundwater Basin | 1973 | Los Angeles |
| San Gabriel Valley Groundwater Basin – Puente Narrows | 1985 | Los Angeles |
| Raymond Groundwater Basin | 1944 | Los Angeles |
| Rialto-Colton Subbasin of the Upper Santa Ana Valley Basin | 1961 | San Bernardino |
| Santa Margarita River Watershed – Santa Margarita Valley, Temecula Valley, and Cahuilla Valley groundwater basins | 1966* | Riverside and San Diego |
| Santa Maria Valley Groundwater Basin | 2008 | San Luis Obispo and Santa Barbara |
| Santa Paula Subbasin of the Santa Clara River Valley Groundwater Basin | 1996 | Ventura |
| Six Basins Area in upper Santa Ana Valley | 1998 | Los Angeles and San Bernardino |
| Tehachapi Valley West Basin and Tehachapi Valley East Basin | 1973 | Kern |

| Basin Name | Date of Final Court Decision | County |
|---|---|---|
| Upper Los Angeles River Area–<br>San Fernando Valley Groundwater Basin | 1979 | Los Angeles |
| Warren Valley Groundwater Basin | 1977 | San Bernardino |
| West Coast Subbasin of the Coastal Plain of Los Angeles Basin | 1961 | Los Angeles |
| Western San Bernardino – Upper Santa Ana Groundwater Basin | 1969 | San Bernardino |

Sources: DWR 2003a, 2014a; LOCSD 2013

Note:

* Santa Margarita Watershed Adjudication addresses both groundwater and surface water if water contributes to Santa Margarita River and its tributaries flows (SMRW 2014). The agreements include interlocutory judgements for Murrieta-Temecula Groundwater Basin that describes non-Indian water rights subject to court jurisdiction, land and water rights not subject to court jurisdiction, reserved water rights for the Pechanga Reservation, and appropriative storage and diversion rights in conjunction with use of groundwater by the Vail Company.

### 7.2.2 California Statewide Groundwater Elevation Monitoring Program

Senate Bill X7-6, enacted in November 2009, mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins defined in Bulletin 118. This amendment to Division 6 of the Water Code, specifically Part 2.11 Groundwater Monitoring, requires the collaboration between local monitoring entities and California Department of Water Resources (DWR) to collect groundwater elevation data. The law requires local agencies to monitor and report the groundwater elevation in the basins. To achieve this goal, DWR developed the CASGEM Program to establish a permanent, locally-managed program of regular and systematic monitoring in all of the state's alluvial groundwater basins.

DWR is required to establish a priority schedule for monitoring groundwater basins, and to report to the Legislature on the findings from these investigations (Water Code section 10920 et. seq). The 2012 CASGEM Status Report to the Legislature describes that more than 400 monitoring entities have been identified and water level data are being submitted to DWR (DWR 2012). The prioritization of basins is to identify, evaluate, and determine the need for additional groundwater level monitoring. The prioritization approach includes the following eight criteria.

- Overlying population in the groundwater basin
- Projected growth of the overlying population
- Number of public water supply wells

- Total number of water supply wells
- Irrigated acreage overlying the groundwater basin
- Reliance on groundwater as the primary source of water by the overlying land uses
- Impacts on groundwater, including overdraft, subsidence, saline intrusion, and other water quality degradation
- Any other information relevant to the groundwater conditions

Groundwater basins designations in the study area are described for each basin in the following subsection of this chapter (DWR 2014e).

### 7.2.3 Sustainable Groundwater Management Act

In September 2014, the SGMA was enacted. The SGMA establishes a new structure for locally managing California's groundwater in addition to existing groundwater management provisions established by Assembly Bill (AB) 3030 (1992), Senate Bill (SB) 1938 (2002), and AB 359 (2011), as well as SBX7-6 (2009).

The SGMA includes the following key elements:

- Provides for the establishment of a Groundwater Sustainability Agency (GSA) by one or more local agencies overlying a designated groundwater basin or subbasin identified in DWR Bulletin 118-03
- Requires all DWR Bulletin 118 groundwater basins found to be of "high" or "medium" priorities to prepare Groundwater Sustainability Plans (GSPs)
- Provides for the proposed revisions, by local agencies, to the boundaries of a DWR Bulletin 118 basin, including the establishment of new subbasins
- Provides authority for DWR to adopt regulations to evaluate GSPs, and review the GSPs for compliance every 5 years
- Requires DWR to establish best management practices and technical measures for GSAs to develop and implement GSPs
- Provides regulatory authority to the State Water Resources Control Board (SWRCB) for developing and implementing interim groundwater management plans under certain circumstances (such as lack of compliance with development of GSPs by GSAs)

The SGMA defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." Undesirable results are defined as any of the following effects.

- Chronic lowering of groundwater levels (not including overdraft during a drought if a basin is otherwise managed)
- Significant and unreasonable reduction of groundwater storage

- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

Based on basin priority definitions defined by DWR's CASGEM program in June 2014 and confirmed in January 2015, the SGMA requires the formation of GSPs by 2020 or 2022. GSPs for medium and high priority basins identified subject to critical conditions of overdraft are required by 2022. All other high and medium priority basins must complete a GSP by 2020. Updates to CASGEM-defined June 2014 designated priorities are possible and can affect GSP deadline requirements. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs.

### 7.2.4 Regional and Local Groundwater Ordinances

Many counties within the study area considered in this EIS have adopted or are considering groundwater ordinances. The ordinances primarily address well installation, groundwater extraction, and export of the groundwater to areas outside the basin of origin. Local county groundwater ordinances vary by authority, agency, or region but typically involve permitting for well installation, and provisions to limit or prevent groundwater overdraft, to regulate transfers, and to protect groundwater quality.

Table 7.2 provides a list of substantial county groundwater ordinances within the study area that could affect groundwater supply availability.

**Table 7.2 County Groundwater Ordinances in the Study Area with a Summary of Regulations**

| County | Ordinance Number and Title | Description |
|---|---|---|
| Trinity | County Code Title 15: Buildings and Construction, Chapter 15.20: Water wells. | Well standards. |
| Trinity and Humboldt | Hoopa Valley Tribal Council Title 37: Pollution Discharge Prohibition Ordinance | Regulates surface water and groundwater operations. |
| Humboldt | County Code Title VI: Water and Sewage, Division 3: Wells. | Well standards. |
| | Hoopa Valley Tribe: Not identified at this time. | Not applicable. |
| Del Norte | County Code Title 7: Health and Welfare Chapter 32: Regulations of Wells and Preservation of Groundwater. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Shasta | County Code Title 18: Environment 18.08: Groundwater Management. | Requires permit for groundwater extraction for use outside county. |
| Shasta | County Code Title 8: Health and Safety, 8.56: Water Wells. | Well standards. |
| Plumas | County Code Title 6: Sanitation and Health, Chapter 8: Water Wells. | Well standards.<br>Groundwater management plans have been adopted in Plumas County, but not in the vicinity of the study area. |
| Tehama | County Code Title 9: Health and Safety, Chapter 9.40: Aquifer Protection. | Prohibits groundwater from being exported out of county.<br>Requires permit to use groundwater from wells on a parcel on other parcels of land. |
| Tehama | County Code Title 9: Health and Safety, Chapter 9.42: Well Construction, Rehabilitation, Repair and Destruction. | Well standards. |
| Glenn | County Code Title 20: Water 20.030: Groundwater Coordinated Resource Management Plan. | Basin Management Objectives and monitoring network to detect changes in groundwater level, quality, land subsidence; and defines acceptable ranges of groundwater levels. |
| | County Code Title 20: Water, 20.080: Water Well Drilling Permits and Standards. | Well standards. |
| Colusa | County Code Chapter 43: Groundwater Management. | Requires permit for groundwater extraction for use outside county. |
| | County Code Chapter 35: Well Standards. | Well standards. |
| Butte | County Code Chapter 33A: Basin Management. | Basin Management Objectives for: groundwater quality and groundwater levels, and other protections to reduce land subsidence. |
| | County Code Chapter 23B: Water Wells. | Well standards. |
| Yuba | County Code Title VII: Health and Sanitation, Chapter 7.03: Water wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Sutter | County Code Section 700: Health and Sanitation, Chapter 765: Water Wells. | Well standards. |
| Placer | County Code Chapter 13: Public Services, Article 13.08: Water Wells. | Well standards. |
| El Dorado | County Code Title 8: Health and Safety, Chapter 8.39: Well Standards. | Well standards.<br>Groundwater management plans have been adopted in El Dorado County, but not in the vicinity of the study area. |
| Sacramento | County Code Title 6: Health and Sanitation, Chapter 6.28: Wells and Pumps. | Well standards. |
| Yolo | County Code Title 10: Environment Chapter 7: Groundwater. | Requires permit for groundwater extraction for use outside of the county. |
| | County Code Title 6: Sanitation and Health, Chapter 8: Water Quality, Article 10: Standards, Criteria, and Regulations of Wells. | Well standards. |
| Solano | County Code Chapter 13.6: Injection Wells. | Restricts operation of injection wells. |
| | County Code Chapter 13.10: Well Standards. | Well standards. |
| Napa | County Code Title 13: Waters, Sewers, and Public Services<br>Chapter 13.15: Groundwater Conservation. | Regulates the use of groundwater. |
| | County Code Title 13: Waters, Sewers, and Public Services<br>Chapter 13.12: Wells. | Well standards. |
| San Joaquin | County Code Title 5: Health and Sanitation, Division 4: Wells and Well Drilling. | Well standards. |
| | County Code Title 5: Health and Sanitation, Division 8: Groundwater. | Requires permit for groundwater use outside of the county. |
| Stanislaus | County Code Title 9: Health and Safety, Chapter 9.37: Groundwater Mining and Export Prevention. | Regulates groundwater use and prohibits export of water outside of the county (except as noted in the requirements). |
| | County Code Title 9: Health and Safety, Chapter 9.36: Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Madera | County Code Title 13: Waters and Sewers, V Groundwater Exportation, Groundwater Banking, and Importation of Foreign Water, for Purposes of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands Within their Boundaries.<br>Chapter 13.1: Rules and Regulations Pertaining to Groundwater Banking—Importation of Foreign Water, for the Purpose of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands within their Boundaries—Exportation of Groundwater Outside the County. | Regulates development of groundwater banking, including importation of groundwater to be stored in the groundwater bank, and exportation of groundwater for use outside of the county; and prohibits groundwater injection. |
| | County Code Title 13: Waters and Sewers, I: Water, Chapter 13.52: Well Standards. | Well standards. |
| Merced | County Code Title 9: General Health and Safety, Chapter 9.28: Wells. | Well standards. |
| Fresno | County Code Title 14: Waters and Sewers, Chapter 14.03: Groundwater Management. | Regulates groundwater use outside of the county. |
| | County Code Title 14: Waters and Sewers, Chapter 14.04: Well Regulations – General Provisions. | Well standards. |
| | County Code Title 14: Waters and Sewers Chapter 14.08: Well Construction, Pump Installation and Well Destruction Standards. | Well standards. |
| Tulare | County Code Part IV: Health, Safety, and Sanitation, Chapter 13: Well. | Well standards. |
| Kings | County Code Chapter 14A: Water Wells. | Well standards. |
| Kern | County Code Title 14: Utilities Chapter 14.08: Water Supply Systems, Article III: Well Standards. | Well standards. |
| Contra Costa | County Code Title 4: Health and Safety, Chapter 414: Waterways and Water Supply, Chapter 414-4: Water supply. | Well standards. |
| Alameda | County Code Title 6: Health and Safety, Chapter 6.88: Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Santa Clara | Santa Clara Valley Water District Act (California Water Code Appendix, Chapter 60). | Santa Clara Valley Water District is the designated agency to manage water within Santa Clara County, including groundwater management to recharge the basin, conserve water, increase water supply, and prevent waste or diminution of the water supply. |
| | Santa Clara Valley Water District Well Ordinance 90-1. | Well standards. |
| San Benito | County Code Title 15: Public Works, Chapter 5.05: Water, Article I: Groundwater Aquifer Protections. | Regulates use of groundwater on non-contiguous parcels with separate owners than parcel with well, injection of groundwater, and operations that could adversely affect other groundwater users or the groundwater aquifer. |
| | County Code Title 15: Public Works, Chapter 5.05: Water, Article III: Well Standards. | Well standards. |
| San Luis Obispo | County Code Title 8: Health and Sanitation, Chapter 8.40: Construction, Repair, Modification and Destruction of Wells. | Well standards. |
| Santa Barbara | County Code Chapter 34A: Wells. | Well standards. |
| Ventura | County Code Division 4: Public Health, Chapter 8: Water, Article 1: Groundwater Conservation. | Well standards. |
| Los Angeles | County Code Title 11: Health and Safety, Chapter: 11.38 Water and Sewers, Part 2: Water and Water Wells. | Well standards. |
| Orange | County Code Title 4: Health and Sanitation and Animal Regulations, Division 5: Water Conservation, Article 3 Construction and Abandonment of Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| San Diego | County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 4: Wells. | Well standards. |
| | County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 7: Groundwater. | Regulates actions for the protection, preservation, and maintenance of groundwater resources. |
| Riverside | County Code Title 13: Public Services, Chapter 13.20: Water Wells. | Well standards. |
| San Bernardino | County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 3: Water Wells. | Well standards. |
| | County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 5: Desert Groundwater Management. | Regulates groundwater basins not adjudicated by judicial decree; and wells not within the boundaries of the Mojave Water Agency and public water agencies within the Morongo Basin, incorporated areas, or Federal lands. This section does not apply to wells used for existing mining operations, small agricultural operations, small wells, or replacement wells of similar size to abandoned wells. This section does not apply to areas with a groundwater management plan and a memorandum of understanding with the county. |

Sources: Trinity County 2014; Hoopa Valley Tribe 2008; Humboldt County 2014; Del Norte County 2014; Shasta County 2014 a, b; Plumas County 2014; Tehama County 2014; Glenn County 2014; Colusa County 2014 a, b; Butte County 2014 a, b; Yuba County 2014; Sutter County 2014; Placer County 2014; El Dorado County 2014; Sacramento County 2014; Yolo County 2014; Solano County 2014; Napa County 2014; San Joaquin County 2014; Stanislaus County 2014; Madera County 2014; Merced County 2014; Fresno County 2014; Tulare County 2014; Kings County 2014; Kern County 2014; Contra Costa County 2014; Alameda County 2014; SCVWD 2014 a, b; San Benito County 2014; San Luis Obispo County 2014a; Santa Barbara County 2014; Ventura County 2014; Los Angeles County 2014a; Orange County 2014; San Diego County 2014; Riverside County 2014; San Bernardino County 2014

## 7.3 Affected Environment

This section describes groundwater resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in groundwater resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

Groundwater occurs throughout the study area. However, the groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in this EIS are related to groundwater basins which include users of CVP and SWP water supplies that also use groundwater, and areas along the rivers downstream of CVP or SWP reservoirs that use groundwater supplies. Therefore, the following description of the affected environment is limited to these areas and does not include groundwater basins or subbasins that area not directly or indirectly affected by changes in CVP and SWP operations.

### 7.3.1 Overview of California Groundwater Resources

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is a vital resource in California. Groundwater supplied about 37 percent of the state's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40 percent or more during dry and critical water years in that period (DWR 2013i). About 20 percent of the nation's groundwater demand is supplied from the Central Valley aquifers, making it the second-most-pumped aquifer system in the United States (USGS 2009). The three Central Valley hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75 percent of the state's average annual groundwater use (DWR 2013i).

The DWR has delineated 515 distinct groundwater systems throughout the state, as described in Bulletin 118-03 (DWR 2003a), that are considered to be the most important groundwater basins. These basins and subbasins have various degrees of supply reliability considering yield, storage capacity, and water quality, and are typically alluvial, or non-consolidated (non-fractured rock) aquifers. Figure 7.1 shows the statewide occurrence of groundwater in the groundwater basins and subbasins identified by DWR as Bulletin 118 basins. A majority of the descriptions provided herein are summarized form DWR Bulletin 118 reports.

The importance of groundwater as a resource varies regionally. The Central Coast has the most reliance on groundwater to meet its local uses, with more than 80 percent of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The central and southern San Joaquin Valley (described as the Tulare Lake Area of the San Joaquin Valley Groundwater Basin in this chapter) groundwater use, on average, meets about 50 percent of the total water supplies. The Sacramento Valley and northern portion of the San Joaquin Valley Groundwater Basin use groundwater to meet approximately 30 and 40 percent of the agricultural, municipal, and industrial water demand, respectively. In the coastal areas of Southern California, groundwater use varies from less than 10 percent in western San Diego County to between 35 and 50 percent of the agricultural, municipal, and industrial water supplies in counties along the coast western Ventura, Los Angeles, and Riverside counties and Orange County, on an annual average basis. In the inland areas of Southern California, groundwater use varies from approximately 45 to over 90 percent of the agricultural, municipal, and industrial water supplies (DWR 2013).

A comprehensive assessment of overdraft in all of the state's groundwater basins has not been conducted since Bulletin 118-80 was published in 1980, but overdraft is estimated at between 1 to 2 million acre-feet annually (DWR 2003a). In DWR's Bulletin 118-80 (DWR 1980), an assessment of critically overdrafted basins was conducted, as shown in Figure 7.2. This assessment identified 11 basins in critical condition of overdraft. Based on SGMA requirements, the state must identify basins subject to critical conditions of overdraft in 2015, publish the final list in 2016, and use this list in the Bulletin 118 Interim Update 2017. This revised list is being finalized at the same time as this EIS document is finalized. This revised draft list added three basins in the EIS study area that are considered in critical conditions of overdraft (DWR 2015):

- Merced (5-22.04): Subsidence in El Nido area of 0.6 to 1.0 ft/year
- Delta-Mendota ((5-22.07): Significant, on-going and irreversible subsidence
- Westside (5-22.09): Significant, on-going and irreversible subsidence

In the past 20 years, specific groundwater studies have been conducted by regional water agencies or the U.S. Geological Survey (USGS) to update the statewide survey conducted by DWR in 1980 (USGS 2000a, 2006, 2008, 2009, 2012, 2014). The results of many of those studies are discussed in the following subsections of this chapter.

### 7.3.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater, and, therefore, are not considered a major source. A number of shallow wells adjacent to the river provide water for domestic purposes (Reclamation et al. 2006a; NCRWQCB et al. 2009). Groundwater present in these alluvial valleys is in close hydraulic connection with the Trinity River and its tributaries. Both groundwater discharge to surface streams as well as leakage of steam flow to underlying aquifers are expected to occur at various locations.

The Bulletin 118-03 (DWR 2003a, 2004do, 2004dp) identified only two groundwater basins underlying the Trinity River Region in the Study Area, Hoopa

Valley and Lower Klamath River Valley groundwater basins, as shown in Figure 7.3. These groundwater basins are small, isolated, valley-fill aquifers that provide a very limited quantity of groundwater to satisfy local domestic, municipal, and agricultural needs. Groundwater pumped from these aquifer systems is used strictly for local supply.

As described in Chapter 5, Surface Water Resources and Water Supplies, several communities use infiltration galleries along the Trinity River and the tributaries to convey surface water to groundwater wells, including the Lewiston Community Services District, Lewiston Valley Water Company, and Lewiston Park Mutual Water Company (NCRWQCB et al. 2009).

Groundwater within the Hoopa Valley Indian Reservation occurs along alluvial terraces (Hoopa Valley Tribe 2008). The aquifers are approximately 10 to 80 feet deep. Some of the shallow wells are productive only during winter and early spring months.

The Lower Klamath River Valley Groundwater Basin extends over 7,030 acres in Del Norte and Humboldt counties, including areas along the Lower Klamath River (Reclamation 2010a). Groundwater along the Lower Klamath River occurs in alluvial fans near the confluences of major tributaries and along terrace and floodplain deposits adjacent to the river (Yurok Tribe 2012). The aquifers range in depth from 10 to 80 feet and are used by some members of the community.

The Hoopa Valley and Lower Klamath River Valley groundwater basins were designated by the CASGEM program as very low and low priorities, respectively.

Groundwater quality is suitable for many beneficial uses in the region. In other locations, the groundwater can include naturally occurring metals, including manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Other groundwater quality issues include nitrate contamination (DWR 2013i). Groundwater and surface water contamination is suspected at several former and existing mill sites that historically used wood treatment chemicals. Discharges of pentachlorophenol, polychlorodibenzodioxins, and polychlorodibenzofurans have likely occurred due to the poor containment practices typically used in historical wood treatment applications. Additional investigation, sampling and monitoring, and enforcement actions have been limited by the insufficient resources that exist to address this historical toxic chemical problem (NCRWQCB 2005).

### 7.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

Groundwater for the Central Valley Region is described in relation to the basins described by DWR in Bulletin 118-03 (DWR 2003a). The overall area includes the Sacramento Valley Basin which extends through the Sacramento Valley, and the San Joaquin Valley Groundwater Basin (including the Tulare Lake Area, which extends through the San Joaquin Valley). The Delta and Suisun Marsh area are located partially in the Sacramento Valley Basin and partially in the

San Joaquin Valley Groundwater Basin. The Delta and Suisun Marsh area is described separately because of its distinct characteristics as an estuary at the confluence of the Sacramento and the San Joaquin rivers.

#### *7.3.3.1 Sacramento Valley*

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin is one of the largest groundwater basins in the state, and extends from Redding in the north to the Delta in the south (USGS 2009).

Approximately one-third of the Sacramento Valley's urban and agricultural water needs are met by groundwater (DWR 2003a). The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation becomes recharge to the groundwater aquifer or flows back to surface waterways.

Overall, the Sacramento Groundwater Basin is approximately balanced with respect to annual recharge and pumping demand. However, there are several locations showing early signs of persistent drawdown, suggesting limitations due to increased groundwater use in dry years. Locations of persistent drawdown include: Glenn County, areas near Chico in Butte County, northern Sacramento County, and portions of Yolo County.

The water quality of groundwater in the Sacramento Valley is generally good, as described below for individual basins. Several areas have localized aquifers with high nitrate, total dissolved solids (TDS) or boron concentrations. High nitrate concentrations frequently occur due to residuals from agricultural operations or septic systems. High TDS, a measure of salinity, concentration can be an indicator of brackish or connate water when it occurs in high concentrations. High boron concentration usually is associated with naturally occurring deposits.

##### 7.3.3.1.1 Overview of Groundwater Basins in the Sacramento Valley

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Redding Groundwater Basin is situated in the extreme northern end of the valley and is a separate, isolated groundwater basin, but due to similarities in geology and stratigraphy is discussed as part of the overall Sacramento Valley. It is bordered by the Coast Ranges on the west, and by the Cascade Range and Sierra Nevada mountains on the east.

The Sacramento Valley Groundwater Basin has been divided into 17 subbasins by DWR, as shown in Figure 7.4, based on groundwater characteristics, surface water features, and political boundaries (DWR 2003a). However, from a hydrologic standpoint, these individual groundwater subbasins have a high degree of hydraulic connection because the rivers do not always act as barriers to groundwater flow. Therefore, the Sacramento Valley Groundwater Basin functions primarily as a single laterally extensive alluvial aquifer, rather than numerous discrete, smaller groundwater subbasins.

For discussion purposes, and due to their common characteristics, the Sacramento Valley is further sub-divided into the Upper Sacramento Valley, the Lower

Sacramento Valley West of the Sacramento River, and the Lower Sacramento Valley East of the Sacramento River.

*General Hydrogeology of the Sacramento Valley*

Freshwater in the Sacramento Valley Groundwater Basin occurs within the continental deposits. Hydrogeologic units containing freshwater along the eastern portion of the basin, primarily occur in the Tuscan and Mehrten formations, and are derived from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the Sierra Nevada. The primary hydrogeologic unit in the western portion of the Sacramento Valley is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits. Generally, groundwater flows inward from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet below the ground surface, with shallower depths along the Sacramento River and greater depths along the basin margins. Wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. The deepest elevation of the base of freshwater in the Sacramento Valley ranges between 400 feet and 3,350 feet below mean sea level (Berkstresser 1973). The location where the base of freshwater is the deepest occurs in the Delta near Rio Vista. Near the valley margins and the Sutter Buttes, the base of freshwater is relatively shallow; suggesting that the base of freshwater may coincide with bedrock or connate water trapped in shallower deposits close to the basin margins (Berkstresser 1973).

Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, especially in areas where water demands are met primarily, and in some locales exclusively, by groundwater. These areas include portions of the far west side of the Sacramento Valley in Glenn County, portions of Butte County near Chico, in portions of Yolo County, and in the northern Sacramento County area. The persistent areas of drawdown could be early signs that the limits of sustainable groundwater use have been reached in these areas. Due to the drought that started in 2011, surface water supplies have declined and new wells have been installed. Between January and October 2014, over 100 water supply wells were drilled in both Shasta and Butte counties (DWR 2014d).

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (non-recoverable changes) of fine-grained sediments related to groundwater withdrawal. Areas of subsidence from groundwater level declines have been measured in the Sacramento Valley at several locations. Subsidence monitoring was established following several studies in the 1990s that indicated more than four feet of subsidence since 1954 in some areas, such as in Yolo County (Ikehara 1994). Initial data from the Yolo County extensometers indicated subsidence in the Zamora area, which has subsequently been confirmed with a countywide global positioning system network installed in 1999 and monitored in 2002 and 2005. Subsidence up to 0.4 feet occurred between 1999 and 2005 in the Zamora area (Frame Surveying and Mapping 2006). The Zamora area does not currently use CVP or SWP water supplies. However, this area was designated as part of the CVP Sacramento Valley Irrigation Canals service area in the Reclamation Act of 1950 and as amended in the Reclamation Act of 1980 and Central Valley Project Improvement Act.

#### 7.3.3.1.2 Upper Sacramento Valley

The Upper Sacramento Valley includes the Redding Groundwater Basin and upper portions of the Sacramento Valley Groundwater Basin (DWR 2003a). The Redding Groundwater Basin extends from approximately Redding in Shasta County through the northern portions of Tehama County. The portions of the Sacramento Valley Groundwater Basin in the Upper Sacramento Valley are located primarily in Tehama County with small portions extending into Glenn County near Orland and Butte County near Chico in the south. The geology of this area is dominated by the Tuscan and Tehama Formations. The hydrology of this area is dominated by numerous smaller drainages that originate in the Sierra Nevada, Cascade, and Coast Ranges and drain to the Sacramento River (DWR 2003a).

*Hydrogeology and Groundwater Conditions*

The Redding Groundwater Basin comprises the northernmost part of the Sacramento Valley and is bordered by the Klamath Mountains to the north, the Coast Ranges to the west, the Cascade Mountains to the east, and the Red Bluff Arch to the south. This basin consists of a sediment-filled, symmetrical, southward-dipping trough formed by folding of the marine sedimentary basement rock. These deposits are overlain by a thick sequence of inter-bedded, continentally-derived, sedimentary, and volcanic deposits of Late Tertiary and Quaternary age. The primary fresh water-bearing deposits in the basin are the Pliocene age volcanic deposits of the Tuscan Formation and the Pliocene age continental deposits of the Tehama Formation (DWR 2003a, 2003b, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f).

The Tehama Formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the Coast Ranges to the west. The Tehama Formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing to the east towards the Sacramento River (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Tuscan formation is derived from the Cascade Range to the east and is primarily composed of volcaniclastic sediments.

The Redding Groundwater Basin includes six subbasins: Anderson, Rosewood, Bowman, Enterprise, Millville, and South Battle Creek (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Anderson subbasin is one of the main groundwater units in the Redding Basin. Groundwater levels in the unconfined and confined portions of the aquifer system fluctuate annually by 2 to 4 feet during normal precipitation years and up to 10 to 16 feet during drought years (DWR 2003b). Between spring 2010 and spring 2014 in the Redding Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet. The groundwater levels in some areas declined up to 10 feet between Fall 2013 and Fall 2014 (DWR 2014c, 2014d).

Tehama County overlies three subbasins within the Redding Groundwater Basin and seven subbasins in the Sacramento Valley Groundwater Basin. The Rosewood, South Battle Creek, and Bowman subbasins in the Redding Groundwater Basin are located in Tehama County. The Red Bluff, Corning, Bend, Antelope, Dye Creek, Los Molinos, and Vina subbasins in the Sacramento Valley Groundwater Basin are located in Tehama County (DWR 2004b, 2004c, 2004f, 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). The Corning subbasin extends into northern Glenn County near Orland. The Vina subbasin extends into northern Butte County near Chico. Groundwater levels in these subbasins show a significant seasonal variation due to high groundwater use for irrigation during the summer months. Groundwater levels showed significant declines in some wells associated with the 1976 to 1977 and 1987 to 1992 drought periods. Groundwater levels appeared to recover quickly during subsequent wet years. Groundwater levels in the Corning area of Tehama County showed a general decline before 1965 due to increased groundwater pumping for agricultural uses. Following construction by the CVP of the Tehama-Colusa Canal and the Corning Canal, surface water was delivered to these areas and there was a subsequent upward trend in groundwater levels following initial operations (Tehama County Flood Control and Water Conservation District 1996). Between spring 2010 and spring 2014 in the Upper portion of the Sacramento Valley Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells approximately 2.5 feet to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the Redding Groundwater Basin is generally good to excellent for most uses. Some areas of poor quality due to high salinity from marine sedimentary rock exist at the margins of the basin. Portions of the basin are characterized by high boron, iron, manganese, and nitrates in localized areas (DWR 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). In general, groundwater in the Sacramento Valley Groundwater Basin within Tehama County is of excellent quality, with some localized areas with groundwater quality concerns related to boron, calcium, chloride, magnesium, nitrate, phosphorous, and TDS (DWR 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). In the vicinity of Antelope, east of Red Bluff, historical high nitrates in groundwater occur. Higher boron levels have been detected in wells located in the eastern portion of Tehama County. High salinity occurs near Salt Creek, which most likely originates from the Tuscan Springs, which is a source of high boron and sulfates.

The Vina subbasin was designated by the CASGEM program as high priority. The Anderson, Enterprise, Bowman, Red Bluff, Corning, Antelope, Dye Creek, and Los Molinos subbasins were designated medium priority. The Rosewood, Millville, South Battle Creek, and Bend subbasins were designated very low priority in the June 2014 CASGEM designation.

*Groundwater Use and Management*

Tehama County uses groundwater to meet approximately 65 percent of its total water needs (Tehama County Flood Control and Water Conservation District 2008). Groundwater in the county provides water supply for agricultural, domestic, environmental, and industrial uses.

One of the main users of groundwater in this area is the Anderson-Cottonwood Irrigation District. Approximately 5 percent of the irrigated acres rely upon groundwater (DWR 2003b). Groundwater also is the primary water supply for residences and small scale agricultural operations.

#### 7.3.3.1.3 Lower Sacramento Valley (West of Sacramento River)

The Lower Sacramento Valley area west of the Sacramento River includes three main groundwater subbasins: Colusa, Yolo, and Solano (DWR 2003a, 2004m, 2004n, 2006b).

*Hydrogeology and Groundwater Conditions*

*Colusa Subbasin*

The Colusa subbasin is bordered by the Coast Ranges to the west, Stony Creek to the north, Sacramento River to the east, and Cache Creek to the south. The Colusa subbasin extends primarily in western Glenn and Colusa counties. This subbasin is composed of continental deposits of late Tertiary age, including the Tehama and the Tuscan Formations, to Quaternary age, including alluvial and floodplain deposits as well as Modesto and Riverbank Formations. The Tehama Formation represents the main water bearing formation for the Colusa subbasin (DWR 2003b, 2006b). Groundwater levels are fairly stable in this subbasin, except during droughts, such as in 1976 and 1977 and 1987 to 1992 (DWR 2013a). Groundwater levels in the Colusa subbasin declined in the 2008 drought, and increased during the wetter periods of 2010 and 2011 to the pre-drought 2008 levels (DWR 2014c, 2014d). Historically, groundwater levels fluctuate by approximately 5 feet seasonally during normal and dry years (DWR 2006b, 2013a). Recent information indicates that groundwater levels declined at multiple wells in the Colusa subbasin approximately 10 to 20 feet between spring 2010 and spring 2014 in southwestern Colusa subbasin (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality for the Colusa subbasin is characterized by moderate to high TDS; with localized areas of high nitrate and manganese concentrations near the town of Colusa (DWR 2013a, 2006b). High TDS and boron concentrations have been observed near Knights Landing. High nitrate levels have been observed near Arbuckle, Knights Landing, and Willows.

The Colusa subbasin was designated by the CASGEM program as medium priority.

*Yolo Subbasin*

The Yolo subbasin lies to the south of the Colusa subbasin primarily within Yolo County. The primary water bearing formations for the Yolo subbasin are the same as those for the Colusa subbasin. Younger alluvium from flood basin deposits and stream channel deposits lie above the saturated zone and tend to provide significant well yields. In general, groundwater levels are stable in this subbasin, except during periods of drought, and in certain localized pumping depressions in the vicinity of Davis, Woodland, and Dunnigan and Zamora areas (DWR 2004m, 2013a). However, between spring 2010 and spring 2014 in the Yolo subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality is generally good for beneficial uses except for localized impairments including elevated concentrations of boron in groundwater along Cache Creek and in the Cache Creek Settling Basin area, elevated levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (DWR 2004m, 2013a). The cities of Davis and Woodland, which heavily rely on groundwater supply, lost nine municipal wells since 2011 due to high nitrate concentrations (YCFCWCD 2012). Sources of high nitrate concentrations near these cities have been determined to be primarily from agricultural and wastewater operations. High salinity levels have also been reported in some areas that may be related to groundwater use for irrigation which tends to increase salt concentrations in groundwater.

In Yolo County, as much as 4 feet of groundwater withdrawal-related subsidence has occurred since the 1950s. Groundwater withdrawal-related subsidence has damaged or reduced the integrity of highways, levees, irrigation canals, and wells in Yolo County, particularly in the vicinities of Zamora, Knights Landing, and Woodland (Water Resources Association of Yolo County 2007).

The Yolo subbasin was designated by the CASGEM program as high priority.

*Solano Subbasin*

The Solano subbasin includes most of Solano County, southeastern Yolo County, and southwestern Sacramento County. In the Solano subbasin, general groundwater flow directions are from the northwest to the southeast (DWR 2004n, 2013a). Increasing agricultural and urban development in the 1940s in the Solano subbasin has caused significant groundwater level declines. Today, groundwater levels are relatively stable but show significant declines during drought cycles. Groundwater level data also suggest that these declines tend to recover quickly during subsequent wet years. Between spring 2010 and spring 2014 in the Solano subbasin, recent information indicates that groundwater levels declined at multiple wells by at least 10 feet (DWR 2014c, 2014d).

Groundwater quality in the Solano subbasin is generally good and is deemed appropriate for domestic and agricultural use (DWR 2004n, 2013a). However, TDS concentrations are moderately high in the central and southern areas of the basin with localized areas of high calcium and magnesium.

The Solano subbasin was designated by the CASGEM program as medium priority.

*Groundwater Use and Management*

Many irrigators on the west side of the Sacramento Valley relied primarily on groundwater prior to completion of the CVP Tehama-Colusa Canal facilities which conveyed surface water to portions of Colusa County.

In the Colusa subbasin, although surface water is the primary source of water to meet water supply needs, groundwater is also used to assist in meeting agricultural, domestic, municipal, and industrial water needs, primarily in areas outside of established water districts. The Tehama Colusa Canal Authority service area is also an area of groundwater use in the Colusa subbasin. Although the Tehama-Colusa Canal Authority delivers surface water to agricultural users when the CVP water supplies are restricted due to hydrologic conditions, water users rely upon groundwater to supplement limited surface water supplies.

Groundwater is the source of water for municipal and domestic uses in Yolo County except for the City of West Sacramento, as described in Chapter 5, Surface Water Resources and Water Supplies. Recently, in normal years, approximately 40 percent of the irrigation users in Yolo County rely on groundwater (Yolo County 2009). For the East Yolo South area of the County (eastern Yolo subbasin), a 2006 study estimated that groundwater supplies about 80 to 85 percent of the total annual water demand in the county (YCFCWCD 2012).

Within Yolo and Sacramento counties portions of the Solano subbasin, groundwater is primarily used for domestic and irrigation uses. Within Solano County, groundwater is used exclusively by most rural residential landowners and the cities of Rio Vista and Dixon (Solano County 2008). The City of Vacaville uses groundwater to provide approximately 30 percent of the water supply. Other communities rely upon surface water, as described in Chapter 5, Surface Water Resources and Water Supplies. Irrigation users within the Solano Irrigation District rely upon surface water. All other irrigation users rely upon groundwater.

#### 7.3.3.1.4 Lower Sacramento Valley (East of Sacramento River)

The Lower Sacramento Valley area is located to the east of the Sacramento River, and includes seven groundwater subbasins: West Butte, East Butte, North Yuba, South Yuba, Sutter, North American, and South American (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

*Hydrogeology and Groundwater Conditions*

The aquifer system throughout the Lower Sacramento Valley east of the Sacramento River is composed of Tertiary to late Quaternary age deposits. The confined portion of the aquifer system includes the Tertiary-age Tuscan and Laguna formations. The Tuscan formation consists of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash deposits. The Laguna formation consists of moderately consolidated and poorly to well cemented interbedded alluvial sand, gravel, and silt with a low permeability, overall. The Quaternary portion of the aquifer system, typically unconfined, is largely composed of unconsolidated gravel, sand, silt, and clay stream channel and alluvial fan deposits. South and east of the Sutter Buttes, the deposits contain Pleistocene alluvium, which is composed of loosely compacted silts, sands, and gravels that are moderately permeable; however, nearly impermeable hardpans and claypans also exist in this deposit, which restrict the vertical movement of groundwater (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

*West and East Butte Subbasins*

The West Butte subbasin is located within Butte, Glenn, and Sutter counties. In the West Butte subbasin, groundwater levels declined during the 1976 to 1977 and 1987 to 1992 droughts, followed by a recovery in groundwater levels to pre-drought conditions of the early 1980s and 1990s (DWR 2004o, 2013a). A comparison of spring-to-spring groundwater levels from the 1950s and 1960s, to levels in the early 2000s, indicates about a 10-foot decline in groundwater levels in portions of this subbasin. Several groundwater depressions exist in the Chico area, due to year-round groundwater extraction for municipal uses. Between spring 2010 and spring 2014 in the West Butte subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet near Chico (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

The East Butte subbasin is located with Butte and Sutter counties. In the northern portion of the East Butte subbasin, annual groundwater fluctuations in the confined and semi-confined aquifer system ranges from 15 to 30 feet during normal years (DWR 2004p, 2013a). In the southern part of Butte County, groundwater fluctuations for wells constructed in the confined and semi-confined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Between spring 2010 and spring 2014 in the East Butte subbasin, recent information indicates that groundwater levels either increased or declined at multiple wells by approximately 2 to 3 feet near Oroville (DWR 2014c, 2014d).

High nitrates occur near the Chico area in the West Butte subbasin. There are localized areas in the subbasin with high boron, calcium, electrical conductivity (EC), and TDS concentrations (DWR 2004 o, 2013a). There are several groundwater areas near Chico that historically had high perchloroethylene concentrations from industrial sites. Following implementation of groundwater treatment, the chemicals have not been detected (Butte County 2010).

There are localized high concentrations of calcium, salinity, iron, manganese, magnesium, and TDS throughout the East Butte subbasin (DWR 2004p, 2013a).

The West Butte subbasin was designated by the CASGEM program as high priority. The East Butte subbasin was designated as medium priority.

*North and South Yuba Subbasins*

The North Yuba subbasin is located within Butte and Yuba counties. The South Yuba subbasin is located within Yuba County. In the North Yuba and South Yuba subbasins areas along the Feather River, the groundwater levels have been generally stable since at least 1960, with some seasonal fluctuations between spring and summer conditions. Groundwater levels in the central parts of the two subbasins declined until about 1980, when surface water deliveries were extended to these areas and groundwater levels started to rise. Hydrographs in the central portions of the North and South Yuba subbasins also show the effect of groundwater substitution transfers (during 1991, 1994, 2001, 2002, 2008, and 2009), in the form of reduced groundwater levels followed by recovery to pre-transfer levels (YCWA 2010). Between spring 2010 and spring 2014 in the North Yuba and South Yuba subbasins, recent information indicates that groundwater levels declined at multiple wells by 10 to 20 feet, especially near Yuba City (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

Historical water quality data show that in most areas of the North and South Yuba subbasins, trends of increasing concentrations of calcium, bicarbonate, chloride, alkalinity, and TDS occur. In general, groundwater salinity increases with distance from the Yuba River. No groundwater quality impairments were documented at the DWR monitoring wells in the North Yuba subbasin (DWR 2006c). High salinity occurred in the Wheatland area of the South Yuba subbasin within the South Yuba Water District and Brophy Irrigation District (DWR 2006d; YCWA 2010).

The North Yuba and South Yuba subbasins were designated by the CASGEM program as medium priority.

*Sutter Subbasin*

The Sutter subbasin is located in Sutter County. In the Sutter subbasin, groundwater levels have remained relatively constant. The water table is very shallow and most groundwater levels in the subbasin tend to be within about 10 feet of ground surface (DWR 2006e, 2013a). Between the spring 2010 and spring 2014 in the Sutter subbasin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the western portion of the Sutter subbasin includes areas with high concentrations of arsenic, boron, calcium magnesium bicarbonate, chloride, fluoride, iron, manganese, sodium, and TDS. In the southern portion of the subbasin, groundwater in the upper aquifer system tends to be high in salinity (DWR 2003b, 2006e).

The Sutter subbasin was designated by the CASGEM program as medium priority.

*North American Subbasin*

The North American subbasin underlies portions of Sutter, Placer, and Sacramento Counties, including several dense urban areas. Since at least the 1950s, concentrated groundwater extraction occurred east of downtown Sacramento, which resulted in a regionally extensive cone of depression. Drawdown in the wells in this areas have been in excess of 70 feet over the past 60 years (SGA 2008). Water purveyors have constructed facilities to import surface water to allow groundwater levels to recover from the historic levels of drawdown. In general, since around the mid-1990s to the late 2000s, water levels remained stable in the southern portion of the subbasin and in some cases groundwater levels are continuing to increase slightly in response to increases in conjunctive use and reductions in pumping near McClellan Air Force Base (SGA 2014). Groundwater levels in Sutter and northern Placer Counties generally have remained stable, although some wells in southern Sutter County have experienced declines (DWR 2006f, 2013a). Overall, groundwater levels are higher along the eastern portion of the North American subbasin and decline towards the western portion (Roseville et al. 2007). There is a groundwater depression in the southern Placer-Sutter counties area near the border with Sacramento County. Between the spring 2010 and spring 2014 in the North American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The area along the Sacramento River extending from Sacramento International Airport northward to the Bear River contains high levels of arsenic, bicarbonate, chloride, manganese, sodium, and TDS (DWR 2006f, 2013a). In an area between Reclamation District 1001 and the Sutter Bypass, high TDS concentrations occur. There have been three sites within the subbasin with significant groundwater contamination issues: the former McClellan Air Force Base, the Union Pacific Railroad Rail Yard in Roseville, and the Aerojet Superfund Site. Mitigation operations have been initiated for all of these sites. In the deeper portions of the aquifer, the groundwater geochemistry indicates the occurrence of connate water from the marine sediments underlying the freshwater aquifer, which mixes with the fresh water. Water quality concerns due to this type of geology include elevated levels of arsenic, bicarbonate, boron, chloride, fluoride, iron, manganese, nitrate, sodium, and TDS (DWR 2003b).

The North American subbasin was designated by the CASGEM program as high priority.

*South American Subbasin*

The South American subbasin is located within Sacramento County. Groundwater levels in the South American subbasin have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered to levels close to the mid-80s by 2000. Over the past 60 years, a general lowering of groundwater levels was caused by intensive use of groundwater in the region. Areas affected by municipal pumping show a lower groundwater level recovery than other areas (DWR 2004q, 2013a). A large cone of depression is centered in the southwestern portion of the subbasin. Between the spring 2010 and spring 2014 in the South American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The groundwater quality is characterized by low to moderate TDS concentrations (DWR 2004q, 2013a). Seven sites historically had significant groundwater contamination, including three Superfund sites near the Sacramento metropolitan area. These sites are in various stages of cleanup.

The South American subbasin was designated by the CASGEM program as high priority.

*Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes. Most of the groundwater extraction occurs via privately owned domestic and agricultural wells.

*West and East Butte Subbasins*

The primary water source in Butte County is surface water (approximately 70 percent, by volume), and groundwater use accounts for about 30 percent of total county water use. In Butte County, most of the irrigation users rely upon surface water and approximately 75 percent of the residential water users rely upon groundwater (Butte County 2004, 2010).

The cities of Chico and Hamilton City are served by groundwater provided by California Water Service Company (California Water Service Company 2011g).

*North and South Yuba Subbasins*

The Yuba County Water Agency actively manages surface water and groundwater conjunctively to prevent groundwater overdraft in the North and South Yuba subbasins. The majority of water demand in these subbasins is crop water use from irrigated agriculture (YCWA 2010).

*Sutter Subbasin*

Agricultural water use in Sutter County is composed, on average, of approximately 60 percent surface water, 20 percent groundwater, and 20 percent of land irrigated by both surface water and groundwater. Permanent crops are predominantly irrigated with groundwater. Groundwater is also used for small communities and rural domestic uses (Sutter County 2011).

*North American Subbasin*

Several agencies manage water resources in the North American subbasin: South Sutter Water District, Placer County Water Agency, Natomas Central Mutual Water Company, and several urban water purveyors which are part of the Sacramento Groundwater Authority (SGA), a joint powers authority (SGA 2014). The northern portion of this subbasin is rural and agricultural, while the southern portion is urbanized, including the Sacramento Metropolitan area. Many of the urban agencies in Placer County rely upon surface water for normal operations, and have developed or are planning on developing groundwater for emergency situations (Roseville et al. 2007). In the urban area encompassed by SGA, some agencies rely entirely on groundwater for their water supply (SGA 2014).

Local planning efforts have been implemented in a local groundwater planning area known as the American River Basin region. This area encompasses Sacramento County and the lower watershed portions of Placer and El Dorado counties, and overlies the productive North American and South American subbasins. Groundwater is a regionally significant source of water supply, and is used as a primary source for many agencies in the region. However, in recent years, regional conjunctive use programs have allowed for the optimization of water supplies and a decrease in groundwater use has been observed in the past 5 years (RWA 2013).

Since 2000, groundwater extraction decreased in the northeastern portion of the North American subbasin as additional surface water supplies were made available under conjunctive use operations implemented following the Water Forum Agreement in 2000. In 2007, groundwater extraction increased because additional surface water was not available due to dry surface water supply conditions (SGA 2008, 2011).

*South American Subbasin*

The South American subbasin lies entirely within Sacramento County and is overlain by a majority of urban and densely populated areas. Many of the water users in this subbasin use surface water.

The main water purveyors that use South American subbasin groundwater include the Elk Grove Water District, California-American Water Company, Golden State Water Company, and the Sacramento County Water Agency. The entities serve the communities of Antelope, Arden, Lincoln Oaks, Parkway, Rosemont, and portions of the City of Rancho Cordova (California-American Water Company 2011; EGWD 2011; Golden State Water Company 2011l; Sacramento County Water Agency 2011).The majority of groundwater pumping is for agricultural uses (SCGA 2010). The South American subbasin also includes portions of the area known as the American River Basin, as described above under the North American subbasin section.

#### 7.3.3.2 Delta

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River groundwater basins converge, as shown in Figure 7.5. The Delta includes the Solano subbasin and the South American subbasin in the Sacramento Valley Groundwater Basin (as described above); the Tracy subbasin, the Eastern San Joaquin subbasin, and the Cosumnes subbasin in the San Joaquin Valley Groundwater Basin (as described in subsequent sections of this chapter for the San Joaquin); and the Suisun-Fairfield Valley Basin (as described in subsequent sections of this chapter for the San Francisco Bay Area Region).

#### 7.3.3.2.1 Hydrogeology and Groundwater Conditions

In some areas of the western and central Delta floodplain, floodplain deposits contain organic material (peat) that range in thickness from 0 to 150 feet. Below the surficial floodplain deposits, unconsolidated non-marine sediments occur, at depths of a few hundred feet near the Coast Range to nearly 3,000 feet near the eastern margin of the Sacramento Valley Groundwater Basin. These non-marine sediments form the major water-bearing formations in the Delta.

In general, shallow groundwater conditions and extensive groundwater-surface water interaction characterize the Delta. Spring runoff generated by melting snow in the Sierra Nevada increases flows in the Sacramento and San Joaquin rivers and their tributaries and cause groundwater levels near the rivers to rise. Because the Delta is a large floodplain and the shallow groundwater is hydraulically connected to the surface water, changes in river stages affect groundwater levels and vice versa. Groundwater levels in the central Delta are very shallow, and land subsidence on several islands has resulted in groundwater levels close to the ground surface. Maintaining groundwater levels below crop rooting zones is critical for successful agriculture, especially for islands that lie below sea level. Many farmers rely on an intricate network of drainage ditches and pumps to maintain groundwater levels of about 3 to 6 feet below ground surface. The accumulated agricultural drainage is discharged into adjoining surface water bodies (USGS 2000a). Without this drainage system, many of the islands would be subject to extremely high groundwater, bogs, or localized flooding.

Groundwater generally flows from the Sierra Nevada in the east toward the low-lying lands of the Delta to the west. However, a number of pumping depressions have reversed this trend, and groundwater inflow from the Delta toward these pumping areas has been observed, primarily in the Stockton area.

Subsidence in the Delta is well-documented and a major source of concern for farming operations. The oxidation of peat soils is the primary mechanism of subsidence in the Delta, and some areas are located below sea level. Another mechanism for subsidence is wind erosion. There is a possibility that certain areas in the Delta could continue to subside 2 to 4 more feet over the next 35 years (DWR 2013i).

#### 7.3.3.2.2 Groundwater Use and Management

Groundwater is used throughout the Delta for domestic and irrigation water supplies. Irrigation supplies are provided by wells and plant uptake in the root zone. An accurate accounting of groundwater used in the region is not available because wells are not metered and there is no method to measure root-zone irrigation.

Groundwater is used for potable water supplies by the Delta communities of Clarksburg, Courtland, Freeport, Hood, Isleton, Rio Vista, Ryde, and Walnut Grove. In the rural portions of the Delta, private groundwater wells provide residential and agricultural water supplies (Sacramento County 2010; Yolo County 2009; SCWA et al. 2005; Solano County 2008; San Joaquin County 2009;

Contra Costa County 2005). In some portions of the Delta, groundwater use is limited because of low well yields and poor water quality. Shallow groundwater in the western Delta may be saline due to hydraulic connection with western Delta waterways that are influenced by sea water intrusion. Shallow groundwater levels can be detrimental if the groundwater encroaches into the crop root zones. Therefore, groundwater pumping frequently is used to drain shallow groundwater and surface water from agricultural fields.

#### *7.3.3.3 Suisun Marsh*

To the west, the Suisun Marsh overlies the Suisun–Fairfield Valley subbasin. The Suisun-Fairfield Groundwater Basin is adjacent to, but hydrogeologically distinct from, the Sacramento River Groundwater Basin, and is adjacent to Suisun Bay. This basin is bounded by the Coast Ranges to the north and west and the Sacramento River Groundwater Basin in the east, as shown in Figure 7.5. It is separated from the Sacramento River Groundwater Basin by the English Hills.

##### 7.3.3.3.1 Hydrogeology and Groundwater Conditions

In the Suisun-Fairfield Valley Groundwater Basin, freshwater occurs within the alluvial deposits that overlie the Sonoma volcanics (Travis AFB 1997; USGS 1960).

The overall direction of groundwater flow in the Suisun-Fairfield Valley Groundwater Basin is from the uplands toward Suisun Marsh (USGS 1960; Reclamation et al. 2011). Depth to groundwater varies seasonally, with higher groundwater levels occurring during the rainy season (Solano County 2008). Prior to implementation of the Solano Project that conveys water into Solano County from Lake Berryessa as part of the Solano Project and the SWP North Bay Aqueduct, groundwater depressions were occurring near Fairfield. Following importation of surface water from the Solano Project and the North Bay Aqueduct, surface water was used more extensively to reduce the groundwater overdraft (Solano County 2008; Travis AFB 1997). Few groundwater monitoring sites exist in the basin, and most are near ongoing groundwater investigations. Data from these groundwater investigations suggest that groundwater levels in the basin are generally stable.

Groundwater quality issues within the Suisun-Fairfield Valley Groundwater Basin include high boron, TDS, and volatile organic compound concentrations near Travis Air Force Base (USGS 1960, 2008). Volatile organic compound plumes at Travis Air Force Base are largely contained on base, but volatile organic compound constituents have migrated up to 0.5-mile off base at three sites. Containment and remediation is occurring at each of these sites (Travis AFB 2005).

The Suisun-Fairfield Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### 7.3.3.3.2 Groundwater Use and Management

Information on groundwater supplies in the Suisun-Fairfield Valley Groundwater Basin is limited. Groundwater was the primary water source for the Suisun–Fairfield Valley Groundwater Basin, including the cities of Fairfield and Suisun City, through the 1950s. This groundwater production resulted in local areas of depressed groundwater levels. As surface water became available, groundwater use declined. Studies have shown that the basin provides low well yields and therefore is probably not used as a major water supply (Reclamation et al. 2011). Many private well owners in the Suisun-Fairfield Valley Groundwater Basin use groundwater for irrigation. However, due to the brackish quality of the groundwater, surface water is used for potable water supplies (Reclamation et al. 2011).

### *7.3.3.4 San Joaquin Valley*

The San Joaquin Valley Groundwater Basin extends from the Sacramento-San Joaquin Delta in the north to the Tehachapi Mountains in the South. Groundwater is estimated to provide over 47 percent of the overall water supply in the San Joaquin Valley, including 70 percent of municipal uses and 43 percent of irrigation supplies from 2005 through 2010 (DWR 2013i). The San Joaquin Valley has an average annual precipitation between 5 to 18 inches. Due to the low amounts of average annual precipitation, limited surface water supply and extensive agricultural water use, there are areas of significant overdraft that exist in the San Joaquin Valley Groundwater Basin. Eight subbasins in the San Joaquin Valley Groundwater Basin were identified in a state of critical overdraft: Chowchilla, Eastern San Joaquin, Madera, Kings, Kaweah, Tule, Tulare Lake, and Kern (DWR 1980). Three of these subbasins are on the eastern side of the San Joaquin River: Eastern San Joaquin, Chowchilla, and Madera. Recent studies have indicated that overdraft continues to exist in these subbasins (DWR 2013i). By 1970, over 5,200 square miles of irrigable land had subsided by a minimum of 1 foot. The maximum subsidence occurred near Mendota at almost 30 feet (9 meters) (Reclamation 2013a). Due to the drought that started in 2011, surface water supplies have declined and new wells have been constructed. Between January and October 2014, over 100 wells were drilled in both Kern and Kings counties, almost 200 in Stanislaus County, almost 250 in Merced County, and over 350 in both Fresno and Tulare counties (DWR 2014d).

The elevation of the base of freshwater in the western and central San Joaquin Valley ranges from 600 to 800 feet below mean sea level (WWD 2013). This area has experienced subsidence of up to 28 feet between 1926 and 1970 (USGS 2009). The water quality of the semi-perched aquifer on the western side of the San Joaquin Valley is impaired with high salinity, selenium, and boron concentrations. These constituents are from both naturally occurring deposits in the Coast Ranges to the west and agricultural activities. The chemicals become trapped in the soil matrix due to the low permeability clay layers close to the surface. There are also localized areas with high concentrations of naturally occurring arsenic or selenium.

Portions of the San Joaquin Valley Groundwater Basin in the Cosumnes, Tracy, and Eastern San Joaquin subbasins were designated by the State Water Resources Control Board in 2000 as Hydrogeologically Vulnerable Areas and Groundwater Protection Areas based on hydrogeologic permeability. These areas could be more vulnerable to groundwater quality impairment if applied surface water, including recycled water, contained high concentrations of constituents of concern to the beneficial users of the groundwater (CVRWQCB 2014b).

#### 7.3.3.4.1 Northern Portions of the San Joaquin Valley Groundwater Basin

Extending south into the Central Valley from the Delta to the southern extent marked by the San Joaquin River, DWR has delineated nine subbasins within the northern portion of the San Joaquin Valley Groundwater Basin based on groundwater divides, barriers, surface water features, and political boundaries (DWR 2003a), as shown in Figure 7.6. The Cosumnes, Eastern San Joaquin, and Tracy subbasins partially underlie the Delta. The Delta-Mendota, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins are located between the Delta and the San Joaquin River.

The northern portion of the San Joaquin Valley Groundwater Basin is marked by laterally extensive deposits of thick fine-grained materials deposited in lacustrine and marsh depositional systems. These units, which can be tens to hundreds of feet thick, create vertically differentiated aquifer systems within the subbasins. The Corcoran Clay (or E-Clay), occurs in the Tulare Formation and separates the alluvial water-bearing formations into confined and unconfined aquifers. The direction of groundwater flow generally coincides with the primary direction of surface water flows in the area, which is to the northwest toward the Delta (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006g, 2006h, 2006k). Groundwater levels fluctuate seasonally and a strong correlation exists between depressed groundwater levels and periods of drought, when more groundwater is pumped in the area to support agricultural operations.

Water users in the northern portion of the San Joaquin Valley Groundwater Basin rely upon groundwater, which is used conjunctively with surface water for agricultural, industrial, and municipal supplies (DWR 2003a). Groundwater is estimated to account for about 38 percent of the overall water supply in the northern portion of the San Joaquin Valley Groundwater Basin (DWR 2013i). Annual groundwater pumping in the northern portion of the San Joaquin Valley Groundwater Basin accounts for about 19 percent of all groundwater pumped in the state of California. Groundwater use in the northern portion of the San Joaquin Valley Groundwater Basin is estimated to average 3.2 million acre-feet per year between 2005 and 2010.

According to the Draft California Water Plan 2013 Update (DWR 2013i), three planning areas within the northern portion of the San Joaquin Valley Groundwater Basin rely heavily on groundwater pumping: the Eastern Valley Floor Planning Area, the Lower Valley Eastside Planning Area, and the Valley West Side Planning Area. Each of these areas has limited local surface water supplies and uses extensive groundwater pumping for their agricultural water supply (DWR 2013i).

The northern portion of the San Joaquin Valley Groundwater Basin discussion is divided into two sub-regions: West of the San Joaquin River, and East of the San Joaquin River, as described below.

*West of the San Joaquin River*

The Tracy and the Delta-Mendota subbasins are located on the west side of the San Joaquin River.

*Hydrogeology and Groundwater Conditions*

Along the western portion of the San Joaquin Valley, the Tulare formation comprises the primary freshwater aquifer. The Tulare Formation originated as reworked sediments from the Coast Ranges re-deposited in the San Joaquin Valley as alluvial fan, flood basin, deltaic (pertaining to a delta) or lacustrine, and marsh deposits (USGS 1986).

*Tracy Subbasin*

The Tracy subbasin underlies eastern Contra Costa County and western San Joaquin County. A large portion of the subbasin is located within the Delta. In the Tracy subbasin, groundwater generally flows from south to north and discharges into the San Joaquin River. According to DWR and the San Joaquin County Flood Control and Water Conservation District, groundwater levels in the Tracy subbasin have been relatively stable over the past 10 years, apart from seasonal variations resulting from recharge and pumping (DWR 2006g, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tracy subbasin by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

In the Tracy subbasin, areas of poor water quality exist throughout the area. Elevated chloride concentrations are found along the western side of the subbasin near the City of Tracy and along the San Joaquin River. Overall, Delta groundwater wells in the Tracy subbasin are characterized by high levels of chloride, TDS, arsenic, and boron (DWR 2006g, 2013b; USGS 2006). The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Tracy subbasin (CVRWQCB 2014b). Supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern.

The Tracy subbasin was designated by the CASGEM program as medium priority.

*Delta-Mendota Subbasin*

The Delta-Mendota subbasin underlies portions of Stanislaus, Merced, Madera, and Fresno counties. The geologic units present in the Delta-Mendota subbasin consist of the Tulare Formation, terrace deposits, alluvium, and flood-basin deposits. Groundwater occurs in three water-bearing zones: the lower zone contains confined fresh water in the lower section of the Tulare Formation; the upper zone contains confined, semi-confined, and unconfined water in the upper section of the Tulare formation; and a shallow zone that contains unconfined water (DWR 2006h, 2013b). The groundwater is characterized by moderate to extremely high salinity with localized areas of high iron, fluoride, nitrate, and boron (DWR 2006h, 2013b).

In the Delta-Mendota subbasin, groundwater levels have generally declined by as much as 20 feet in the northern portion of the basin near Patterson between 1958 and 2006. Surface water imports in the early 1970s resulted in decreased pumping, and a steady recovery of groundwater levels. However, the lack of imported surface water availability during the drought periods of 1976 to 77, 1986 to 1992, and 2007 to 2009 resulted in increases in groundwater pumping, and associated declines in groundwater levels to near-historic lows (USGS 2012). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Delta-Mendota subbasin by up to 20 feet (DWR 2014c, 2014d).

In areas adjacent to the Delta-Mendota Canal in this subbasin, extensive groundwater withdrawal has caused land subsidence of up to 10 feet in some areas. Land subsidence can cause structural damage to the Delta-Mendota Canal which has caused operational issues for CVP water delivery. Historical wide-spread soil compaction and land subsidence between 1926 and 1970 has caused reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, other canals, and roadways in the area. To better understand subsidence issues near the Delta-Mendota Canal and improve groundwater management in the area, the U.S. Geological Survey (USGS) provided and evaluated information on groundwater conditions and the potential for additional land subsidence in the San Joaquin Valley (USGS 2013a). Results show that at least 1.8 feet of subsidence occurred near the San Joaquin River and the Eastside Bypass from 2008 to 2010 period, affecting the southern part of the Delta-Mendota Canal by about 0.8 inches of subsidence during the same period. It was estimated that subsidence rates doubled in 2008 in some areas. The subsidence measured was primarily inelastic (or permanent, not reversible, due to the compaction of fine-grained material). The area of maximum active subsidence is shown to be located southwest of Mendota and extends into the Merced subbasin to the south of El Nido. Land subsidence in this area is expected to continue to occur due to uncertainties and limitations (especially climate-related changes) in surface water supplies to meet irrigation demand and the continuous need to supplement water supply with groundwater pumping.

*Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

#### *Tracy Subbasin*

The primary water source in Contra Costa County is surface water. Groundwater is used by individual homes and businesses and the communities of Brentwood, Bethel Island, Knightsen, Byron and Discovery Bay (Contra Costa County 2005).

The Diablo Water District groundwater blending facility provides water to users in the City of Oakley by blending groundwater and treated water from Contra Costa Water District (DWD 2011).

Contra Costa Water District has an agreement with the East Contra Costa Irrigation District to purchase surplus irrigation water for municipal and industrial purposes in East Contra Costa Irrigation District's service area (CCWD 2011). The agreement includes an option to implement an exchange of surface water for groundwater that can be used in the Contra Costa Water District service area when the CVP allocations are less than full contract amounts. This groundwater exchange water was implemented during the 2007 to 2009 drought.

Groundwater and surface water are used within western San Joaquin County for agricultural operations and for the cities of Stockton, Lathrop, and Tracy (San Joaquin 2009). In the 1980s, about 30 percent of the water supplies in San Joaquin County were based on groundwater (including the Tracy, Cosumnes, and Eastern San Joaquin subbasins). By 2007, groundwater was used to supply over 60 percent of water demand in the county.

#### *Delta-Mendota Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Delta-Mendota subbasin (Reclamation and DWR 2011). Groundwater is primarily used for domestic and industrial water supplies in Stanislaus County, including for the City of Patterson (Stanislaus County 2010; Patterson 2014). In the Delta-Mendota subbasin within Merced County, approximately 3 percent of groundwater withdrawals are used for municipal and industrial purposes (including uses in the city of Gustine, Los Banos, and Santa Nella), and 97 percent of the groundwater withdrawals are used for agricultural purposes (Merced County 2012). Most of the portions of Madera County within the Delta-Mendota subbasin use groundwater for domestic and agricultural uses (Madera County 2002, 2008). In portions of Western Fresno County within the Delta-Mendota subbasin, domestic water users rely upon groundwater (including the cities of Mendota and Firebaugh), and agricultural water users rely upon surface water and/or groundwater (Mendota 2009; Firebaugh 2015; Fresno County 2000).

### *East of the San Joaquin River*

The east side of the San Joaquin River is underlain by seven groundwater subbasins: the Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins. Three of these subbasins are in a critical state of overdraft: the Chowchilla, Eastern San Joaquin, and Madera (DWR 2013i).

### Hydrogeology and Groundwater Conditions

Several of the hydrogeologic units present in the southern Sacramento Valley extend south into the San Joaquin Valley. Along the eastern boundary of the Central Valley, the Ione, Mehrten, Riverbank, and Modesto formations are primarily composed of sediments originating from the Sierra Nevada.

Historically, surface water and groundwater were hydraulically connected in most areas of the San Joaquin River and its tributaries. This resulted in a significant quantity of groundwater actively discharging into streams in most of this watershed. However this condition changed as increased groundwater pumping in the area lowered groundwater levels and reversed the hydraulic gradient between the surface water and groundwater systems, resulting in surface water recharging the underlying aquifer system through streambed seepage. Long-term groundwater production throughout this basin has lowered groundwater levels faster than natural recharge rates. Areas where this overdraft has occurred include eastern San Joaquin County, Merced County, and western Madera County. This occurs along the San Joaquin River where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. This condition reduces groundwater and surface water outflows to the Delta, lowers the water table, and may increase the potential for land subsidence (USFWS 2012).

Generally, the groundwater in the San Joaquin River subbasins east of the San Joaquin River is of suitable quality for most urban and agricultural uses with only local impairments. There are localized areas with high concentrations of boron, chloride, iron, nitrate, TDS, and organic compounds (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006i, 2006j, 2006k). The use of groundwater for agricultural supply is impaired in western Stanislaus and Merced counties due to elevated boron concentrations. Groundwater use for drinking water supply is also impaired in the Tracy, Modesto-Turlock, Merced, and Madera areas due to elevated nitrate concentrations (USFWS 2012).

Dibromochloropropane (DBCP), a soil fumigant that was extensively used on grapes and cotton before it was banned, is prevalent in groundwater near Merced and Stockton and in the Merced, Modesto, Turlock, Cosumnes, and Eastern San Joaquin subbasins (CVRWQCB 2011; DWR 2004r; USFWS 2012). Many areas with high concentrations of DBCP have undergone groundwater remediation, and the DBCP concentrations are declining.

Declining groundwater levels in the subbasins east of the San Joaquin River have resulted in an area approximately 16-miles long with high salinity due to saltwater intrusion from the Delta (USFWS 2012).

#### Cosumnes Subbasin

The Cosumnes subbasin underlies western Amador County, northwestern Calaveras County, southeastern Sacramento County, and northeastern San Joaquin County. Groundwater levels in the Cosumnes subbasin have fluctuated significantly over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered by that same amount through 2000. Areas affected by municipal pumping show a lower magnitude of groundwater level recovery during this period than in other areas of the subbasin (DWR 2006i, 2013b). Within the portion of Sacramento County in the Cosumnes subbasin, it is estimated that the recent average annual decline in groundwater levels has been approximately 1 foot, with a lower rate of decline in more recent years (South Area Water Council 2011). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Cosumnes subbasin by up to 10 feet (DWR 2014c, 2014d).

The Cosumnes subbasin contains groundwater of very good quality, with localized high concentrations of calcium bicarbonate and pesticides (DWR 2006i, 2013b).

The Cosumnes subbasin was designated by the CASGEM program as medium priority.

*Eastern San Joaquin Subbasin*

The Eastern San Joaquin subbasin underlies western Calaveras County, a large portion of San Joaquin County, and a portion of Stanislaus County. Groundwater levels in the Eastern San Joaquin subbasin have continuously declined in the past 40 years due to groundwater overdraft. Cones of depression are present near major pumping centers such as the City of Stockton and the City of Lodi (DWR 2006j, 2013b). Groundwater level declines of up to 100 feet have been observed in some wells. In the 1990s, groundwater levels were so low that many wells were inoperable and many groundwater users were obligated to construct new deeper wells (NSJCGBA 2004). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Eastern San Joaquin subbasin by up to 20 feet (DWR 2014c, 2014d).

In the Eastern San Joaquin subbasin, the groundwater is characterized with low to high salinity levels and localized areas of high calcium or magnesium bicarbonate, salinity, nitrates, pesticides, and organic constituents (DWR 2006j, 2013b). The high groundwater salinity is attributed to poor-quality groundwater intrusion from the Delta caused by the pumping-induced decline in groundwater levels, especially in the groundwater underlying the Stockton area since the 1970s (SJCFCWCD 2008). High chloride concentrations have also been observed in the Eastern San Joaquin subbasin. Ongoing studies are evaluating the sources of chloride in groundwater along a line extending from Manteca to north of Stockton. Initial concern was that long-term overdraft conditions in the eastern portion of the subbasin were enabling more saline water from the Delta to migrate inland. Other possible sources include upward movement of deeper saline formation water and agricultural practices (USGS 2006). In addition, large areas of groundwater with elevated nitrate concentrations have been observed in several portions of the subbasin, such as areas southeast of Lodi and south of Stockton and east of Manteca, and in areas extending towards the San Joaquin-Stanislaus County line (USFWS 2012).

The Eastern San Joaquin subbasin was designated by the CASGEM program as high priority.

### *Modesto Subbasin*

The Modesto subbasin underlies northern Stanislaus County. In the Modesto subbasin, water levels have declined nearly 15 feet on average between 1970 and 2000 (DWR 2004r, 2013b), with the major declines occurring in the eastern portion of the subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Modesto subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater is characterized by low to high TDS concentrations with localized areas of boron, chlorides, DBCP, iron, manganese, and nitrate concentrations (DWR 2004r, 2013b; Stanislaus County 2010).

The Modesto subbasin was designated by the CASGEM program as high priority.

### *Turlock Subbasin*

The Turlock subbasin underlies portions of Stanislaus and Merced counties. In the Turlock subbasin, water levels declined nearly 7 feet on average from 1970 through 2000 (DWR 2006k, 2013b). Comparison of groundwater contours from 1958 and 2006 shows that historically, groundwater flows occurred from east to west, toward the San Joaquin River. Groundwater pumping centers to the east of the City of Turlock have drawn the groundwater toward these cones of depression, allowing less water to flow toward the San Joaquin River, and diminishing the discharge of groundwater to the river. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Turlock subbasin by up to 20 feet (DWR 2014c, 2014d). The storage capacity of the Turlock subbasin is estimated at about 15,800,000 acre-feet (DWR 2006k, 2013b).

The groundwater quality is characterized with low to high concentrations of TDS and localized high concentrations of boron, chlorides, DBCP, nitrates, and TDS (DWR 2013b).

The Turlock subbasin was designated by the CASGEM program as high priority.

### *Merced Subbasin*

The Merced subbasin underlies most of Merced County. In the Merced subbasin, water levels have declined nearly 30 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin (DWR 2004s, 2013b). The estimated specific yield of the groundwater subbasin is 9 percent. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Merced subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater quality is characterized by low to high TDS concentrations and localized areas with high concentrations of chloride, DBCP, iron, and nitrate (DWR 2004s, 2013b; USFWS 2012).

The Merced subbasin was designated by the CASGEM program as high priority.

#### *Chowchilla Subbasin*

The Chowchilla subbasin underlies southwestern Merced County and northwestern Madera County. In the Chowchilla subbasin, water levels declined nearly 40 feet on average from 1970 to 2000. Water level declines were more severe in the eastern portion of the subbasin from 1980 to present, but the western portion of the subbasin showed the strongest declines before 1980 (DWR 2004t, 2013b). Groundwater recharge in this subbasin is primarily from irrigation water percolation. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

There are localized areas with high concentrations of chloride, iron, nitrate, and hardness (DWR 2004t, 2013b). Organic chemicals were detected in some wells in the Chowchilla subbasin between 1983 and 2003 (CVRWQCB 2011).

The Chowchilla subbasin was designated by the CASGEM program as high priority.

#### *Madera Subbasin*

The Madera subbasin underlies most of Madera County. In the Madera subbasin, water levels have declined nearly 40 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin from 1980 to the present, but the western subbasin showed the strongest declines before this period (DWR 2004u, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

Groundwater in the Madera subbasin is characterized by low to high TDS and localized areas with high concentrations of chlorides, iron, nitrates, and hardness (DWR 2004u, 2013b). Occurrences of organic chemicals have been observed including DBCP and pesticides (CVRWQCB 2011; DWR 2004u, 2013b).

The Madera subbasin was designated by the CASGEM program as high priority.

### *Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

#### *Cosumnes Subbasin*

Currently, urban and agricultural water users on the valley floor are reliant on groundwater for water supply. Water demands in the Cosumnes Subbasin area are supported by nearly 95 percent groundwater (South Area Water Council 2011). Groundwater and surface water are used for agricultural and domestic water supplies in the Cosumnes subbasin (CVRWQCB 2011). Groundwater is used by many agricultural water users and the community of Galt (CVRWQCB 2011; South Area Water Council 2011).

The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Cosumnes subbasin. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

*Eastern San Joaquin Subbasin*

Groundwater and surface water are used for agricultural and domestic water supplies in the Eastern San Joaquin subbasin (CVRWQCB 2011). Groundwater is the major source of water supply for agricultural areas in eastern San Joaquin County (NSJCGBA 2007). Groundwater is used by many agricultural water users and the communities of Escalon, Lodi, Manteca, Ripon, and Stockton (NSJCGBA 2004, 2007). The cities of Manteca and Stockton use both groundwater and surface water, while Lodi, Escalon, and Ripon primarily use groundwater for their municipal needs.

The City of Stockton uses both surface water and groundwater for its municipal and industrial water needs. Due to overdraft of the aquifer beneath Stockton, the city has limited annual groundwater extraction. All of these demands on the finite groundwater resources available in the basin historically have resulted in annual groundwater withdrawals in excess of the natural recharge volume in the East San Joaquin subbasin (DWR 2003a, 2006j). This extensive use of groundwater to meet local demand results in localized overdraft conditions within the subbasin.

The Northeastern San Joaquin County Groundwater Banking Authority is a joint-powers authority that develops local projects to strengthen water supply reliability in Eastern San Joaquin County. The Northeastern San Joaquin County Groundwater Banking Authority facilitated the development and adoption of the Eastern San Joaquin Groundwater Basin Groundwater Management Plan and completed an Integrated Regional Water Management Plan (IRWMP). This plan outlines the requirements for an integrated conjunctive use program that takes into account the various surface water and groundwater facilities in eastern San Joaquin County and promotes better groundwater management to meet future basin demands (NSJCGBA 2004). Conjunctive use refers to the use and management of the groundwater resource in coordination with surface water supplies by users overlying the basin. Potential projects that could be implemented to improve groundwater conditions in the area include urban and agricultural water use efficiency projects, recycled municipal water projects, groundwater banking operations, new surface water storage opportunities, improved conveyance facilities, and utilizing new sources of surface water (NSJCGBA 2007). Pursuant to the IRWMP, a program-level Environmental Impact Report identified potential changes to the environmental and mitigation measures to reduce identified significant adverse impacts (NSJCGBA 2011).

The Farmington Groundwater Recharge Program led by Stockton East Water District, in conjunction with the U.S. Army Corp of Engineers, and other local water agencies, was developed to utilize flood-season and excess irrigation water supplies in the Eastern San Joaquin groundwater subbasin to recharge the groundwater aquifer. This program supports replenishment of a critically overdrafted groundwater basin by recharging an average of 35,000 acre-feet of water annually into the Eastern San Joaquin subbasin. The program includes recharge of surface water on 800 to 1,200 acres of land using direct field-flooding. In addition, the program increases surface water deliveries in-lieu of groundwater pumping to reduce overdraft (Farmington Program 2012).

A joint conjunctive use and groundwater banking project was evaluated by the East San Joaquin Parties Water Authority and East Bay Municipal Utility District, named the Mokelumne Aquifer Recharge and Storage Project (NSJCGBA 2004). The goal of this project was to store surface water underground in wet years, and in dry years, East Bay Municipal Utility District would extract and export the recovered water supply (NSJCGBA 2004, 2009). Several studies have concluded that the test area is suitable for recharge and recovery of groundwater; however, more testing needs to be done to further evaluate the feasibility of this project.

The Central Valley Regional Water Quality Control Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

##### *Modesto Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Modesto subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Modesto (DWR 2004r; Stanislaus County 2010).

##### *Turlock Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Turlock subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Turlock in Stanislaus County and the communities of Delhi and Hilmar in Merced County (DWR 2006k; Stanislaus County 2010; Merced County 2012).

##### *Merced Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Merced subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the communities of Atwater, El Nido, Le Grand, Livingston, Merced, Planada, and Winton (DWR 2004s; Merced County 2012).

*Chowchilla Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Chowchilla subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Chowchilla (DWR 2006k; Madera County 2002).

*Madera Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Madera subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Madera (DWR 2006k; Madera County 2002, 2008).

#### 7.3.3.4.2 Tulare Lake Area of the San Joaquin Valley Groundwater Basin

The Tulare Lake Area overlies seven groundwater subbasins of the San Joaquin Valley Groundwater Basin, as defined by DWR (DWR 2003a): the Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern subbasins, as shown in Figure 7.7. The Kern and Pleasant Valley subbasins have distinct hydrogeology and groundwater management from the other subbasins, and therefore are described separately.

*Northern Tulare Lake Area: Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern Subbasins*

*Hydrogeology and Groundwater Conditions*

*Hydrogeology*

The aquifer system in the Tulare Lake Area consists of younger and older alluvium, flood-basin deposits, lacustrine and marsh deposits and unconsolidated continental deposits. These deposits are configured within most parts of the basin to form an unconfined to semi-confined upper aquifer and a confined lower aquifer. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation, which occurs at depths between 200 and 850 feet within the central and western portions of the basin, specifically in the Westside and Tulare Lake subbasins and in the western Kings, Kaweah, and Tule subbasins. Fine-grained lacustrine deposits up to 3,600 feet thick also are present in the Tulare Lake region (DWR 2003a, 2004v, 2004w, 2006l, 2006m, 2006n, 2006o, 2006p).

Prior to extensive use of groundwater in the basin, groundwater generally flowed toward Tulare Lake. Due to depressed groundwater levels and interception of surface water, the Tulare Lake Area is dry except during extreme flood events; and recharge of the Tulare Lake Area is limited.

Groundwater withdrawals in the Tulare Lake Area account for approximately 38 percent of the total groundwater withdrawals in the state of California (DWR 2013i). The CVP and SWP surface water supplies are used by many agricultural water users and several communities in the Tulare Lake Area to reduce reliance on groundwater and allow for groundwater recharge. In drier years when the CVP and SWP water supplies are limited, extensive groundwater pumping occurs to meet the water demands. In drier years, water users in the

Westside, Kings, Tulare Lake, and Kaweah subbasins may use groundwater for up to 75 percent of their water supply (DWR 2013i).

Areal recharge from precipitation provides most of the groundwater recharge, and seepage from stream channels provides the remaining groundwater recharge. Most of the recharge occurs as mountain-front recharge in the coarse-grained upper alluvial fans where streams enter the basin (USGS 2009). Prior to development of the Tulare Lake Area, surface water and groundwater exchange occurred throughout the basin in response to hydrologic conditions. When rapid agricultural growth and groundwater development occurred, the primary interaction of surface water with groundwater occurred as stream flow loss to underlying aquifers. In areas of severe overdraft in the Tulare Lake Area of the San Joaquin Valley Groundwater Basin, complete disconnection between groundwater and overlying surface water systems has occurred. In some areas with disconnected hydrology where streambeds are used as conveyance elements for irrigation purposes and to recharge groundwater, the streams become losing streams. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in this area by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

*Groundwater Quality*

In the northern Tulare Lake Area (including the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins), groundwater in the upper unconfined/semi-confined aquifer is characterized by high calcium and magnesium sulfate as well as high TDS (DWR 2006l, 2006m, 2006n, 2013c). The lower confined aquifer is approximately 300 feet below the ground surface and above the Corcoran Clay, and is characterized by high sodium sulfates and less dissolved solids than the upper aquifer.

Groundwater quality in the northern Tulare Lake Area is poor in portions of the upper aquifer, due to agricultural drainage issues and naturally occurring high salinity soils. Groundwater in the Westside subbasin is of poor quality due to historical agricultural drainage. The high clay content of the soils that comprise the upper aquifer restricts the movement of groundwater in the aquifer, further contributing to water quality impacts from root zone drainage. Studies have shown that the quality of the upper 20 to 200 feet of the saturated groundwater zone have been affected by crop irrigation and drainage issues (Reclamation 2006). The eastward movement of saline groundwater from the Westside subbasin also adversely affects the groundwater quality in adjacent subbasins, such as in the vicinity of the City of Mendota and Fresno Slough (Reclamation 2006).

The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). In the Kaweah subbasin, groundwater is characterized by moderate to high TDS concentrations (DWR 2004v, 2013c). In the Tule subbasin, low to moderate TDS concentrations occur in the most of the subbasin with high concentrations in areas with poor drainage (DWR 2004w, 2013c). On the western side of the subbasin there is shallow saline water. The eastern side of the subbasin has areas of high nitrates (DWR 2013c, 2004b). The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). Portions of the Kings subbasin are characterized by high nitrate concentrations due to historical agricultural practices (CVRWQCB 2011; DWR 2006n, 2013c). High DBCP and other pesticides concentrations occur in localized areas within the Westside, Kings, Tulare Lake, Kaweah, and Tule subbasins (CVRWQCB 2011).

A recent study evaluated high nitrate concentrations in groundwater and related public health issues in four community water systems with recorded violations related to nitrates in drinking water (Pacific Institute 2011). The communities served by the water systems were evaluated to assess the quality of groundwater provided by their water distribution systems and potential costs to the communities. Overall, this significant degradation of groundwater quality throughout the area has implications on public health and economic sustainability of the region. The findings of the report indicated that improved notification procedures, new funding mechanisms, and improved regulations and incentives are needed to provide safe drinking water, as described in Chapter 18, Public Health. The four water systems included Beverly Grand Mutual Water Company (Tule subbasin), Lemon Cove Water Company (east of Tule subbasin), El Monte Village Mobile Home Park (Kings subbasin), and Soults Mutual Water Company (Kings subbasin) in Tulare County.

High groundwater salinity occurs in many locations in the Tulare Lake Area. Salts are imported into the Tulare Lake Area through irrigation with Delta water and salts added through application of fertilizers, and other salt containing materials. Except in very wet years, the Tulare Lake Area has no natural drainage, so imported salts accumulate in the groundwater unless captured and sequestered. This salt accumulation causes groundwater quality degradation for potable and agricultural uses.

To the high nitrate and salinity problems, the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) was formed as a strategic initiative to address accumulation of salts and nitrates throughout the region in a comprehensive, consistent and sustainable manner (CVRWQCB 2015; SWRCB 2015). The Central Valley Regional Water Quality Control Board and the State Water Resources Control Board in cooperation with stakeholders and the Central Valley Salinity Coalition collaborate to review and update the Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley groundwater basins and the Delta Plan for salinity management, as described in Chapter 6, Surface Water Quality. The goals of this program are to address groundwater nitrate legacy conditions and current loadings, direct impacts of high nitrates on drinking water supplies from diverse sources, and economic costs for water treatment or alternate supplies. A final Salinity and Nitrate Management Plan is scheduled to be completed in May 2016.

*Overall Groundwater Conditions*

The Westside, Kings, Tulare Lake, Kaweah, Tule, and Kern subbasins were designated by the CASGEM program as high priority. The Pleasant Valley subbasin was designated as low priority.

*Groundwater Use and Management*

The northern Tulare Lake Area uses groundwater for its many water needs. Groundwater is used conjunctively with surface water, where possible, when surface water supplies are not sufficient to meet the region's demand for agricultural, industrial, and municipal uses (DWR 2003a). For example, the cities of Fresno and Visalia are almost entirely dependent on groundwater for their water supplies. Most groundwater subbasins in the Tulare Lake Area are in a state of overdraft as a consequence of groundwater pumping that exceeds the basin's safe yield (the amount of natural and induced recharge available to replenish the basin). As a result, the aquifers in these groundwater basins contain a significant amount of potential storage space that can be filled with additional recharged water. However, cities in the northern Tulare Lake Area are considering other water sources and/or groundwater banking programs.

*Westside Subbasin*

The Westside subbasin is located within western Fresno County and northwestern Kings County. The majority of lands within the Westside subbasin are within the Westlands Water District which uses CVP surface water, water transferred from other agencies, and groundwater. Groundwater levels in the Westside subbasin have fluctuated over the past 46 years in response to the availability of surface water deliveries from the CVP (WWD 2013). The lowest recorded average groundwater level below the Corcoran Clay between 1950 and 1968 (prior to delivery of CVP water to the subbasin) was 156 feet below mean sea level, which occurred in 1967. Groundwater elevations increased after 1968 to 89 feet above mean sea level in 1987.

Groundwater levels are closely related to the availability of surface water. In the 1977 drought when CVP water supplies were substantially reduced, groundwater withdrawals decreased the groundwater elevation by 97 feet in 1 year (WWD 2013). In 1991 and 1992 (during the 1987 to 1992 drought), the groundwater elevation declined to 62 feet below mean sea level. In 1996, the Westlands Water District adopted a groundwater management plan to preserve and enhance reliable groundwater resources; provide long-term availability of high quality groundwater; maintain local control of groundwater in the district; and minimize the cost and impact of groundwater use (WWD 2013a). The groundwater levels recovered following the drought that ended in 1992. However, in 2010, the CVP allocation was 45 percent of the contract amount, and the average groundwater elevation was 9 feet above mean sea level (WWD 2011). In 2012, the CVP allocation was 40 percent of the contract amount, and the average groundwater elevation decreased to 1 foot above mean sea level (WWD 2013). Recent information indicates that between the spring 2013 and spring 2014, groundwater levels have declined at some wells in the Westside subbasin by up to 40 feet within the 1-year period (DWR 2014c, 2014d).

Subsidence has occurred in the Westside subbasin as a result of the high rate of historic groundwater pumping resulting in reduced groundwater levels and the compaction of fine grained soils. In some areas, the land surface elevation has decreased substantially. It is estimated that extensive groundwater pumping prior to delivery of CVP water resulted in compaction of water bearing sediments and land subsidence of 1 to 24 feet between 1926 and 1972 (WWD 2013). The Westland Water District has referenced that the Department of Water Resources estimated the amount of subsidence since 1983 to be almost 2 feet in some areas of the District with most of that subsidence occurring since 1989 (WWD 2013). The USGS monitoring between 2003 and 2010 indicated no subsidence in the Westside subbasin area during the same time period while at least 1.8 feet of subsidence occurred in the Delta-Mendota subbasin area near the southern part of the Delta-Mendota Canal (USGS 2013a).

*Kings Subbasin*

The Kings subbasin includes most of central and eastern Fresno County, and northern Kings and Tulare County (DWR 2006n, 2013c). Two major groundwater depressions occur near the Fresno-Clovis urban area and approximately 20 miles southwest of Fresno in the Raisin City Water District (DWR 2013c). On average, the majority of this subbasin has experienced generalized declines in groundwater levels of approximately 20 feet between 2003 and 2011 (KRCD 2012a). The Kings subbasin is in overdraft condition and overdraft continues to be a major long-term problem due to increasing water demand and reduced surface water supply reliability. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kings subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Fresno County, including for water users in the communities of Fresno, Clovis, Sanger, Fowler, Selma, Kingsburg, Reedley, Dinuba, Orange Cove, Raisin City, and Riverdale (CVRWQCB 2011; Fresno County 2000; KRCD 2012a).

The City of Fresno, which previously used groundwater for the municipal water supplies, has developed a surface water supply program. The groundwater is recharged through direct recharge and from applied agricultural water, and groundwater inflows from the adjacent foothills (City of Fresno 2015).

Several water agencies are coordinating efforts in the Kings subbasin to mitigate the extensive historical declines in groundwater levels resulting from pumping withdrawals. Current Kings subbasin groundwater recharge efforts include a total of 4,000 acres of dedicated recharge ponds (CGRA 2012). One of the biggest groundwater recharge efforts in the Kings subbasin area is the McMullin On-farm Flood Capture and Recharge Project near Raisin City (KRCD 2013).

*Tulare Lake Subbasin*

The Tulare Lake subbasin includes most of Kings County (DWR 2006m, 2013c). In the Tulare Lake subbasin, water levels have declined nearly 17 feet on average from 1970 through 2000. Fluctuations in water levels have been most exaggerated in the Tulare Lakebed area of the subbasin, which has experienced both the steepest declines and the steepest rises over time. Groundwater overdraft conditions also prevail in this subbasin, similar to the Kings subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tulare Lake subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Kings County, including the communities of Corcoran, Hanford, Lemoore, and Kettleman Hills (CVRWQCB 2011; KRCD 2012a).

*Kaweah Subbasin*

The Kaweah subbasin includes a portion of eastern Kings County and northwestern Tulare County. Water levels in this subbasin declined about 12 feet on average from 1970 through 2000 (DWR 2004v, 2013c). The basin is subject to large fluctuations in water levels since the 1970s to as low as 35 feet lower than the 1970 water level in 1995 to 25 feet higher in 1988. These fluctuations correspond to successive dry years (declines) and wet years (rebounds), respectively. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kaweah subbasin by up to 20 feet (DWR 2014c, 2014d). The Kaweah Delta Water Conservation District operates recharge facilities to supplement groundwater recharge that occurs along the natural stream channels (KDWCD 2006). Water is released from the Terminus Reservoir on the Kaweah River to flow into over 40 recharge basins throughout the basin. Use of CVP water from the Friant-Kern Canal by Tulare Irrigation District and Ivanhoe Irrigation District reduces the need for groundwater withdrawals when the CVP water is available.

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in the subbasin, including for water users in the communities of Visalia, Tulare, and Lindsay (CVRWQCB 2011; Tulare County 2010).

*Tule Subbasin*

The Tule subbasin includes southwestern Tulare County. Water levels in this subbasin increased by about 4 feet on average from 1970 through 2000 (DWR 2004w, 2013c). Water levels have fluctuated during dry and wet years between 16 feet below the 1970 water level in 1995 to 20 feet above the 1970 water level in 1988. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tule subbasin by up to 20 feet (DWR 2014c, 2014d). The Deer Creek and Tule River Authority implemented a groundwater management plan in 2006 in the Tule Subbasin (DCTRA 2012). The plan participants include Lower Tule River Irrigation District, Pixley Irrigation District, Porterville Irrigation District, Terra Bella Irrigation District, Saucelito Irrigation District, Tea Pot Dome Irrigation District, Vandalia Irrigation District, Tipton Community Services District, Poplar Community Services District (primarily the City of Porterville), and Woodville Public Utility District. Many of these agencies have CVP water service contracts and some of these agencies have surface water rights. Groundwater recharge occurs in more than 25 groundwater recharge basins and along the Tule River and Deer Creek channels.

*Southern Tulare Lake Area: Kern County Subbasin*

The Kern County subbasin is located between the Tule and Tulare Lake groundwater subbasins on the north, the Sierra Nevada and Tehachapi Mountains granitic rock on the east, and the marine sediments of the Coast Ranges on the west. The major water suppliers within the Kern County subbasin include Kern County Water Agency and the City of Bakersfield.

*Hydrogeology and Groundwater Conditions*

The unconfined aquifer in the Kern County Groundwater subbasin is composed primarily of sediments that were deposited during the tertiary and quaternary age. The Tulare Formation, located in the western portion of the subbasin, includes the Corcoran Clay unit which occurs at depths of 300 to 650 feet and overlies the confined aquifer (DWR 2006o, 2013c).

Net groundwater level changes in the Kern County subbasin varied in different portions of the subbasin between 1970 and 2000 (DWR 2006o, 2013c). Since the late 1970s, the groundwater levels have ranged from an increase of over 30 feet in the southeastern portion of the subbasin to a decrease of up to 25 feet near Bakersfield and 50 feet near McFarland/Shafter. Recent information indicates that between the spring 2013 and spring 2014, groundwater levels declined at some wells in the Kern County subbasin by up to 40 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Complete hydraulic disconnection between the groundwater and overlying surface water systems has occurred in the Kern County area. Kern River, a losing stream, is used as a conveyance element for irrigation purposes and to recharge groundwater.

Groundwater quality in the region is generally characterized by calcium bicarbonate in the shallow aquifers, and the groundwater quality is generally suitable for most uses. Lower aquifers have higher sodium concentrations (DWR 2006o, 2013c). Salinity is a significant groundwater quality issue in the region. Salt from imported CVP and SWP water accumulates annually in groundwater because the Tulare Lake is a closed system without any natural outlets (KCWA 2011).

Shallow groundwater with high salinity occurs in the western and southern portions of the Kern County subbasin and is related to drainage problems for irrigated agriculture (DWR 2006o, 2013c). An agricultural drainage study showed that shallow groundwater occurs between 0 and 30 feet below the ground surface in the southern portion of the Kern County subbasin (DWR 2013j). The shallow groundwater is characterized by high TDS, sodium chloride, selenium, and sulfates (DWR 2013j). Areas with high nitrate and pesticide concentrations occur in localized areas due to historic agricultural practices including irrigation and dairy wastes (CVRWQCB 2011; DWR 2006o). Elevated arsenic concentrations tend to occur in isolated areas associated with lakebed deposits. Selenium and chromium also naturally occur in portions of the subbasin (KCWA 2011).

*Groundwater Use and Management*

The Kern County subbasin is located in western Kern County. The majority of the lands within the Kern County subbasin are within Kern County Water Agency or the City of Bakersfield. Water supplies in the subbasin include local surface water, CVP and SWP water supplies, and groundwater. The subbasin includes a portion of the land evaluated in the Tulare Lake Basin Portion of the Kern Region IRWMP. It is estimated that over the long-term, approximately 39 percent of water supplies in this area are met by groundwater (KCWA 2011). Groundwater can provide up to 60 percent of the total water supply in drier years.

Much of the groundwater is withdrawn by individuals or farmers who do not maintain groundwater extraction records. Historically, groundwater extractions were estimated based upon electricity use, changes in groundwater storage, or changes in crop patterns and/or water requirements (DWR 2004o, 2013c; KCWA 2011).

Most of the groundwater is used by agriculture and the communities of Bakersfield, Rosedale, Shafter, Delano, Taft, and Wasco (KCWA 2011). The City of Bakersfield and surrounding unincorporated areas use surface water and groundwater. The groundwater supplies in 2010 include water provided by California Water Service Company; East Niles Community Services District;, Kern County Water Agency Improvement District No. 4 and North of the River Municipal Water District; and Vaughn Water Company (California Water Service Company 2011a; ENCSD 2011; KCWA 2011; KCWA and NORMWD 2011; Vaughn Water Company, Inc. 2011). The water entities along with adjacent water agencies manage the groundwater basin levels through ongoing recharge projects and conjunctive use projects.

*Conjunctive Use and Groundwater Banking*

Conjunctive use is an important component of water management in the Kern County subbasin. Many groundwater banking facilities supplement water supplies delivered to customers in dry years, when insufficient surface water supplies are available to meet demands.

More than 30,000 acres of groundwater recharge ponds are estimated to exist in the Kern County subbasin area (KCWA 2011). Infrastructure used for groundwater banking includes recharge basins, recharge canals, recovery wells, and conveyance pipelines. In addition, connections to regional conveyance infrastructure conveys water from the local water supplies, including the Kern River; Friant-Kern Canal; the Cross Valley Canal; and California Aqueduct to the recharge areas. Groundwater banking programs have developed various interties to the regional conveyance systems, such as the Semitropic Water Storage District Intake Canal and the Kern Water Bank Canal (KCWA 2011).

The major groundwater banking programs in Kern County include the Kern Water Bank operated by the Kern Water Bank Authority; the Semitropic Groundwater Bank, operated by the Semitropic Water Storage District; a groundwater bank operated by the North Kern Water Storage District; a groundwater bank operated by the City of Bakersfield; and a groundwater bank operated by Rosedale-Rio Bravo Water Storage District.

The Kern Water Bank Authority is located west of Bakersfield and covers nearly 30 square miles of the Kern County subbasin. The Kern Water Bank includes recharge ponds where water from local surface streams and the SWP infiltrates into the aquifer (KCWA n.d.; KWBA 2011). Eighty-four recovery wells are used to pump groundwater out of the aquifer in dry years when additional water is needed for irrigation since the program began operations in 1995 (KCWA 2011).

The Semitropic Water Storage District is located west of Wasco and covers more than 220,000 acres (SWSD 2011a). The Semitropic Water Storage District Stored Water Recovery Unit (a subunit of the overall Semitropic Water Storage District Water Bank) partnered with the Antelope Valley Water Bank, located close to Rosamond in the Kern County portion of the Antelope Valley, to form the Semitropic-Rosamond Water Bank Authority (SWSD 2011b). The major banking partners of Semitropic Water Storage District include (SWSD 2014):

- Metropolitan Water District of Southern California
- Santa Clara Valley Water District
- Alameda County Water District
- Zone 7 Water Agency
- Poso Creek Water Company
- Newhall Land & Farming Company
- San Diego County Water Authority
- Homer, LLC
- City of Tracy
- Harris Farms

Other banking programs include (KCWA and NORMWD 2011; KCWA 2011, n.d.):

- Arvin-Edison Water Storage District Banking

- Buena Vista Water Storage District Banking
- Cawelo Water District Banking
- City of Bakersfield 2800 Acres Recharge Facility
- Kern County Water Agency Improvement District No. 4 Pioneer Project and Allen Road Complex Well Field
- Kern Delta Water District Banking
- Kern Tulare and Rag Gulch Water Districts Banking
- Rosedale-Rio Bravo Water Storage District Banking (developed with Kern County Water Agency Improvement District No. 4)

*Western Tulare Lake Area: Pleasant Valley Subbasin*

The Pleasant Valley subbasin is located within the western portions of Fresno and Kings Counties.

*Hydrogeology and Groundwater Conditions*

Tertiary continental and marine sediments of the Coast Ranges and Kettleman Hills form the western boundary of the Pleasant Valley subbasin (DWR 2006p, 2013c). Alluvium of the San Joaquin Valley extends into the subbasin from the north, east, and south. Ephemeral streams from the Coast Ranges and Kettleman Hills flow into the subbasin. Groundwater recharge occurs primarily along these and other streams within the subbasin.

In the Pleasant Valley subbasin, groundwater levels are generally continuing a historical trend of decline. DWR measurements indicated a decline of 5 to 25 feet during the 1990s (DWR 2006p, 2013c).

Water quality in the Pleasant Valley subbasin is characterized by high TDS (CVRWQCB 2011; DWR 2006p, 2013c). Localized areas of high concentrations of boron, calcium, chlorides, magnesium, pesticides, sodium, bicarbonates, and sulfates occur in the groundwater.

The Pleasant Valley subbasin was designated by the CASGEM program as low priority.

*Groundwater Use and Management*

Groundwater is used to meet agricultural and municipal water demands in the Pleasant Valley subbasin (DWR 2006p, 2013c). Due to limited recharge capabilities in the subbasin, surface water is used either completely or conjunctively in western Fresno and Kings Counties. The communities of Avenal and Coalinga use CVP surface water due to groundwater quality, as described in Chapter 5, Surface Water Resources and Water Supplies (Reclamation 2012).

### 7.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. The SWP water users in Napa County do not use groundwater. Therefore, groundwater resources for Napa County are not described in this EIS.

There are several groundwater basins in the San Francisco Bay Area Region; however, only some of the basins are within the CVP and SWP service areas evaluated in this EIS. The portions of the San Francisco Bay Area Region within the CVP and/or SWP service areas include the Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, San Ramon Valley, Livermore Valley, Castro Valley, and Santa Clara Valley groundwater basins within the San Francisco Bay Hydrologic Region; and Gilroy-Hollister Valley Groundwater Basin within the Central Coast Hydrologic Region.

Groundwater represents approximately 15 percent of the agricultural, municipal, and industrial water supplies in the San Francisco Bay Area (DWR 2013i). Conjunctive use programs have been implemented by several agencies to optimize the use of groundwater and surface water sources.

Groundwater quality in the San Francisco Bay Area is generally suitable for most agricultural and municipal uses, but concerns exist about groundwater contamination from industrial and agricultural chemical spills, leaky underground and above ground storage tanks, landfill leachate, and poorer-quality surface water bodies. There were over 800 groundwater cleanup projects in the area with the majority resulting from leaky fuel tanks (DWR 2013i). Portions of the San Francisco Bay Area Region along the shorelines include aquifers that are susceptible to seawater intrusion.

In the southern San Francisco Bay Area Region, groundwater and surface water are connected through in-stream and off-stream artificial recharge projects, in which surface water is delivered to water bodies that permit the infiltration of water to recharge underlying aquifers. Surface waters recharge aquifers in other regions of the San Francisco Bay Area Region along streambeds, especially in areas with depressed groundwater levels that have resulted from extensive groundwater pumping.

This section describes groundwater in subbasins within CVP and/or SWP water service areas, including Pittsburg Plain, Clayton Valley, Arroyo Del Hambre Valley, Ygnacio Valley, and San Ramon Valley subbasins in Contra Costa County; East Bay Plain and Livermore Valley subbasins in Contra Costa and Alameda counties; Castro Valley subbasin in Alameda County; Santa Clara and Llagas Area subbasins in Santa Clara County; and Bolsa, Hollister, and San Juan Bautista Area subbasins in San Benito County, as shown in Figure 7.8.

#### *7.3.4.1 San Francisco Bay Hydrologic Region*

##### 7.3.4.1.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the San Francisco Bay Hydrologic Region contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay (DWR 2004x, 2004y, 2004z, 2004aa, 2004ab, 2004ac, 2004ad, 2004ae, 2006q, 2006r, 2013d). Aquifers in these basins are hydrologically connected to surface water bodies, such as the San Joaquin River, Suisun Bay, local streams, and San Francisco Bay.

The movement of groundwater is locally influenced by features such as faults and structural depressions and operating production wells; however, groundwater generally flows toward the nearby bays. Groundwater levels in the area exhibit seasonal variation and have been historically depressed from significant groundwater use. However, as groundwater use decreased over the last few decades following implementation of surface water projects, groundwater levels have risen significantly. Over the entire period of record, groundwater levels have shown only a slight decline and are stable in more recent years.

*Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins*

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins represent the majority of groundwater storage in northern Contra Costa County. Except for portions of the Pittsburg Plain, most of these groundwater basins are not located within the Delta.

These basins extend inland from Suisun Bay towards Mt. Diablo. The Pittsburg Plain Groundwater Basin is composed of Pleistocene deposits of consolidated and unconsolidated clay sediments; overlain by alluvial soft water-saturated muds, peat, and loose sands (DWR 2004x, 2013d). The Clayton Valley and Ygnacio Valley groundwater basins are composed of unconsolidated alluvium and semi-consolidated alluvium interbedded with clay, sand, and gravel lenses. Along Suisun Bay, the water bearing formations are composed of alluvial soft water-saturated muds, peat, and loose sands (DWR 2004y, 2004z, 2004aa, 2013d).

Groundwater levels are relatively stable because the groundwater is recharged from streams (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). The streams include Kirker and Willow creeks in the Pittsburg Plain Groundwater Basin; Marsh Creek in the Clayton Valley Groundwater Basin; Walnut and Grayson creeks in the Ygnacio Valley Groundwater Basin; and Alhambra Creek in the Arroyo Del Hambre Valley Groundwater Basin. There are no recent data for these basins related to groundwater levels or storage capacities.

The groundwater in this area is characterized by moderate to high TDS (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). High nitrate concentrations occur in some rural areas of these basins (Contra Costa County 2005).

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins were designated by the CASGEM program as very low priority.

*San Ramon Valley Groundwater Basin*

The San Ramon Valley Groundwater Basin is located in southern Contra Costa County and extends from the Alamo area southward under the Town of Danville and City of San Ramon to the county boundary.

The basin is a closed basin characterized by alluvial fan deposits of sand, gravel, silt, and clay sediments (DWR 2004ab, 2013d). Multiple faults within the basin affect groundwater movement.

There are no recent data for this basin related to groundwater levels, storage capacities, or quality (DWR 2004ab, 2013d).

The San Ramon Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Livermore Valley Groundwater Basin*

The Livermore Valley Groundwater Basin extends under northeastern Alameda County and southern Contra Costa County. The Livermore Valley Groundwater Basin contains groundwater-bearing materials originating from continental deposits from alluvial fans, outwash plains, and lakes (DWR 2006q, 2013d).

The Main Basin is the aquifer that includes the highest yielding aquifers and highest quality groundwater (Zone 7 2012). The Main Basin generally is divided into the Upper Aquifer Zone and Lower Aquifer Zone which are separated by a relatively continuous silty clay lens. Water from the Upper Aquifer Zone moves into the Lower Aquifer Zone when groundwater levels in the upper zone are high.

Well yields are mostly adequate and in some areas can produce large quantities of groundwater for all types of wells (DWR 2006q, 2013d). The movement of groundwater is locally impeded by structural features such as faults that act as barriers to groundwater flow, resulting in varying water levels in the basin. Groundwater follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers (Zone 7 2005).

Groundwater levels in the main portion of the Livermore Valley Groundwater Basin started declining in the early 1900s when groundwater pumping removed large quantities of groundwater (Zone 7 2005, 2010, 2013). This trend continued until the late 1960s when Zone 7 Water Agency began importing SWP water. Subsequently, Zone 7 Water Agency developed surface water projects to capture local runoff. Local runoff and SWP water is stored in Lake Del Valle and used to recharge groundwater within the Livermore Valley. The importation of additional surface water alleviated the pressure on the aquifer, and groundwater levels started to rise in the 1970s. However, historical lows were reached during periods of drought. During the recent dry period, groundwater levels declined 7 to 17 feet throughout the aquifers used by Zone 7 Water Agency between 2011 and 2012.

The Livermore Valley Groundwater Basin is characterized by localized areas of high boron, nitrate, and TDS (DWR 2006q, 2013; Zone 7 2012). High boron levels can be attributed to marine sediments adjacent to the basin.

Nitrate concentrations generally are within potable water criteria; however, high nitrate concentrations occur in some locations of the upper aquifer (Zone 7 2012). The source of nitrates appears to be related to agricultural activities, wastewater disposal, and natural sources from decaying vegetation.

Salinity of the aquifer depends upon the quality of the water used for recharge operations. Salinity has increased over the past 30 years (Zone 7 2012) especially in the western portion of the Main Basin. Aquifers in the central and eastern portions of the Livermore Valley Groundwater Basin are generally recharged through streambeds and are characterized by lower salinity due to the high recharge rate.

The Livermore Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Castro Valley Groundwater Basin*

The Castro Valley Groundwater Basin is located in the Castro Valley area of Alameda County between San Lorenzo Creek on the east and the Hayward Fault on the west (Castro Valley 2012).

The basin is composed of alluvial deposits of sand, gravel, silt, and clay sediments (DWR 2004ac, 2013d). Previous studies indicated that the maximum yield was about 140,000 gallons per day (Castro Valley 2012).

The groundwater is characterized by bicarbonates with calcium and sodium. Localized contamination has occurred in this shallow aquifer related to agricultural activities and underground storage tanks (Castro Valley 2012).

The Castro Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Santa Clara Valley Groundwater Basin*

The Santa Clara Valley Groundwater Basin includes three subbasins in areas that are within the CVP and/or SWP service areas. The three subbasins include the East Bay Plain subbasin in Contra Costa and Alameda counties, Niles Cone subbasin in Alameda County, and Santa Clara subbasin in Santa Clara County.

*East Bay Plain Subbasin*

The East Bay Plain subbasin is an alluvial plain that extends from San Pablo Bay southward to the Niles Cone subbasin, and extends under San Francisco Bay (DWR 2004ad, 2013d; EBMUD 2013). The alluvium consists of unconsolidated sediments of mud, silts, sands, and clays. Multiple faults within the subbasin affect groundwater movement. Groundwater levels declined to approximately 250 feet below the ground surface until the mid-1960s when groundwater levels began to increase. By 2000, groundwater levels were close to the ground surface. The groundwater quality is characterized as calcium and sodium bicarbonate with moderate to high TDS. Higher TDS concentrations occur near San Francisco Bay where localized sea water intrusion has occurred. High nitrate concentrations occur in localized areas due to historic agricultural activities.

The East Bay Plain subbasin was designated by the CASGEM program as medium priority.

*Niles Cone Subbasin*

The Niles Cone subbasin is mainly comprised of the alluvial fan along Alameda Creek. The Hayward Fault crosses the Niles Cone subbasin and further separates the subbasin into the Below Hayward Fault (west of the Hayward Fault) and Above Hayward Fault (east of the Hayward Fault) subbasins (ACWD 2012; DWR 2006r, 2013d).

The Niles Cone subbasin was in overdraft condition through the early 1960s. After 1962, groundwater levels increased as SWP water was delivered to the area and used to recharge the groundwater subbasin (DWR 2006r, 2013d).

The main groundwater quality impairment in the Niles Cone subbasin is saltwater intrusion caused by groundwater pumping (ACWD 2012; DWR 2006r, 2013d). In the 1950s the migration of saline water extended into the Above Hayward Fault subbasin, and migrated into deeper aquifers. Alameda County Water District has developed aquifer reclamation programs to help control the movement of saline water and restore the quality of groundwater in the affected aquifers, as described below.

Niles Cone subbasin was designated by the CASGEM program as medium priority.

*Santa Clara Subbasin*

The Santa Clara subbasin is located within Santa Clara County along a structural trough that parallels the Coast Ranges and extends from the Diablo Range and Santa Cruz Mountains. The water bearing formations of the Santa Clara subbasin include unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004ac, 2013d). The upper alluvial fan in the northern portion of the subbasin is characterized by coarse-grained sediments (SCVWD 2010). Towards the central portion of the subbasin, thick silty clay lenses are inter-bedded with thin sand and gravel lenses. The northern and central portions of the subbasin are locally referred to as the Santa Clara Plain (SCVWD 2011). The southern portion of the subbasin consists of extensive alluvial deposits of unconsolidated and semi-consolidated sediments and is referred to as the Coyote Valley (SCVWD 2010). The central portions and areas along the edges of the Santa Clara Plain subbasin consist of unconfined aquifers that provide recharge to the basin (SCVWD 2010, 2011). The Shallow Aquifer consists of water-bearing sediments that are less than 150 feet deep. The Principal Aquifer provides most of the groundwater supply for the Santa Clara Valley and is separated from the Shallow Aquifer by a confining lens in some areas of the Santa Clara Plain. The groundwater recharge primarily occurs due to percolation of water on the soil from precipitation or artificial recharge operations (as described below), seepage from stream beds, and subsurface inflow from surrounding hills.

In the Coyote subbasin, the groundwater aquifer is primarily unconfined with areas of perched groundwater above discontinuous clay deposits (SCVWD 2010, 2011). Groundwater recharge occurs along the streambeds. When the groundwater levels are high in the Coyote subbasin, groundwater seeps into the streams.

The movement of groundwater in the Santa Clara subbasin is locally influenced by groundwater recharge activities, proximity to streams, and operating production wells (SCVWD 2010). Regionally, groundwater in the Santa Clara Subbasin generally flows northwest toward the San Francisco Bay.

The Santa Clara subbasin has historically experienced decreasing groundwater level trends. Between 1900 and 1960, water level declines of more than 200 feet from groundwater pumping have induced unrecoverable land subsidence of nearly 13 feet (SCVWD 2011). Importation of surface water using CVP, SWP, and San Francisco Public Utilities District water supplies; and the development of an artificial recharge program have resulted in rising groundwater levels since the late 1960s. The groundwater levels in some portions of this subbasin declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

The groundwater quality in the Santa Clara subbasin is good to excellent and suitable for most beneficial uses. The groundwater meets all drinking water standards and can be used without additional treatment (SCVWD 2001, 2010). Some areas affected by historical saltwater intrusion exist in the northern portion of the Santa Clara subbasin in the Shallow Aquifer. Recent groundwater monitoring has indicated that seawater intrusion appears to be stabilizing (SCVWD 2012a). High nitrate concentrations occur in the Coyote Valley.

Santa Clara subbasin was designated by the CASGEM program as medium priority.

#### 7.3.4.1.2 Groundwater Use and Management

Use of groundwater in the San Francisco Bay Hydrologic Region varies extensively. In the basins within Contra Costa County (Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, and San Ramon Valley), local wells are used for small agricultural activities and landscape irrigation by individual land owners. In the Livermore Valley Groundwater Basin, groundwater is used for a major portion of the water supply.

*Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins*

Groundwater use is limited within northern Contra Costa County within the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins. This area is located within the Contra Costa Water District or East Bay Municipal Utilities District service areas. These districts provide surface water to most water users in this area.

Within the Contra Costa Water District service area, groundwater use is limited (CCWD 2011). The use of existing Contra Costa Water District wells at the Mallard Well Fields is limited because of the threat of contamination from adjacent industrial areas.

The City of Pittsburg operates two municipal wells from the Pittsburg Plain Groundwater Basin (Pittsburg 2011).

The City of Martinez operates up to two wells in the Arroyo Del Hambre Valley Groundwater Basin to provide irrigation water to a municipal park (Martinez 2011).

*San Ramon Valley Groundwater Basin*

Groundwater use is limited within the San Ramon Valley Groundwater Basin located in southern Contra Costa County. Local wells are used for small agricultural activities and landscape irrigation by individual land owners. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

*Livermore Valley Groundwater Basin*

In the Livermore Valley Groundwater Basin, Zone 7 Water Agency administers oversight of the groundwater basins used for water supply and provides water to California Water Service Company, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton. Zone 7 Water Agency only withdraws groundwater that has been recharged using surface water supplies (Zone 7 2010). The California Water Service Company, Dublin San Ramon Services District, and City of Pleasanton also withdraw groundwater (California Water Service Company 2011h; DSRSD 2011; City of Livermore 2011; City of Pleasanton 2011).

Zone 7 Water Agency manages the groundwater levels and quality in the Livermore Valley Groundwater Basin to maintain groundwater levels that would avoid subsidence and provide emergency reserves for the worst credible drought (DWR 2006q, 2013d).

Zone 7 Water Agency artificially recharges the Livermore Valley Groundwater Basin with local surface water supplies and SWP water by releasing the surface waters into the Arroyo Mocho and Arroyo Valle (Zone 7 2005, 2010). The infiltrated water is then pumped from the groundwater basin for various uses, mostly during the summer and during drought periods when local surface water supplies are diminished and the available SWP water supplies are less than the entitlement value Zone 7 Water Agency, City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and California Water Service Company are permitted to withdraw groundwater from this subbasin.

In 2009, the Zone 7 Water Agency began operation of the Mocho Groundwater Demineralization Plant (Zone 7 2010). This plant is a wellhead treatment plant that produces potable water using reverse osmosis to remove TDS and hardness from the Main Basin.

*Castro Valley Groundwater Basin*

Groundwater use is limited within the Castro Valley Groundwater Basin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (Castro Valley 2012). This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

*Santa Clara Valley Groundwater Basin*

The Santa Clara Valley Groundwater Basin includes the East Bay Plain, Niles Cone, and Santa Clara subbasins.

*East Bay Plain Subbasin*

Groundwater use is limited within the East Bay Plains subbasin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (DWR 2004ad, 2013d; EBMUD 2013). Well fields that served the communities were initially constructed in the late 1800s and early 1900s, and were closed by 1930. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area. East Bay Municipal Utilities District initiated the Bayside Groundwater Project in 2009 to store surface water in wet years for use during droughts.

*Niles Cone Subbasin*

Alameda County Water District is the primary water agency that relies upon the Niles Cone subbasin. This Alameda County Water District uses fresh groundwater from the Niles Cone subbasin and desalinated brackish groundwater in addition to local and imported surface water supplies. The Niles Cone subbasin is primarily recharged in the Alameda Creek watershed by percolation of local runoff and SWP water (ACWD 2011, 2012). In wetter years, when local water supplies are abundant, Alameda County Water District diverts some of the SWP allocation to the Semitropic Water Storage District in Kern County through a water banking agreement (as described above for the Kern County subbasin). This agreement allows Alameda County Water District to subsequently recover this water during drier years through an exchange agreement with Semitropic Water Storage District (ACWD 2012).

Alameda County Water District provides retail water supplies to the cities of Fremont, Newark, and Union City. The district has implemented treatment of brackish groundwater to allow previously unused groundwater to be used as a potable water source (ACWD 2011, 2012). In 2003, the Alameda County Water District Newark Desalination Facility began to remove salts and other constituents from the Niles Cone subbasin groundwater that is subject to seawater intrusion using a reverse-osmosis process. The aquifer reclamation program also includes withdrawing water to prevent a plume of brackish water in the Centerville-Fremont Aquifer from further migrating toward the Alameda County Water District Mowry Wellfield. Future groundwater desalination facilities are being evaluated by the district.

*Santa Clara Subbasin*

Local water agencies and individual landowners use groundwater in the Santa Clara subbasin. The Santa Clara subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP and/or SWP that is discharged to streambeds and recharge facilities (SCVWD 2011).

Treated water is provided by the Santa Clara Valley Water District to retail water agencies in order to promote conjunctive use of groundwater. The water entities in the Santa Clara subbasin that use treated surface water include the cities of Milpitas, Mountain View, Palo Alto, San Jose, Santa Clara, and Sunnyvale; California Water Service (Los Altos), Purissima Water District, and San Jose

Water Company. Several of these entities also use surface water from San Francisco Public Utilities Commission as part of their overall water supply.

In the Santa Clara subbasin, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011). Groundwater provides approximately 40 to 50 percent of total water supply in Santa Clara County in average water year conditions (SCVWD 2010). Within the Santa Clara subbasin, the users of the most groundwater include San Jose Water Company, City of Santa Clara, Great Oaks Water Company, California Water Service, and individual land owners primarily in the southern portion of the subbasin (SCVWD 2012a).

The Santa Clara Valley Water District is responsible for groundwater management in the Santa Clara subbasin, and operates a robust and flexible conjunctive use program that uses a variety of surface water sources: local supplies, imported SWP and CVP supplies, and imported transfer options. Surface water is also supplied to some water users by the San Francisco Public Utilities Commission (SCVWD 2001, 2010). The district operates an extensive system of in-stream and off-stream artificial recharge facilities to replenish the groundwater basin and provide more flexibility to manage water supplies. Eighteen major recharge systems allow local reservoir water and imported water to be released in over 30 local creeks and 71 percolation ponds that provide 393 acres for artificial recharge to the groundwater basin. Recharge in this subbasin occurs along streambeds and off-stream managed basins. Most of the recharge facilities are located in the Santa Clara subbasin. Two major recharge facilities, the Lower Llagas and Upper Llagas recharge systems, are located in the Llagas subbasin of the Gilroy-Hollister Groundwater Basin, as described below (SCVWD 2011, 2012a). The amount of water artificially recharged throughout the entire district depends upon the availability of local, CVP, and/or SWP surface water supplies.

#### *7.3.4.2 Central Coast Hydrologic Region: Gilroy-Hollister Valley Groundwater Basin*

Portions of the Gilroy-Hollister Valley Groundwater Basin within the CVP and/or SWP water service areas include the Llagas Area, Hollister Area, and San Juan Bautista Area subbasins.

##### 7.3.4.2.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the Gilroy-Hollister Valley Groundwater Basin contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay. Within four subbasins in the study area of this EIS, groundwater flows towards the Pajaro River which flows to Monterey Bay (DWR 2004af, 2004ag, 2004ah, 2004ai, 2013d).

*Llagas Area Subbasin*

The water bearing formations of the Llagas subbasin include continental deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004af, 2013d; SCVWD 2010, 2011). Alluvium along the edges and the center portions of the subbasin are underlain by dense clayey soils. Younger alluvium does not have a well-defined clay subsoil.

As described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin, Santa Clara Valley Water District manages groundwater in the Llagas Area subbasin. Groundwater withdrawals in the Llagas subbasin have been relatively stable in recent years; and groundwater elevation has been stable since the late 1990s (SCVWD 2012a).

The groundwater quality in the Llagas subbasin is of good to excellent mineral composition and suitable for most beneficial uses (SCVWD 2010, 2012a). High nitrate concentrations occur in localized areas throughout the subbasin due to historical agricultural practices and wastewater effluent disposal. Santa Clara Valley Water District implemented a Nitrate Management Program in 1997 and nitrate concentrations are beginning to decline.

*Bolsa Area, Hollister Area, and San Juan Bautista Subbasins*

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins extend over northern San Benito County. The subbasins are comprised of a sedimentary sequence that contains the principal aquifers underlying the Hollister and San Juan Valleys. The water bearing formation includes clay, silt, sand, and gravel (DWR 2004ag, 2004ah, 2004ai, 2013e).

The main water bearing formation in this area is composed of alluvium in the Bolsa Area and Hollister Area subbasins (San Benito County Water District 2012). The water bearing formations in the northern San Juan Bautista Area consist of alluvium (San Benito County Water District 2012). Groundwater movement within the aquifers is affected by the numerous faults, including the San Andreas and Calaveras Faults. Groundwater aquifers in this area include both unconfined and confined aquifer conditions with surficial clay deposits in the northern portions of these subbasins.

Groundwater in these subbasins is characterized by artesian conditions when groundwater levels are high, such as in the early 1900s (San Benito County Water District 2012). After the mid-1940s, groundwater levels declined with increased withdrawals. One of the lowest levels occurred in the late 1970s when the groundwater elevation was approximately 150 feet lower than the high water level conditions. In 2012, groundwater elevations ranged from 80 feet above mean sea level in the Bolsa Area subbasin to 700 feet above mean sea level in the San Juan Bautista Area subbasin.

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins have localized areas with high concentrations of boron, chloride, hardness, metals, nitrate, sulfate, potassium, and TDS (San Benito County Water District 2012). The most substantial constituents include high TDS concentrations in the southeastern Bolsa Area subbasin, Hollister Area subbasin, and northern San Juan Bautista Area subbasin. High nitrate concentrations occur in the northern San Juan Bautista Area subbasin.

*Overall Groundwater Conditions*

The Llagas Area subbasin was designated by the CASGEM program as high priority. The Hollister Area and San Juan Bautista Area subbasins were designated as medium priority.

#### 7.3.4.2.2 Groundwater Use and Management

*Llagas Area Subbasin*

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is the primary water supply for local water agencies and individual landowners in the Llagas Area subbasin. The subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP that is discharged to recharge facilities managed by Santa Clara Valley Water District, as described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin (SCVWD 2011). The two major recharge facilities in the Llagas Area subbasin include the Lower Llagas and Upper Llagas recharge systems (SCVWD 2010).

The primary municipal water suppliers are the cities of Gilroy and Morgan Hill. Groundwater is used by these local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011).

*Bolsa Area, Hollister Area, and San Juan Bautista Subbasins*

Local water agencies and individual landowners use groundwater in the Bolsa Area, Hollister Area, and San Juan Bautista subbasins. The subbasins are primarily recharged from percolation of local runoff in streambeds, including water from Hernandez and Paicines Reservoirs that is released to Tres Pinos Creek (San Benito County Water District 2012).

San Benito County Water District provides CVP water to the cities of Hollister and San Juan Bautista, Sunnyslope County Water District, residential areas surrounding Hollister and Tres Pinos, and agricultural areas in northern San Benito County to reduce groundwater use by these areas (San Benito County Water District 2012). Most other water users in the subbasins rely upon groundwater and/or local surface water stored in Hernandez and Paicines Reservoirs.

In 2011, groundwater supplies provided 49 percent of the water used for agriculture, municipal, domestic, and industrial supply in the areas of the subbasin supplied by CVP water (San Benito County Water District 2012).

### 7.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Central Coast Region encompasses the southern planning area of the Central Coast Hydrologic Region (DWR 2009a).

The SWP water is provided to the Central Coast Region by the Central Coast Water Authority (CCWA 2013a). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to the 43 million gallon per day water treatment plant at Polonto Pass. The treated water is conveyed to municipal water users in San Luis Obispo and Santa Barbara counties to reduce groundwater overdraft in these areas.

Portions of the Central Coast Region that use SWP water are included in the Central Coast Hydrologic Region which includes 50 delineated groundwater basins, as defined by DWR (DWR 2003a). The basins vary from large extensive alluvial aquifers to small inland valleys and coastal terraces. Groundwater in the large alluvial aquifers exists in thick unconfined and confined basins.

Groundwater is generally used for urban and agricultural use in the Central Coast Region.

#### *7.3.5.1 Hydrogeology and Groundwater Conditions*

The areas within the SWP service area in the Central Coast Region include the Morro Valley and Chorro Valley groundwater basins in San Luis Obispo County; Santa Maria River Valley Groundwater Basin in San Luis Obispo and Santa Barbara counties; and San Antonio Creek Valley, Santa Ynez River Valley, Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins in Santa Barbara County, as shown in Figure 7.9.

##### 7.3.5.1.1 Morro Valley and Chorro Valley Groundwater Basins

In the portions of San Luis Obispo County within the SWP service area near Morro Bay, groundwater is provided by Morro Valley and Chorro Valley groundwater basins. The water bearing formations are alluvium that consists of clays, silts, sands, and gravel that extend into the Pacific Ocean (DWR 2004aj, 2004ak, 2013e). The alluvium is recharged by seepage from streambeds and precipitation and irrigation water applied to the soils.

The groundwater has moderate TDS (DWR 2004aj, 2004ak, 2013e). Localized areas have high nitrate concentrations (Morro Bay 2011). Localized areas with organic contamination are also present; however, actions have been implemented to reduce the concentrations. Seawater intrusion occurs in localized areas near the Pacific Ocean.

The Morro Valley and Chorro Valley groundwater basins were designated by the CASGEM program as high priority.

##### 7.3.5.1.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is located in San Luis Obispo and Santa Barbara counties. The water bearing formation is primarily unconfined alluvium with localized confined areas near the coast (DWR 2004 al, 2013e; SMVMA 2012). Recharge occurs along the streambeds. Groundwater levels in the Basin have fluctuated over the past 100 years with declining groundwater levels until the mid-1970s, recovery through the mid-1980s, and declining levels through the mid-1990s. Following importation of SWP water, groundwater levels increased to historic high levels. However, in the last decade, groundwater levels have gradually declined which could be partially due to reductions in Twitchell Reservoir releases for groundwater recharge since 2000. Groundwater levels have been maintained at levels above 15 feet above mean sea level in shallow and deep aquifers near the coast to avoid seawater intrusion. Groundwater recharge occurs along streambeds. Water released from Twitchell and Lopez reservoirs increase groundwater recharge rates (SMVMA 2012).

Groundwater quality issues in the Santa Maria Valley Groundwater Basin include hardness, nitrates, salinity, sulfate and volatile organic compounds (DWR 2004al, 2013e; San Luis Obispo County 2011; SMVMA 2012). TDS concentrations are moderate to high. There are localized areas in the basin with high sulfate concentrations. Volatile organic compound contamination was a major issue for two wells used by the City of San Luis Obispo in the late 1980s. High nitrate concentrations occur in the shallow aquifer due to historic agricultural practices. Higher salinity levels occur in the shallow aquifer near the coast than within the inland areas or in the deep aquifer.

The Santa Maria River Valley Groundwater Basin was designated by the CASGEM program as high priority.

#### 7.3.5.1.3 San Antonio Creek Valley Groundwater Basins

San Antonio Creek Valley Groundwater Basin is located along the Pacific Ocean within San Luis Obispo and Santa Barbara counties. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of sand, clay, silt, and gravel (DWR 2004dq, 2013e). Groundwater flows towards the Pacific Ocean. A groundwater barrier to the east of the Pacific Ocean creates the Barka Slough. Groundwater has declined in some areas of the basin over the past 60 years. Groundwater quality issues include areas with high salinity near the Pacific Ocean.

The San Antonio Creek Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### 7.3.5.1.4 Santa Ynez River Valley Groundwater Basins

Several groundwater basins in Santa Barbara County are in a state of overdraft, including the Santa Ynez River Valley Groundwater Basin. The Santa Ynez Groundwater Basin is located along the Pacific Ocean in southwestern Santa Barbara County. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of gravel, sand, silt, and clay (DWR 2004an, 2013e). Groundwater flows towards the Santa Ynez River, and then towards the Pacific Ocean. Groundwater recharge occurs along the stream beds.

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2013e).

The Santa Ynez River Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### 7.3.5.1.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

The Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins are located in southwestern Santa Barbara County along the Pacific Ocean and near the boundary with Ventura County. The water bearing formations in the Goleta, Foothill, Santa Barbara, and Montecito groundwater basins are unconsolidated alluvium of clay, silt, sand, and/or gravel that overlays the generally confined Santa Barbara Formation of marine sand, silt, and clay (DWR 2004an, 2004ao, 2004ap, 2004aq, 2013e).

In the Carpinteria Groundwater Basin, the alluvium extends under the agricultural plain (DWR 2004ar, 2013e). A confined aquifer occurs under a thick clay bed in the lower part of the alluvium. This basin includes the Santa Barbara Formation; as well as the Carpinteria Formation, of unconsolidated to poorly consolidated sand with gravel and cobble; and the Casitas Formation, of poorly to moderately consolidated clay, silt, sand, and gravel.

Several faults restrict groundwater flow throughout these basins. Recharge occurs along streambeds and from subsurface inflow into the basin from upland areas. Water released from Lake Cachuma increases groundwater recharge rates.

The groundwater levels in portions of these groundwater basins declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet (DWR 2014d).

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2004ao, 2004ap, 2004aq, 2004ar, 2013e; GWD and LCMWC 2010). High concentrations of nitrate, iron, and manganese occur in localized areas in the Goleta Groundwater Basin. Localized areas of high nitrate and sulfate concentrations occur within the Foothill Groundwater Basin. High concentrations of calcium, magnesium, bicarbonate, and sulfate occur in localized areas of the Santa Barbara Groundwater Basin. High concentrations of iron and manganese occur in localized areas of the Montecito Groundwater Basin. Localized areas with high nitrates occur within the Carpinteria Groundwater Basin. Other basins are in equilibrium due to management of the basin through conjunctive use by local water districts (Santa Barbara County 2007). The Goleta Groundwater Basin generally is near or above historical groundwater conditions (Goleta Groundwater Basin and La Cumbre Mutual Water Company 2010), with the northern and western portions of the basin having groundwater levels near the ground surface. High groundwater levels may result in degradation to building foundations and agricultural crops (water levels within the crop root zone).

The Goleta Groundwater Basin was designated by the CASGEM program as medium priority. Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins were designated as very low priority.

#### *7.3.5.2 Groundwater Use and Management*

Groundwater is an important source of water supply for the population of the Central Coast; it is the region's primary water source.

##### 7.3.5.2.1 Morro Valley and Chorro Valley Groundwater Basins

As described in Chapter 5, Surface Water Resources and Water Supplies, the City of Morro Bay uses groundwater from Morro Valley and Chorro Valley groundwater basins. These basins have been designated by the State Water Resources Control Board as riparian underflow basins. The City of Morro Bay and other users of these basins have received water rights permits which limits the rate and volume of groundwater withdrawals (Morro Bay 2011).

##### 7.3.5.2.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is the primary water supply for irrigation in southwestern San Luis Obispo County and northwestern Santa Barbara County. Groundwater also is a major portion of the water supplies for the communities of Pismo Beach, Grover Beach, Arroyo Grande, Oceano, Nipomo, and several smaller communities in San Luis Obispo County; and Guadalupe, Santa Maria, and Orcutt in Santa Barbara County (City of Grover Beach 2011). In many cases, groundwater is the total water supply for these communities including Nipomo Community Services District (NCSD 2011).

The groundwater basin was adjudicated as defined by a settlement agreement, or stipulation, in 2005 that was filed in 2008. The stipulation defined the safe yield of the basin and measures to protect groundwater supplies (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011, Santa Maria 2011). The stipulation provided for the Northern Cities Management Area, Nipomo Mesa Management Area, and Santa Maria Valley Management Area. The groundwater adjudication considers groundwater recharge from precipitation and applied irrigation water; and water released from Reclamation's Twitchell Reservoir and San Luis Obispo Flood Control and Water Conservation District's Lopez Reservoir that recharge the basin from the downstream stream beds.

The cities of Pismo Beach, Grover Beach, Arroyo Grande; Oceano Community Services District; San Luis Obispo County; and San Luis Obispo Flood Control and Water Conservation District have formed the Northern Cities Management Area to manage and protect groundwater supplies in accordance with the adjudication stipulation (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011). Historical monitoring reporting indicates that the groundwater levels have varied from 20 feet above to 20 feet below mean sea level. When groundwater levels are below mean sea level, there is a potential for sea water intrusion. In 2008, groundwater levels in this area were approximately 10 feet below mean sea level. In 2010, groundwater levels had recovered and ranged from 0 to 20 feet above mean sea level. Overdraft conditions occurred more frequently prior to the groundwater adjudication and completion of the Central Coast Water Authority project that provides SWP water supplies to the area. There is a deep aquifer under the City of Arroyo Grande (Pismo Formation) that provides groundwater not addressed in the adjudicated Santa Maria Groundwater Basin.

Agricultural water users and the communities of Guadalupe, Orcutt, and Santa Maria use groundwater in the Santa Maria Valley Management Area of the Santa Maria Groundwater Basin (SMVMA 2012). Historically, groundwater was used to provide almost 50 percent of the water supply to the City of Santa Maria. Recently, groundwater supplies have become 10 to 20 percent of the total water supply to the city (Santa Maria 2011). Groundwater provides most of the water supplies in Orcutt (Golden State Water Company 2011a).

#### 7.3.5.2.3 San Antonio Creek Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the San Antonio Creek Valley Groundwater Basin, including the Los Alamos area (DWR 2004dq, 2013e).

#### 7.3.5.2.4 Santa Ynez River Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the Santa Ynez River Valley Groundwater Basin. As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is used by all agricultural water users and the communities of Buellton, Lompoc, Solvang, Mission Hills, Vandenberg Village, and Santa Ynez (DWR 2004am, 2013e; Santa Barbara County 2007).

#### 7.3.5.2.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

Groundwater is used agricultural and domestic water supplies in the Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins within Santa Barbara County. Goleta Water District and La Cumbre Mutual Water Company are the major communities that use groundwater in the Goleta Groundwater Basin (DWR 2004an; GWD 2011; GWD and LCMWC 2010). This basin is operated under an adjudication settlement in 1989 and a voter-passed groundwater management plan. Historically, Goleta Water District provided up to 14 percent of the water supply by groundwater. As described in Chapter 5, Surface Water Resources and Water Supplies, Goleta Water District has increased use of surface water from Lake Cachuma and the SWP; and decreased long-term average use of groundwater to about 5 percent of the total water supply.

Portions of the La Cumbre Mutual Water Company and City of Santa Barbara use groundwater from the Foothill Groundwater Basin. The City of Santa Barbara also relies upon groundwater from the Santa Barbara Groundwater Basin. The City of Santa Barbara manages groundwater in accordance with the Pueblo Water Rights (Santa Barbara 2011).

Montecito Water District uses groundwater from the Montecito Groundwater Basin. Carpinteria Valley Water District uses groundwater from the Carpinteria Groundwater Basin (Carpinteria Valley WD 2011). Total groundwater pumping averages approximately 3,700 acre-feet per year.

### 7.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. The Southern California Region groundwater basins are as varied as the geology that occurs in different geographic portions of the region. Therefore, the following discussions are organized in the following subregions.

- Ventura County and northwestern Los Angeles County
- Central and southern Los Angeles County and Orange County
- Western San Diego County
- Western and central Riverside County and southern San Bernardino County
- Antelope Valley and Mojave Valley

#### *7.3.6.1 Western Ventura County and Northwestern Los Angeles County*

The areas within the SWP service area in Ventura County and northwestern Los Angeles County in the Southern California Region include the Acton Valley Groundwater Basin in Los Angeles County; Santa Clara River Valley, Thousand Oaks Area, and Russell Valley groundwater basins in Ventura and Los Angeles counties; and Simi Valley, Las Posas Valley, Pleasant Valley, Arroyo Santa Rosa Valley, Tierre Rejada, and Conejo Valley groundwater basins in Ventura County, as shown in Figure 7.10.

##### 7.3.6.1.1 Hydrogeology and Groundwater Conditions

*Acton Valley Groundwater Basin*

The Acton Valley Groundwater Basin is located upgradient of the Santa Clara River Valley Groundwater Basin and drains towards the Santa Clara River. Water bearing formations include unconsolidated alluvium of sand, gravel, silt, and clay with cobbles and boulders; and poorly consolidated terraced deposits (DWR 2004as; 2013f). Recharge occurs along the streambed, water applied to the soils, and subsurface inflow. Groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high concentrations of TDS, sulfate, nitrate, and chlorides.

Acton Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Santa Clara River Valley Groundwater Basin*

The Santa Clara River Valley Groundwater Basin is the source of local groundwater along the Santa Clara River watershed from the Santa Clarita Valley in northwestern Los Angeles County to the Pacific Ocean near the City of Oxnard in Ventura County. The Santa Clara River Valley Groundwater Basin includes the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins in Ventura county; and Santa Clara River Valley East Subbasin in Los Angeles County. Groundwater movement is effected by the occurrence of several fault zones (DWR 2004at, 2004au, 2006s, 2006t, 2006u, 2013f). Groundwater recharge occurs along the Santa Clara River and its tributaries, and by percolation of precipitation and applied irrigation water.

The Santa Clara River Valley East Subbasin is characterized by unconsolidated alluvium of sand, gravel, silt, and clay; poorly consolidated terrace deposits of gravel, sand, and silt; and the Saugus Formation of poorly consolidated sandstone, siltstone, and conglomerate (DWR 2006s, 2013f).

The Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins are characterized by alluvium of silts and clays interbedded with sand and gravel lenses; and the San Pedro Formation of fine sands and gravels over the alluvium (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f).

Groundwater quality in the Santa Clara River Valley Groundwater Basin is suitable for a variety of beneficial uses. However, some areas have been impaired by elevated TDS, nitrate, and boron concentrations (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f; CLWA et al. 2012). Groundwater quality is characterized by fluctuating salinity that increases during dry periods. Localized areas of high nitrates and organic compounds occur due to historic agricultural activities and wastewater disposal.

The Piru, Oxnard, and Santa Clara River Valley East subbasins were designated by the CASGEM program as high priority. The Fillmore, Santa Paula, and Mound subbasins were designated as medium priority.

*Simi Valley Groundwater Basin*

The Simi Valley Groundwater Basin is located in Ventura County (DWR 2004av, 2013f). Water bearing formations in this basin are characterized by generally unconfined alluvium of gravel, clays, and sands; with local clay lenses that provide confined aquifers. The Simi Fault confines the basin on the northern boundary. Groundwater recharge occurs along stream beds. Groundwater quality is characterized as calcium sulfate with localized areas of high TDS and organic contaminants.

Simi Valley Groundwater Basin was designated by the CASGEM program as low priority.

*Las Posas Valley and Pleasant Valley Groundwater Basins*

The Las Posas Valley and Pleasant Valley groundwater basins are located in western Ventura County. Groundwater is found within these basins in thick alluvium that is dominated by sand and gravel in the eastern part of the Las Posas Valley Groundwater Basin; and by silts and clays with lenses of sands and gravels in the western part of the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f). Underlying the alluvium are the San Pedro and Santa Barbara formations of gravels, sands, silts and clays with a discontinuous aquitard located within the Santa Barbara Formation. The movement of groundwater is locally influenced by features such as faults, structural depressions and constrictions and operating production wells; however, groundwater generally flows west-southwest toward the Oxnard Subbasin. Hydrographs from the Las Posas Valley and Pleasant Valley

Groundwater Basins have exhibited a variety of groundwater-level histories over the past couple decades. Most hydrographs in the eastern part of the Las Posas Valley Groundwater Basin indicate relatively unchanged groundwater levels or a slight rise since 1994. Most hydrographs in the western Las Posas Valley and Pleasant Valley groundwater basins indicate that groundwater levels have risen to and been maintained at moderate levels since 1992.

Groundwater quality in the Las Posas Valley and Pleasant Valley groundwater basins is suitable for a variety of beneficial uses. Moderate to high TDS concentrations occur in the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f).

The Las Posas Valley and Pleasant Valley groundwater basins were designated by the CASGEM program as high priority.

*Arroyo Santa Rosa Valley Groundwater Basin*

The Arroyo Santa Rosa Valley Groundwater Basin is located within Ventura County. The water bearing formations include alluvium of gravel, sand, and clay; and the alluvial San Pedro Formation of sand and gravel (DWR 2006y, 2013f). Groundwater recharge occurs along the Santa Clara River and the tributaries, and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basin. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high sulfate and nitrate concentrations occur within the basin.

Arroyo Santa Rosa Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins*

The Tierra Rejada Valley, Conejo Valley, and Thousand Oaks groundwater basins in southern Ventura County are characterized by shallow alluvium that overlays marine sandstone and shale of the Modelo and Topanga formations (DWR 2004aw, 2004ax, 2004ay, 2013f). In some portions of the basin, the Topanga Formation of volcanic tuff, debris flow, and basaltic flow occurs. Groundwater recharge occurs along the streambeds and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basins. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high alkalinity and nitrate concentrations occur within the basins. High iron and TDS occur in the Thousand Oaks Area Groundwater Basin (Thousand Oaks 2011).

Conejo Valley Groundwater Basin was designated by the CASGEM program as low priority. The Tierra Rejada Valley and Thousand Oaks Area groundwater basin were designated as very low priority.

*Russell Valley Groundwater Basin*

The Russell Valley Groundwater Basin is located along the boundaries of Ventura and Los Angeles counties (DWR 2004az, 2013f). This small groundwater basin is characterized by unconsolidated, poorly bedded, sand, gravel, silt, and clay with cobbles and boulders. The groundwater is recharged by precipitation within the basin. Groundwater quality is characterized by sodium bicarbonate and calcium bicarbonate with high sulfates and TDS in some localized areas.

Russell Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### 7.3.6.1.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the basins have been adjudicated and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions. In Ventura County, the Fox Canyon Groundwater Management Agency was established in 1982 to implement a groundwater plan that identifies withdrawal allocations and groundwater elevation and quality criteria (MWDSC 2007).

*Acton Valley Groundwater Basin*

As described in Chapter 5, Surface Water Resources and Water Supplies, the Acton community primarily uses groundwater supplemented by SWP water treated at the Antelope Valley East Kern Acton Water Treatment Plant (Los Angeles County 2014b).

*Santa Clara River Valley Groundwater Basin*

Communities and agricultural water users in the Santa Clara River Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012).

Four retail water purveyors provide water service to most residents of the Santa Clara River Valley East Subbasin. These water purveyors include the Castaic Lake Water Agency; Santa Clarita Water Division, Los Angeles County Waterworks District Number 36; Newhall County Water District; and Valencia Water Company. Groundwater is used by the communities of Santa Clarita, Saugus, Canyon Country, Newhall, Val Verde, Hasley Canyon, Valencia, Castaic, Stevenson Ranch (CLWA et al. 2012).

Water purveyors in the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins include United Water Conservation District and Ventura County. United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater issues within the United Water Conservation District service area (which includes all of the basin) include overdraft conditions, sea water intrusion, and high nitrate concentrations.

*Simi Valley Groundwater Basin*

The Simi Valley area primarily relies upon surface water supplies, including SWP water supplies. Groundwater is used to supplement these supplies and by users that cannot be easily served with surface water. Groundwater is provided by Golden State Water Company service area and Ventura County Waterworks

District No. 8. The Golden State Water Company provides less 10 percent of the total water supply to the area (Golden State Water Company 2011b). Ventura County Waterworks District No. 8 provides groundwater to a golf course, nursery, and industrial user in the Simi Valley area (VCWD8 2011).

*Las Posas Valley and Pleasant Valley Groundwater Basins*

Communities and agricultural water users in the Las Posas Valley and Pleasant Valley groundwater basins use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012). United Water Conservation District and Ventura County manage water service to many residents of the Las Posas Valley and Pleasant Valley groundwater basins.

As described above, United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater is used within the United Water Conservation District service area, which includes western Las Posas Valley and Pleasant Valley groundwater basins. The Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin and Las Posas Valley and Pleasant Valley groundwater basins are within the groundwater management plan established by the Fox Canyon Groundwater Management Agency (Fox Canyon GMA 2013). The groundwater management agency manages and monitors groundwater in areas with groundwater overdraft and seawater intrusion which includes the communities of Port Hueneme, Oxnard, Camarillo, and Moorpark. The long-term average groundwater use within Fox Canyon Groundwater Management Agency includes a portion of the withdrawals reported by United Water Conservation District.

The Calleguas Municipal Water District, in partnership with Metropolitan Water District of Southern California (Metropolitan), operates the Las Posas Basin Aquifer Recharge and Recovery project. Calleguas Municipal Water District stores SWP surplus water in the Las Posas Valley Groundwater Basin, near the City of Moorpark. The current Aquifer Recharge and Recovery system includes 18 wells (Calleguas MWD 2011).

*Arroyo Santa Rosa Valley Groundwater Basin*

Communities and agricultural water users in the Arroyo Santa Rosa Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Camarosa Water District and Fox Canyon Groundwater Management Agency manage groundwater supplies within the basin (Camarosa WD 2013).

*Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins*

Groundwater in the Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area groundwater basins is primarily used by agricultural and individual residential water users. Portions of the Tierra Rejada Valley Groundwater Basin is within the Camarosa Water District; however, this area is primarily open space and agricultural land uses with individual wells (Camarosa WD 2013). The City of Thousand Oaks does operate two wells; however, the city primarily relies upon SWP water supplies because of the high iron concentrations and salinity in the groundwater (Thousand Oaks 2011).

*Russell Valley Groundwater Basin*

Most groundwater users in the Russell Valley Groundwater Basin are agricultural and individual residential water users. Portions of the basin are located within the Calleguas Municipal Water District. However, the district does not use water from this basin (Calleguas MWD 2011). The Las Virgenes Municipal Water District withdraws groundwater from the Russell Basin to augment recycled water supplies (GLCIRWMR 2014).

#### *7.3.6.2 Western Los Angeles County and Orange County*

The areas within the SWP service area in Central and Southern Los Angeles County and Orange County in the Southern California Region include the San Fernando Valley, Raymond, San Gabriel Valley, Coastal Plain of Los Angeles, and Malibu Valley groundwater basins in Los Angeles County; Coastal Plain of Orange County and San Juan Valley groundwater basins in Orange County, as shown in Figure 7.10.

##### 7.3.6.2.1 Hydrogeology and Groundwater Conditions

*San Fernando Valley Groundwater Basin*

The San Fernando Valley Groundwater Basin extends under the Los Angeles River watershed. Groundwater flows toward the middle of the basin, beneath the Los Angeles River Narrows, to the Central Subbasin of the Coastal Plain of Los Angeles Basin. The water bearing formation is mainly unconfined gravel and sand with clay lenses that provide some confinement in the western part of the basin (DWR 2004ba).

Groundwater movement is affected by the occurrence of several fault zones (DWR 2004ba). Groundwater is recharged naturally from precipitation and stream flow and from imported water and reclaimed wastewater that percolates into the groundwater from stormwater spreading grounds.

In the San Fernando Valley Groundwater Basin, the groundwater is characterized by calcium, magnesium, radioactive material, and sulfate bicarbonate with localized areas of high TDS, volatile organic compounds, petroleum compounds, chloroform, pesticides, nitrate, and sulfate (DWR 2004ba, ULARAW 2013). There are several ongoing groundwater remediation programs within the groundwater basin to reduce volatile organic compounds and one program to reduce hexavalent chromium.

San Fernando Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Raymond Groundwater Basin*

The Raymond Groundwater Basin is located to the north of the San Gabriel Valley Groundwater Basin. Groundwater flow is affected by the occurrence of several fault zones; and causes the groundwater to flow into the San Gabriel

Valley Groundwater Basin. The water bearing formations are mainly unconsolidated gravel, sand, and silt with local areas of confinement (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow and from water that percolates into the groundwater from spreading grounds and local dams.

In the Raymond Groundwater Basin, the groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high volatile organic compounds, nitrate, radioactive material, and perchlorate (DWR 2004bb). There is an ongoing groundwater remediation program within the groundwater basin to reduce volatile organic compounds and perchlorate.

Raymond Groundwater Basin was designated by the CASGEM program as medium priority.

*San Gabriel Valley Groundwater Basin*

Groundwater in the San Gabriel Valley Groundwater Basin flows from the San Gabriel Mountains towards the west under the San Gabriel Valley to the Whittier Narrows where it discharges into the Coastal Plain of the Los Angeles Groundwater Basin (DWR 2004bc). Groundwater in the San Gabriel Valley Groundwater Basin also is interconnected to groundwater in the Chino subbasin of the Upper Santa Ana Valley Groundwater Basin in Riverside County. The northeastern portion of the San Gabriel Valley Groundwater Basin adjacent to the Chino subbasin includes six subbasins and is known as "Six Basins." The water-bearing formations include unconsolidated to semi-consolidated alluvium deposits of gravel, sands, and silts.

Groundwater recharge occurs from direct percolation of precipitation and stream flow, including treated wastewater effluent conveyed in the San Gabriel River (DWR 2004bc). In the San Gabriel Valley Groundwater Basin, the groundwater is characterized by calcium bicarbonate with localized areas of high TDS, carbon tetrachloride nitrate, and volatile organic compounds (DWR 2004bc).

San Gabriel Valley Groundwater Basin was designated by the CASGEM program as high priority.

*Coastal Plain of Los Angeles Groundwater Basin*

The Coastal Plain of Los Angeles Groundwater Basin includes the Hollywood, Santa Monica, Central, and West Coast subbasins.

*Hollywood Subbasin*

The Hollywood subbasin is located to the north of the Central subbasin and upgradient of the Santa Monica subbasin. Groundwater flows towards the Pacific Ocean (DWR 2004bd). The water bearing formations are mainly alluvial gravel. Groundwater is recharged naturally from precipitation and stream flow.

The Hollywood subbasin was designated by the CASGEM program as very low priority.

*Santa Monica Subbasin*

The Santa Monica subbasin is located to the north of the West Coast subbasin and to the west of the Hollywood subbasin. Groundwater flows towards the west and the Hollywood subbasin (DWR 2004be). The water bearing formations are mainly alluvial gravel and sand with semi-perched areas over silt and clay deposits. Unconfined shallow aquifers occur in the northern and eastern portions of the subbasin. Confined deeper aquifers occur in the remaining portion of the subbasin. Groundwater is recharged naturally from precipitation and stream flow.

The Santa Monica subbasin was designated by the CASGEM program as high priority.

*Central Subbasin*

The Central subbasin is located to the east of the West Coast subbasin. The Central subbasin is characterized by shallow sediments and extends from the Los Angeles River Narrows with groundwater flows from the San Gabriel Valley (DWR 2004bf).

The non-pressurized, or forebay, portions of the subbasin are located in the northern portion of the subbasin in unconfined aquifers underlying the Los Angeles and San Gabriel rivers (DWR 2004bf). These areas provide the major recharge areas for the subbasin. The "pressure" areas are confined aquifers composed of permeable sands and gravel separated by less permeable sandy clay and clay, and constitute the main water-bearing formations. Several faults and uplifts create some restrictions to groundwater flow in the subbasin while others run parallel to the groundwater flow and do not restrict flow.

In the Central subbasin, the groundwater is characterized by localized areas of high inorganics and volatile organic compounds (DWR 2004bf).

The Central subbasin was designated by the CASGEM program as high priority.

*West Coast Subbasin*

The West Coast subbasin is located on the southern coast of Los Angeles County to the west of the Central subbasin. The water bearing formations are composed of unconfined and semi-confined aquifers composed of sands, silts, clays, and gravels (DWR 2004bg). Several fault zones paralleling the coast act as partial barriers to groundwater flow in certain areas. The general regional groundwater flow pattern is southward and westward toward the Pacific Ocean. Recharge occurs through groundwater flow from the Central subbasin, and from infiltration along the Los Angeles and San Gabriel rivers. Seawater intrusion occurs along the Pacific Ocean coast.

In the West Coast subbasin, the most critical issue is high TDS along the Pacific Ocean coast due to seawater intrusion. As described below, several agencies have implemented sea water barrier projects to protect the groundwater quality.

The West Coast subbasin was designated by the CASGEM program as high priority.

*Malibu Valley Groundwater Basin*

The Malibu Valley Groundwater Basin is an isolated alluvial basin in northern Los Angeles County along the Pacific Ocean Coast under the Malibu Creek watershed (DWR 2004bh). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow.

In the Malibu Valley Groundwater Basin, the groundwater is characterized by localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast (DWR 2004bh).

The Malibu Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Coastal Plain of Orange County Groundwater Basin*

The Coastal Plain of Orange County Groundwater Basin is located under a coastal alluvial plain in northern Orange County (DWR 2004 bi). Groundwater is recharged naturally from precipitation and injection wells to reduce seawater intrusion. The water bearing formations are mainly interbedded marine and continental sand, silt, and clay deposits (DWR 2004bi). The Newport-Inglewood fault zone parallels the coast and generally forms a barrier to groundwater flow. Groundwater recharge occurs along the Santa Ana River. Water levels are characterized by seasonal fluctuations (DWR 2013f; Orange County 2009). Groundwater flowed towards the Pacific Ocean prior to recent development. However, due to extensive groundwater withdrawals, there are groundwater depressions that result in potential sea water intrusion. Groundwater levels have increased since the 1990s following implementation of several recharge programs.

In the Coastal Plain of Orange County Groundwater Basin, the groundwater is characterized as sodium-calcium bicarbonate with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast, as well as nitrate, and volatile organic compounds (DWR 2004bi).

The Coastal Plain of Orange County Groundwater Basin was designated by the CASGEM program as medium priority.

*San Juan Valley Groundwater Basin*

The San Juan Valley Groundwater Basin is located in southern Orange County (DWR 2004bj). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows from San Juan and Oso creeks and Arroyo Trabuca.

In the San Juan Valley Groundwater Basin, the groundwater is characterized as calcium bicarbonate, bicarbonate-sulfate, calcium-sodium sulfate, and sulfate-chloride with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast and high fluoride near hot springs near Thermal Canyon (DWR 2004bj).

The San Juan Valley Groundwater Basin was designated by the CASGEM program as low priority.

#### 7.3.6.2.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the groundwater basins in Los Angeles and Orange counties have been adjudicated, as summarized in Table 7.1, and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions.

*San Fernando Valley Groundwater Basin*

The communities and agricultural users in the San Fernando Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; ULARAW 2013). The Metropolitan Water District of Southern California provides wholesale surface water supplies to several communities. The cities of Los Angeles, Glendale, Burbank, San Fernando, Crescenta Valley, Bell Canyon, and Hidden Hills provide retail water supplies, including groundwater, to the communities. The groundwater basin has been adjudicated and is managed by the Upper Los Angeles River Area Watermaster.

Groundwater is recharged in the San Fernando Valley Groundwater Basin through seepage of precipitation within the groundwater basin, including the recharge of stormwater at spreading grounds between 1968 and 2012; and storage of imported water (ULARAW 2013). The spreading basins for stormwater flows are operated by Los Angeles County and the cities of Los Angeles and Burbank. A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

The operations of the San Fernando Valley Groundwater Basin are defined by the Upper Los Angeles River Area January 26, 1979 Final Judgment; the Sylmar Basin Stipulations of August 26, 1983; and subsequent agreements. These agreements, as managed by the Upper Los Angeles River Area Watermaster, provide for the right to extract a percent of surface water, including applied recycled water, that enters within specified subbasins of the San Fernando Valley Groundwater Basin with specific calculations to identify maximum withdrawals for the cities of Burbank, Glendale, Los Angeles, and San Fernando and Crescenta Valley Water District; the right to store and withdraw water within specified subbasins by the cities of Burbank, Glendale, Los Angeles, and San Fernando; and the acknowledgment that the City of Los Angeles has an exclusive Pueblo Water Right for the native safe yield of the San Fernando subbasin within the larger San Fernando Valley Groundwater Basin.

*Raymond Groundwater Basin*

The communities in the Raymond Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014). The Metropolitan Water District of Southern California and Foothills Municipal Water District provide wholesale surface water supplies to several communities. The cities of Alhambra, Arcadia, Pasadena, San Marino, and Sierra Madre; Upper San

Gabriel Municipal Water District; and Valley Water Company and several other private water companies, provide retail water supplies, including groundwater, to the communities to Altadena, Las Crescenta-Montrose, La Cañada Flintridge, Rubio Canyon, and South Pasadena. The City of Alhambra and San Gabriel Valley Municipal Water District; can withdraw groundwater from the Raymond Basin, but currently are not operating wells within this groundwater basin (City of Alhambra 2011).

The groundwater basin was the first adjudicated groundwater basin in California and is managed by the Raymond Basin Management Board as the Watermaster (RBMB 2014). The Raymond Basin Management Board limits the amount of groundwater withdrawals in different areas of the basin, and allows for short-term and long-term storage of water in the groundwater basin.

Groundwater is recharged in the Raymond Groundwater Basin through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and the cities of Pasadena and Sierra Madre (MWDSC 2007). Water from Metropolitan Water District of Southern California, which is generally a combination of SWP water and Colorado River water, cannot be used for direct recharge if the TDS is greater than 450 milligrams/liter (RBMB 2014). A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

*San Gabriel Valley Groundwater Basin*

The communities in the San Gabriel Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California, San Gabriel Valley Municipal Water District, Upper San Gabriel Municipal Water District; Three Valleys Municipal Water District, and Covina Irrigating Company provide wholesale surface water and/or groundwater supplies to several communities. The cities of Alhambra, Arcadia, Azusa, Covina, El Monte, Glendora, La Verne, Monrovia, Pomona, San Marino, and Upland; San Gabriel County Water District and Valley County Water District; Golden State Water Company, San Antonio Water Company, San Gabriel Valley Water Company, Suburban Water Systems, Valencia Heights Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Baldwin Park, Bradbury, Claremont, Duarte, Hacienda Heights, Irwindale, La Puente, Montebello, Monterey Park, Pico Rivera, Rosemead, San Dimas, San Gabriel, Santa Fe Springs, Sierra Madre, South El Monte, South San Gabriel, Temple City, Valinda, and Whittier (City of Alhambra 2011; City of Arcadia 2011; City of La Verne 2011; City of Pomona 2011; City of Upland 2011; Golden State Water Company 2011c; SGCWD 2011; SGVWC 2011; Suburban Water Systems 2011; SAWCO 2011; TVMWD 2011; USGVMWD 2011).

The San Gabriel Valley Groundwater Basin includes several adjudicated basins. A portion of the groundwater basin is managed by the San Gabriel River Watermaster and the Main San Gabriel Basin Watermaster (MWDSC 2007; SGVWC 2011). The Watermasters coordinate groundwater elevation and water quality monitoring, coordinate imported water supplies, coordinate recharge operations with imported water and recycled water, manage the amount of groundwater withdrawals in different areas of the basin by balancing the amount of groundwater recharge, and allow for short-term and long-term storage of water in the groundwater basin. Groundwater is recharged through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and a private water company (MWDSC 2007). Water recharged into the spreading basins from Metropolitan Water District of Southern California and San Gabriel Valley Municipal Water District.

The Six Basins portion of the groundwater basin also is adjudicated and managed by the Six Basins Watermaster Board (MWDSC 2007). The Watermaster manages withdrawals and requires replenishment obligation of equal amounts for withdrawals over the operating safe yield of the basin. The Pomona Valley Protective Agency conveys flows from San Antonio Creek and SWP water to the San Antonio Spreading Grounds; and from local waters to the Thompson Creek Spreading Grounds. The City of Pomona conveys flows from local surface waters to the Pomona Spreading Grounds. Los Angeles County Department of Public Works conveys flows from local surface water and SWP water to the Live Oak Spreading Grounds.

The cities of Alhambra, Arcadia, La Verne, Monterey Park, San Gabriel Valley Water Company, and other water entities operate groundwater treatment facilities to remove dichloroethane, chloroform, other volatile organic compounds, and/or nitrates (City of Alhambra 2011; City of Arcadia 2011; City of Monterey Park 2012; MWDSC 2007; SGVWC 2011).

*Coastal Plain of Los Angeles Groundwater Basin*

The Coastal Plain of Los Angeles Groundwater Basin includes four subbasins: Hollywood, Santa Monica, Central and West Coast.

*Hollywood Subbasin*

The primary user of groundwater in the Hollywood subbasin is the City of Beverly Hills (MWDSC 2007). The basin is not adjudicated. The city manages the groundwater subbasin through limits on withdrawals and discharges to the groundwater. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Beverly Hills 2011). All groundwater withdrawn by the city is treated to reduce salinity.

*Santa Monica Subbasin*

The primary user of groundwater in the Santa Monica subbasin is the City of Santa Monica (MWDSC 2007). The basin is not adjudicated. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Santa Monica 2011; MWDSC 2007). Groundwater treatment is provided to a portion of the subbasin withdrawals to reduce volatile organic compounds, and methyl tertiary butyl ether.

*Central Subbasin*

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and Central Basin Municipal Water District provide wholesale surface water supplies to several communities. The cities of Bell, Bell Gardens, Cerritos, Compton, Cudahy, Downey, Huntington Park, Lakewood, Long Beach, Los Angeles, Lynwood, Monterey Park, Norwalk, Paramount, Pico Rivera, Santa Fe Springs, Signal Hill, South Gate, Vernon, and Whittier; Los Angeles County Water District, La Habra Heights County Water District, Orchard Dale Water District, and Paramount Water District; Golden State Water Company, Suburban Water Systems, Bellflower-Somerset Mutual Water Company, Montebello Land & Water Company; Park Water Company, Dominguez Water Corp, California Water Service Company, San Gabriel Valley Water Company, Walnut Park Mutual Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Artesia, Commerce, Dominguez, East La Mirada, East Los Angeles, East Rancho, Florence-Graham, Hawaiian Gardens, La Mirada, Los Nieto, Maywood, Montebello, South Whittier, Walnut Park, Westmount, West Whittier, and Willow Brook (CBMWD 2011; BSMWC 2011; City of Compton 2011; City of Downey 2012; City of Huntington Park 2011; City of Lakewood 2011; City of Long Beach 2011; City of Los Angeles 2011; City of Monterey Park 2012; City of Norwalk 2011; City of Paramount 2011; City of Pico Rivera 2011; City of Santa Fe Springs 2011; City of South Gate; City of Vernon 2011; City of Whittier 2011; LHHCWD 2012; Golden State Water Company 2011d, 2011e, 2011f, 2011g; Suburban Water Systems 2011).

The Central subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the Central subbasin (MWDSC 2007; WRD 2013a). Approximately 25 percent of the water users of groundwater from the Central subbasin are not located on the land that overlies the subbasin (CBMWD 2011). Groundwater from the San Gabriel Valley Groundwater Basin also is used by water users that overlie the Central subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. The Water Replenishment District of Southern California purchases water for water replenishment facilities operated by Los Angeles County Department of Public Works at the Montebello Forebay near the Rio Hondo and San Gabriel Rivers near the boundaries of the Central and West Coast subbasins (CBMWD 2011; Los Angeles County 2015; WRD 2013a). The Montebello Forebay includes the Rio Hondo Coastal Basin Spreading Grounds along the Rio Hondo Channel; the San Gabriel River Coastal Basin Spreading Grounds; and the unlined reach of the lower San Gabriel River from Whittier Narrows Dam to Florence Avenue (LACDPW 2014, WRD 2013a).

The replenishment water is purchased water from two different sources: recycled water from various regional treatment facilities, and imported water (WRD 2013a). The recycled water is used for groundwater recharge at the spreading grounds and at the seawater barrier wells. Water Replenishment District of Southern California must blend recycled water with other water sources to meet the groundwater recharge water quality and volumetric requirements established by the State Water Resources Control Board. This blended water is either imported water from the SWP and/or the Colorado River, or untreated surface water flows from the San Gabriel River, Rio Hondo River, and waterways in the San Gabriel Valley (CBMWD 2011). Up to 35 percent of the replenishment water can be provided from recycled water supplies. Several recent projects have been implemented to store stormwater flows for increased replenishment water volumes.

In the Central subbasin, the Water Replenishment District of Southern California also purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the portion of the Alamitos Barrier Project located in Los Angeles County to reduce seawater intrusion (MWDSC 2007; WRD 2007). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the Alamitos Gap Barrier Project by 2014 (WRD 2013b).

The cities of Long Beach, Monterey Park, South Gate, and Whittier operate groundwater treatment facilities in the Central subbasin (City of Long Beach 2012; City of Monterey Park 2012; City of South Gate; City of Whittier 2011).

*West Coast Subbasin*

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and West Basin Municipal Water District provide wholesale surface water supplies to several communities. The cities of Inglewood, Lomita, Manhattan Beach, and Torrance; Golden State Water Company, California Water Service Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Athens, Carson, Compton, Del Aire, Gardena, Hawthorne, Hermosa Beach, Inglewood, Lawndale, Lennox, Redondo Beach, Torrance (WBMWD 2011a; City of Inglewood 2011; City of Lomita 2011; City of Manhattan Beach 2011; City of Torrance 2011; Golden State Water 2011h; California Water Service Company 2011b, 2011c, 2011d, 2011e). The communities of El Segundo, Long Beach, and Los Angeles overlie the West Coast subbasin; however, no groundwater from this subbasin is used in these communities due to water quality issues and facilities locations. Groundwater use is primarily for emergency uses, including firefighting, in the communities of Hawthorne, Lomita, and Torrance due to high concentrations of minerals (e.g., iron and manganese), sulfides, and/or volatile organic compounds.

The West Coast subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the West Coast subbasin (MWDSC 2007; WBMWD 2011a; WRD 2013a). Groundwater from the Central subbasin is used by some water users that overlie the West Coast subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. In the West Coast subbasin, the Water Replenishment District of Southern California purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the West Coast Barrier Project and the Dominguez Barrier Project (MWDSC 2007; WRD 2007; WRD 2013). Water is purchased by the Water Replenishment District of Southern California for injection at the barrier projects (WRD 2013). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the West Coast Barrier Project and the Dominguez Barrier Project by 2014 and 2017, respectively (WRD 2013b).

California Water Service Company operates groundwater treatment facilities within the community of Hawthorne (California Water Service Company 2011b). The Water Replenishment District of Southern California operates the Robert W. Goldsworthy Desalter near Torrance to reduce salinity for up to 18,000 acre-feet/year of groundwater that is located inland of the West Coast Basin Barrier (WRD 2013a).

The West Basin Municipal Water District treats brackish groundwater at the C. Marvin Brewer Desalter Facility for two wells near Torrance that are affected by a saltwater plume in the West Coast subbasin (WBMWD 2011a).

*Malibu Valley Groundwater Basin*

No groundwater is used by the communities in this groundwater basin, including the Malibu area (Los Angeles County 2011; MWDSC 2007).

*Coastal Plain of Orange County Groundwater Basin*

The communities in the Coastal Plain of Orange County Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County, Orange County Water District, and East Orange County Water District provide wholesale surface water supplies to several communities. The cities of Anaheim, Buena Park, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, La Habra, La Palma, Newport Beach, Orange, Santa Ana, Seal Beach, Tustin, and Westminister; East Orange County Water District, Irvine Ranch Water District, Mesa Consolidated Water District, Rowland Water District, Serrano Water District, Walnut Valley Water District, and Yorba Linda Water District; Golden State Water Company, California Water Service Company, California Domestic Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Brea, Costa Mesa, Cypress, Diamond Bar, Garden Grove, Hacienda Heights, Industry, Irvine, La Palma, La Puente, Los Alamitos, Midway City, Newport Beach, Orange, Panorama Heights, Placentia, Pomona, Rowland Heights, Rossmoor, Seal Beach, Stanton, Villa Park, Walnut, West Covina, West Orange, and Yorba Linda (City of Anaheim 2011; City of Brea 2011; City of Buena Park 2011; City of Fountain Valley 2011; City of Fullerton 2011; City of Garden Grove 2011; City of Huntington Beach 2011; City of La Habra 2011; City of La Palma 2011; City of Newport Beach 2011; City of Orange 2011; City of Santa Ana 2011; City of Seal Beach 2011; City of Tustin 2011; City of Westminster 2011; IRWD 2011; MCWD 2011; RWD 2011; SWD 2011; WVWD 2011; YLWD 2011; Golden State Water Company 2011i, 2011j). Groundwater use is primarily for non-potable water uses in West Covina and for supplemental supplies for users of recycled water in Rowland Heights.

The Coastal Plain of Orange County Groundwater Basin is managed by Orange County Water District in accordance with special State legislation to increase supply and provide uniform costs for groundwater (MWDSC 2007). The basin is managed to maintain a water balance over several years using two step pricing levels to incentivize users to obtain alternative water supplies after withdrawing a basin production target. The groundwater basin is managed to provide approximately a three-year drought supply.

Orange County Water District manages an extensive groundwater recharge program in the Coastal Plain of Orange County Basin (Orange County Water District 2014). The Orange County Water District manages spreading basins along the Santa Ana River and Santiago Creek for groundwater recharge (MWDSC 2007). Water is supplied to these basins with flows diverted from the Santa Ana River into the recharge basins at inflatable rubber dams, SWP water, and recycled water from the Orange County Water District/Orange County Sanitation District Groundwater Replenishment System Advanced Water Purification Facility (OCWD n.d.).

The Orange County Water District also injects water into the Talbert Barrier and the portion of the Alamitos Barrier Project within Orange County. Water supplies for the seawater barriers include water from the Groundwater Replenishment System and SWP water (GWRS n.d.; MWDSC 2007).

The Irvine Desalter Project was initiated in 2007 by Orange County Water District, Irvine Ranch Water District, Metropolitan Water District of Orange County, Metropolitan Water District of Southern California, and the U.S. Navy to reduce TDS and salts (IRWD 2011; MWDSC 2007). Several other treatment facilities remove volatile organic compounds. The city of Tustin operates the Tustin Seventeenth Street Desalter to reduce TDS within the Tustin community (MWDSC 2007). The City of Garden Grove and Mesa County Water District operate treatment facilities to reduce nitrates and compounds that change the color of the water, respectively (City of Garden Grove 2011; MCWD 2011).

*San Juan Valley Groundwater Basin*

The communities in the San Juan Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County provides wholesale surface water supplies to several communities. The City of San Juan Capistrano; Moulton Niguel Water District, Santa Margarita Water District, and South Coast Water District provide retail water supplies to users within their communities and to the communities of Coto de Caza, Dana Point, Laguna Forest, Laguna Woods, Las Flores, Ladera Ranch, Mission Viejo, Rancho Santa Margarita, South Laguna, Talega, (City of San Juan Capistrano 2011; MNWD 2011; SCWD 2011; SMWD 2011). Most of the groundwater use occurs within or near the City of San Juan Capistrano. Groundwater use is small or does not occur within the Santa Margarita Water District, South Coast Water District, and Moulton Niguel Water District service areas.

The San Juan Basin Authority manages water resources development in the San Juan Valley Groundwater Basin and in the surrounding San Juan watershed to protect water quality and water resources (MWDSC 2007; SJBA 2013). In addition to community uses, groundwater also is used for agricultural and industrial purposes and golf course irrigation. Overall, groundwater provides less than 10 percent of the total water supply within the groundwater basin.

The City of San Juan Capistrano Groundwater Recovery Plant reduces iron, manganese, and TDS concentrations. This city is modifying the treatment plant to reduce recently observed high concentrations of methyl tertiary butyl ether (MTBE) (City of San Juan Capistrano 2011; MWDSC 2007). The South Coast Water District operates the Capistrano Beach Groundwater Recovery Facility in Dana Point to reduce iron and manganese concentrations (SCWD 2011; MWDSC 2007).

### *7.3.6.3 Western San Diego County*

The areas within the SWP service area in western San Diego County in the Southern California Region include the San Mateo Valley Groundwater Basin in Orange and San Diego counties; and the San Onofre Valley, Santa Margarita Valley, San Luis Rey Valley, Escondido Valley, San Marcos Area, Batiquitos Lagoon Valley, San Elijo Valley, San Dieguito Creek, Poway Valley, San Diego River Valley, El Cajon Valley, Mission Valley, Sweetwater Valley, Otay Valley, Tijuana Basin groundwater basins in San Diego County, as shown in Figure 7.11.

#### 7.3.6.3.1 Hydrogeology and Groundwater Conditions

In San Diego County, several smaller groundwater basins exist, in the western portion of the county. The most productive groundwater basins are characterized by narrow river valleys filled with shallow sand and gravel deposits. Groundwater occurs farther inland in fractured bedrock and semi consolidated sedimentary deposits with limited yield and storage (SDCWA et al. 2013).

*San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins*

The San Mateo Valley Groundwater Basin is located in southern Orange County and northern San Diego County (DWR 2004bk). The San Onofre Valley and Santa Margarita Valley groundwater basins are located in northwestern San Diego County (DWR 2004bl, 2004bm). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows. In the San Mateo Valley and San Onofre Valley groundwater basins, treated wastewater effluent discharged from the Marine Corps Base Camp Pendleton wastewater treatment plants into local streams also recharges the groundwater. In the San Mateo Valley and Santa Margarita Valley groundwater basins, the groundwater is characterized as calcium-sulfate-chloride. In the San Onofre Valley Groundwater Basin, the groundwater is characterized as calcium-sodium bicarbonate-sulfate. Localized areas with high boron, chloride, magnesium, nitrate, sulfate, and TDS occur in the Santa Margarita Valley Groundwater Basin.

Santa Margarita Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Mateo Valley and San Onofre Valley groundwater basins were designated as very low priority.

*San Luis Rey Valley Groundwater Basin*

The San Luis Rey Valley Groundwater Basin is located in northwestern San Diego County (DWR 2004bn). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel and sand. Under some portions of the alluvial aquifer, partially consolidated marine terrace deposits of partly consolidated sandstone, mudstone, siltstone, and shale occur. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate-sulfate with localized areas of high magnesium, nitrate, and TDS (MWDSC 2007).

San Luis Rey Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins*

The San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins are located in the foothills within central, western San Diego County. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt; consolidated sandstone; or weathered crystalline basement rock (DWR 2004bo, 2004bp, 2004bq, 2004br, 2004bs, 2004bt). The basins area bounded by semi-permeable marine and non-marine deposits and impermeable granitic and metamorphic rocks. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity. There are localized areas with high sulfate and nitrate concentrations in the Santa Maria Valley Groundwater Basin.

San Pasqual Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Marcos Valley, Escondido Valley, Pamo Valley, Santa Maria, and Poway Valley groundwater basins were designated as very low priority.

*Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins*

The Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins are located along the central San Diego County coast of the Pacific Ocean. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt with areas of consolidated sandstone (DWR 2004bu, 2004bv, 2004bw). Some areas of the Batiquitos Lagoon Valley Groundwater Basin are bounded by impermeable crystalline rock. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity.

Batiquitos Valley, San Elijo Valley, and San Dieguito Valley groundwater basins were designated by the CASGEM program as very low priority.

*San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins*

The San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins are located in the southwestern portion of San Diego County. The water bearing formations are mainly alluvium of sand, gravel, cobble, clay, and silt; or siltstone and sandstone (DWR 2004bx, 2004by, 2004bz, 2004ca, 2004cb, 2004cc). Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high levels of salinity. A recent study by USGS evaluated the sources and movement of saline groundwater in these groundwater basins (USGS 2013b). The chloride concentrations ranged from 57 to 39,400 mg/L. The sources of salinity were natural geologic sources and sea water intrusion. There are localized areas with high sulfate and magnesium concentrations.

San Diego River Valley Groundwater Basin was designated by the CASGEM program as medium priority. El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins were designated as very low priority.

#### 7.3.6.3.2 Groundwater Use and Management

Groundwater production and use in the San Diego region is currently limited due to a lack of aquifer storage capacity, available recharge, and degraded water quality due to high salinity. Groundwater currently represents about 3 percent of the water supply portfolio within the areas of San Diego County that could be served by SWP water (SDCWA et al. 2013).

*San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins*

The primary user of groundwater in the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley groundwater basins is the Marine Corps Base Camp Pendleton (FPUD 2011; MWDSC 2007; SCWD 2011; SDCWA et al. 2013). The Marine Corps Base Camp Pendleton withdraws approximately 8,500 acre-feet/year from the three groundwater basins and operates spreading basins to recharge the groundwater in the Santa Margarita Valley Groundwater Basin. Portions of the South Coast Water District overlie the northern portions of the San Mateo Valley Groundwater Basin; however, the district does not withdraw water from that basin. Fallbrook Public Utility District overlies northern portions of the Santa Margarita Valley Groundwater Basin; however, the district currently uses a small amount of groundwater to meet their water demand (FPUD 2011).

The Santa Margarita Valley Groundwater Basin is within an adjudicated watershed (SMRW 2011). The Santa Margarita River Watermaster manages both surface water and groundwater that contributes direct or indirect flows into the Santa Margarita River in accordance with the Modified Final Judgment and Decrees of 1966 by the U.S. District Court in the *United States v. Fallbrook Public Utility et al*. The watershed includes the Santa Margarita Valley Groundwater Basin near the Pacific Ocean and the Temecula Valley groundwater basins in the upper Santa Margarita River Watershed within Riverside County, as discussed in the following subsection. Within San Diego County, the only groundwater user in the Santa Margarita Valley Groundwater Basin is the Marine Corps Base Camp Pendleton.

*San Luis Rey Valley Groundwater Basin*

The communities in the San Luis Rey Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Oceanside 2011; MWDSC 2007; RMWD 2011; VCMWD 2011; YMWD 2014a, 2014b). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of Oceanside; Rainbow Municipal Water District, Valley Center Municipal Water District, and Yuima Municipal Water District; and Rancho Pauma Mutual Water Company and several other private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the Rainbow Municipal Water District or Valley Center Municipal Water District. Groundwater also is used on agricultural lands, especially for orchards in the Pauma area (San Diego County 2010). The Tribal lands also depend upon groundwater including lands within the La Jolla Reservation, Los Coyotes Reservation, Pala Reservation, Pauma & Yuima Reservation, Rincon Reservation, and Santa Ysabel Reservation (SDCWA et al. 2013).

There are three municipal water districts that overlie the San Luis Rey Valley Groundwater Basin that manage water rights protection efforts. Groundwater is the only water supply within the Pauma Municipal Water District and the primary water supplies within the Mootamai Municipal Water District and the San Luis Rey Municipal Water District (SDLAFCO 2011; SDCWA et al. 2013). The districts protect groundwater, surface water rights, and water storage; and to coordinate planning studies and legal activities within the San Luis Rey River watershed. Vista Irrigation District withdraws and stores groundwater in Lake Henshaw and withdraws groundwater in a subbasin located upgradient the San Luis Rey Valley Groundwater Basin.

*San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins*

The communities in the San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins use a combination of surface water and groundwater to meet water demands (City of Escondido 2011; City of Poway 2011; Ramona MWD 2011; RDDMWD 2011; VWD 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The cities of Escondido and Poway; Ramona Municipal Water District, Rincon del Diablo Municipal Water District, Vallecitos Water District, and Vista Irrigation District; and private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the cities of Escondido and Poway, Ramona Municipal Water District, Rincon del Diablo Municipal Water District, and Vallecitos Water District. Ramona Municipal Water District used to use groundwater until high nitrate concentrations required the district to abandon the wells.

*Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins*

The communities in the Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins primarily use surface water to meet water demands (CMWD 2011; OMWD 2011; SDLAFCO 2011; SDWD 2011; SFID 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. Groundwater use is limited to private wells within the Carlsbad Municipal Water District, including the City of Carlsbad; Olivenhain Municipal Water District, including the cities of Encinitas, Carlsbad, San Diego, Solano Beach, and San Marcos, and the communities of Olivenhain, Leucadia, Elfin Forest, Rancho Santa Fe, Fairbanks Ranch, Santa Fe Valley, and 4S Ranch; San Dieguito Water District, including the communities of Encinitas, Cardiff-by-the-Sea, New Encinitas, and Old Encinitas; and Santa Fe Irrigation District, including the City of Solana Beach and the communities of Rancho Santa Fe and Fairbanks Ranch. Groundwater was used within the Carlsbad Municipal Water District area until high salinity caused the area to abandon the wells. Questhaven Municipal Water District manages groundwater for a recreation community located to the west of Escondido.

*San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins*

The communities in the San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins use a combination of surface water and groundwater to meet water demands (California American Water Company 2012; City of San Diego 2011; HWD 2011; OWD

2011; PDMWD 2011; SDCWA et al. 2013; Sweetwater Authority 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of San Diego, Helix Water District, and Sweetwater Authority provide retail surface water and/or groundwater supplies to users within cities of La Mesa, Lemon Grove, National City, and San Diego; portions of Chula Vista and El Cajon; and all or portions of the communities of Bonita, Lakeside, and Spring Valley. The County of San Diego–Campo Water and Sewer Maintenance District, Cuyamaca Water District, Decanso Community Services District, Julian Community Services District, Majestic Pines Community Services District, Wynola Water District, Lake Morena Oak Shores Mutual Water Company, Pine Hills Mutual Water Company, and Pine Valley Mutual Water Company rely upon groundwater to meet their water demands. Groundwater is not used for water supplies within Padre Dam Municipal Water District which serves the City of Santee and portions of the City of El Cajon; Otay Water District which serves portions of the cities of Chula Vista, El Cajon, and La Mesa, and several unincorporated communities; and California American Water which serves the City of Imperial Beach and portions of the cities of Chula Vista, Coronado, and San Diego. Sweetwater Authority operates the Desalination Facility to treat brackish groundwater (San Diego County LAFCO 2011).

#### *7.3.6.4 Western Riverside County and Southwestern San Bernardino County*

The areas within the SWP service area in western and central Riverside County and southern San Bernardino County in the Southern California Region include the Upper Santa Ana Valley Groundwater Basin in Riverside and San Bernardino counties; the Elsinore, San Jacinto Groundwater Basin in Riverside County; and the Temecula Valley Groundwater Basin in Riverside and San Diego counties, as shown in Figure 7.12.

##### 7.3.6.4.1 Hydrogeology and Groundwater Conditions

*Upper Santa Ana Valley Groundwater Basin*

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

*Cucamonga Subbasin*

The Cucamonga subbasin is located within San Bernardino County in the upper Santa Ana River watershed (DWR 2004 cd; MWDSC 2007). Groundwater is contained within the basin by the Red Hill fault. The water bearing formations are mainly alluvium of gravel, sand, and silt with beds of compacted clay. Groundwater is recharged naturally from precipitation and stream flows, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and dibromochloropropane (DBCP) (MWDSC 2007).

The Cucamonga subbasin was designated by the CASGEM program as medium priority.

*Chino Subbasin*

The Chino subbasin is located in San Bernardino County. The Chino subbasin is composed of alluvial material. The Rialto-Colton, San Jose, and the Cucamonga faults act as groundwater flow barriers (DWR 2006z). Along the southern boundary of the subbasin, groundwater can rise to the elevation of the Santa Ana River and be discharged into the stream. Groundwater is recharged naturally from precipitation and stream flows along the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water.

The Chino subbasin is characterized with high TDS and nitrate concentrations and localized areas of high volatile organic compounds, and perchlorate (MWDSC 2007).

The Chino subbasin was designated by the CASGEM program as high priority.

*Riverside-Arlington Subbasin*

The Riverside-Arlington subbasin is located within the Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County (DWR 2004ce). Water bearing formations include alluvial deposits of sand, gravel, silt, and clay. The Rialto-Colton Fault separates this subbasin from the Rialto-Colton subbasin. The Riverside and Arlington portions of the subbasin are also separated. Groundwater flows to the northwest and to the Arlington Gap in the southwest area of the subbasin; and continues into the Temescal subbasin. Groundwater is recharged naturally from precipitation and stream flows in the Santa Ana River, and flow from adjacent subbasins. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and DBCP (MWDSC 2007).

The Riverside-Arlington subbasin was designated by the CASGEM program as high priority.

*Temescal Subbasin*

The Temescal subbasin is located within the Santa Ana River Valley in Riverside County. Water bearing formations consist of alluvium bounded by the Elsinore fault zone on the west and the Chino fault zone on the northwest (DWR 2006aa). Groundwater is recharged naturally from precipitation and stream flows in the tributaries of the Santa Ana River. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, iron, and manganese (MWDSC 2007).

The Temescal subbasin was designated by the CASGEM program as medium priority.

*Cajon Subbasin*

The Cajon subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations consist of alluvium bounded by the San Andreas Fault zone on the south and impermeable rock formations on the east and west (DWR 2004cf). Groundwater is recharged naturally from precipitation, stream flows in the tributaries of the Santa Ana River, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses.

The Cajon subbasin was designated by the CASGEM program as very low priority.

*Rialto-Colton Subbasin*

The Rialto-Colton subbasin is located within the upper Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County. Water bearing formations consist of alluvium bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004cg). Groundwater is recharged naturally from precipitation and stream flows. The groundwater quality is good for the beneficial uses with localized areas of high volatile organic compounds.

The Rialto-Colton subbasin was designated by the CASGEM program as medium priority.

*Bunker Hill Subbasin*

The Bunker Hill subbasin is located in San Bernardino County. The water bearing formations include alluvium of sand, gravel, and boulders with deposits of silt and clay bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004ch). Groundwater is recharged naturally from precipitation, stream flows in the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses. The groundwater is characterized as calcium- bicarbonate with localized areas of high volatile organic compounds and perchlorate within several contamination plumes (*Lockheed Martin Corporation v. United States, Civil Action No. 2008-1160*).

The Bunker Hill subbasin was designated by the CASGEM program as high priority.

*Yucaipa Subbasin*

The Yucaipa subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations include alluvial deposits of sand, gravel, boulders, silt, and clay (DWR 2004ci). Several fault zones restrict groundwater movement. The San Timoteo formation along the western boundary of the basin causes the water to rise to the elevation of the San Timoteo Wash, a tributary of the Santa Ana River. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS and high nitrate concentrations, and localized areas with high volatile organic compounds.

The Yucaipa subbasin was designated by the CASGEM program as medium priority.

*San Timoteo Subbasin*

The San Timoteo subbasin is located within the upper Santa Ana River Valley in Riverside County. Water bearing formations include alluvial deposits of gravel, silt, and clay (DWR 2004cj). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate and good quality for the beneficial uses.

The San Timoteo subbasin was designated by the CASGEM program as medium priority.

*San Jacinto Groundwater Basin*

The San Jacinto Groundwater Basin is located in upper Santa Ana River Valley in Riverside County, and underlies the San Jacinto, Perris, Moreno and Menifee valleys and Lake Perris. The water bearing formations are alluvium over crystalline basement rock (DWR 2006ab). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River and its tributaries, percolation from Lake Perris, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with high TDS and nitrate concentrations and localized areas with high iron, manganese, sulfides, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The San Jacinto Groundwater Basin was designated by the CASGEM program as high priority.

*Elsinore Groundwater Basin*

The Elsinore Groundwater Basin is located in upper Santa Ana River Valley in Riverside County. The water bearing formations are alluvial fan, floodplain, and lacustrine deposits underlain by alluvium of gravel, sand, silt, and clay (DWR 2006ac). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate salinity and localized areas with high fluoride, arsenic, nitrate, iron, manganese, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Elsinore Groundwater Basin was designated by the CASGEM program as high priority.

*Temecula Valley Groundwater Basin*

The Temecula Valley Groundwater Basin is located in the upper Santa Margarita River watershed within Riverside and San Diego counties. The water bearing formations are alluvium of sand, tuff, and silt underlain by fractured bedrock

(DWR 2004ck). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows. The groundwater is characterized as calcium-sodium bicarbonate with high TDS, fluoride, nitrate, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Temecula Valley Groundwater Basin was designated by the CASGEM program as high priority.

#### 7.3.6.4.2 Groundwater Use and Management

*Upper Santa Ana Valley Groundwater Basin*

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

*Cucamonga and Chino Subbasins*

The communities in the Cucamonga and Chino subbasins use a combination of surface water and groundwater to meet water demands (City of Chino 2011; City of Ontario 2011; City of Pomona 2011; City of Upland 2011; Cucamonga Valley WD 2011; FWC 2011; JCSD 2011; MWDSC 2007; MVWD 2011; SAWC 2011; WMWD 2011). The cities of Chino, Ontario, Pomona, and Upland; Cucamonga Valley Water District, Jurupa Community Services District, Monte Vista Water District, and Western Municipal Water District; San Antonio Water Company, Fontana Water Company, Santa Ana River Water Company, and Marygold Mutual Water Company, and Golden State Water Company provide wholesale and/or retail water supplies, including groundwater, to users within their communities and to portions of the City of Rialto, Montclair, Rancho Cucamonga, and San Antonio Heights.

The Cucamonga subbasin was adjudicated in 1958 to allocate groundwater rights in the basin and surface water rights to Cucamonga Creek (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The water supplies are allocated to the Cucamonga Valley Water District, San Antonio Water Company, and the West End Consolidated Water Company. The City of Upland has agreements with San Antonio Water Company and the West End Consolidated Water Company to divert from the subbasin.

The Chino subbasin was adjudicated in 1978 through the Chino Basin Judgment which established the Chino Basin Watermaster to manage the subbasin and enforce the provisions of the judgment (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The judgment and subsequent agreements allocated the available safe yield to three categories, or pools: Overlying Agricultural Pool, including dairies, farms, and the State of California; Overlying Non-Agricultural Pool for industrial users; and the Appropriative Pool Committee, including local cities, public water agencies, and private water companies. The judgment and subsequent agreements included provisions for reallocation of water rights, groundwater replenishment if the subbasin is operated in a controlled overdraft condition, and development of a groundwater management plan. Through "Peace

Agreements" adopted in 2000 and amended in 2004, included provisions to allow: members of the Overlying Non-Agricultural Pool to transfer their water within their pool or to the Watermaster, appropriators to provide water service to overlying lands, and the Watermaster to allocate unallocated safe yield. The Peace Agreement also addressed use of local storage facilities, management of the subbasin under the Dry Year Yield program when imported water, including SWP water, is not fully available. Groundwater replenishment is allowed through spreading basins, percolation, groundwater injection, and in-lieu use of other water supplies, including SWP water. The Chino Basin Watermaster also was required to develop an Optimum Basin Management Plan, adopted in 1998, to address approaches that would enhance basin water supplies, protect and enhance water quality, enhance management of the basin, and equitably finance implementation of programs identified in the plan. The Peace II Agreement was adopted in 2007 addressed procedures related to basin reoperation under controlled overdraft conditions using the Chino Desalters to meet the replenishment obligation and to maintain hydraulic control in the subbasin, and transfers. The Groundwater Recharge Master Plan update was prepared by the Watermaster in 2010.

The Santa Ana Regional Water Quality Control Board adopted a Water Quality Control Plan in 2004 for the entire Santa Ana River Basin which included a Maximum Benefit Basin Plan, recommended by the Chino Basin Watermaster and the Inland Empire Utilities Agency. The plan established water quality objectives in groundwater quality objectives for TDS and Total Inorganic Nitrogen and wasteload allocations to allow use of recycled water for groundwater recharge. The Maximum Benefit Basin Plan includes commitments for surface water and groundwater monitoring programs; implementation of up to 40 million gallons/day of treated groundwater at desalters; implementation of recharge facilities, conjunctive use programs, and recycled water quality management programs; and groundwater management to provide hydraulic controls to protect the Santa Ana River water quality.

Operations of the Chino Basin portion of the upper Santa Ana River are also affected by surface water right judgments administered by the Santa Ana River Watermaster.

A large portion of the natural runoff in the upper Santa Ana River watershed is captured and used to recharge the groundwater aquifers. Flood control channels and percolation basins are operated by San Bernardino County Flood Control District to allow for flood control and groundwater recharge (MWDSC 2007). Groundwater recharge also occurs in spreading basins operated by the City of Upland, San Antonio Water Company, and San Antonio Water Company. The Chino Basin Water Conservation District operates percolation ponds and spreading basins to facilitate groundwater recharge (IEUA 2011).

The Inland Empire Utilities Agency manages production and treatment of recycled water supplies that are used in groundwater recharge operations and as part of conjunctive use programs in the cities of Chino, Chino Hills, Ontario, and Upland; and in the service areas of the Cucamonga Valley Water District, Monte

Vista Water District, Fontana Water Company, and San Antonio Water Company (IEUA 2011). The district is a member of the Chino Basin Watermaster Board of Directors. The Inland Empire Utilities Agency operates several recharge facilities in the Chino subbasin. Recharge water comes from three sources: recycled water, stormwater, and imported SWP water. The Inland Empire Utilities Agency operates the Chino Desalter Authority's Chino I and Chino II Desalters that treat water from 22 wells. The Chino Desalter Authority is a joint powers authority that includes the cities of Chino, Chino Hills, Norco, and Ontario; and the Jurupa Community Services District, Santa Ana River Water Company, Western Municipal Water District, and Inland Empire Utilities Agency. The treated water from the desalters is used for potable water supplies, groundwater recharge with water with reduced salts and nitrates, and improved water quality of the Santa Ana River.

*Riverside-Arlington and Temescal Subbasins*

The communities in the Riverside-Arlington and Temescal subbasins use a combination of surface water and groundwater to meet water demands (City of Corona 2011; City of Norco 2014; City of Rialto 2011; City of Riverside 2011; JCSD 2011; MWDSC 2007; RCWD 2011; SBVMWD 2011; WMWD 2011). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Riverside-Arlington and Temescal subbasins. The cities of Colton, Corona, Norco, Rialto, and Riverside; Elsinore Valley Municipal Water District; Jurupa Community Services District, Lee Lake Water District; Rubidoux Community Services District, San Bernardino Valley Municipal Water District, Western Municipal Water District, and West Valley Water District; and Box Springs Mutual Water Company, Riverside Highland Mutual Water Company, and Terrace Water Company provide retail water supplies, including groundwater, to users within their communities. The Jurupa Community Services District uses wells within the Riverside-Arlington subbasin for non-potable uses (JCSD 2011).

The Riverside portion of the Riverside-Arlington subbasin was adjudicated in 1969 through the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al*. The judgment provided average annual extraction volumes and replenishment schedules for the separate sections of the subbasin as defined by the San Bernardino County and Riverside County boundary (Riverside North and Riverside South portions of the subbasin) (City of Riverside 2011; MWDSC 2007). Within the Riverside North portion, the judgment affects only withdrawals that are to be used in Riverside County because withdrawals for use of water in San Bernardino County are not limited. The Western-San Bernardino Watermaster manages the monitoring and reporting of groundwater conditions of the Riverside portion of the subbasin.

The northern portion of the Riverside portion of the subbasin also was part of the 1969 judgment in the *Orange County Water District v. City of Chino et al.* This judgment primarily includes the Bunker Hill subbasin and small portions of the northern Riverside, Rialto-Colton, and Yucaipa subbasins; and requires minimum downstream flows into the lower Santa Ana River (SBVMWD 2011). To meet the flow obligations, the San Bernardino Valley Municipal Water District is responsible to manage groundwater and surface waters within the San Bernardino Basin Area, as defined in the judgment. The district manages the groundwater by allocation of groundwater withdrawal amounts and requiring replenishment when additional groundwater is withdrawn.

The Arlington portion of the Riverside-Arlington subbasin and the Temescal subbasins are not adjudicated (City of Corona 2011; MWDSC 2007). In 2008, an agreement was adopted between Elsinore Valley Municipal Water District and the City of Corona for use of water from the southern portion of the Temescal subbasin.

The City of Riverside operates two water treatment plants as part of the North Riverside Water Project to remove volatile organic compounds. The City of Corona operates the Temescal Basin Desalter Treatment Plant/Facility and the Western Municipal Water District operates the Arlington Desalter (City of Corona 2011; WMWD 2011) to reduce TDS. The City of Norco operates a groundwater treatment plant to reduce iron, manganese, and hydrogen sulfide (City of Norco 2014).

*Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo Subbasins*

The communities in the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins use a combination of surface water and groundwater to meet water demands (City of Rialto 2011; City of Riverside 2011; MWDSC 2007; SBVMWD 2011; YVWD 2011; WMWD 2011; West Valley WD 2014a). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins. The cities of Colton, Loma Linda, Redlands, Rialto, Riverside, and San Bernardino; Beaumont-Cherry Valley Water District, East Valley Water District, South Mesa Water District, West Valley Water District, Western Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; and several private water companies provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Beaumont, Calimesa, and Yucaipa; the communities of Cherry Valley, Mission Grove, Orange Crest, and Woodcrest; and numerous private water companies.

Groundwater adjudication in these subbasins have occurred over the past 90 years. A portion of the Bunker Hill subbasin underlays the Lytle Creek watershed (City of Rialto 2011). The remaining portion of the Lytle Creek watershed overlays the Lytle Creek groundwater basin that is not included in the DWR Bulletin 118. The entire Lytle Creek groundwater basin, including the portion in the Bunker Hill subbasin, is a major groundwater recharge source to the Bunker Hill and Rialto-Colton subbasins; and was adjudicated in 1924. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, Rancheria Water Company, and Mutual Water Company.

The Rialto-Colton subbasin was adjudicated in 1961 under the *Lytle Creek Water & Improvement Company vs. Fontana Ranchos Water Company et al* (City of Rialto 2011). The adjudication allocated groundwater withdrawals between the cities of Rialto and Colton, West Valley Water District, and Fontana Union Water Company based upon spring groundwater levels at three index wells between March and May of each water year. The groundwater subbasin is managed by the Rialto Basin Management Association. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, and private well users. Use of this aquifer has been limited due to contamination with volatile organic compounds which are currently being treated. The City of Rialto also has agreements with San Bernardino Municipal Water District to store SWP water in the Rialto subbasin. The city can withdraw the stored water without affecting the water allowed to be withdrawn under the 1961 decree.

As described above under the Riverside-Arlington and Temescal Subbasins section, in 1969 the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al*. to preserve the safe yield of the San Bernardino Basin Area through entitlements to groundwater withdrawals to protect the safe yield and establishment of replenishment schedules when the safe yield is exceeded (City of Rialto 2011; SBVMWD 2011). The San Bernardino Basin Area includes the Bunker Hill subbasin and portions of the Rialto-Colton and Yucaipa subbasins; and portions of the Mill Creek, Lytle Creek, and upper Santa Ana River watersheds. The Western-San Bernardino Watermaster, which includes Western Municipal Water District and San Bernardino Municipal Water District, manages the monitoring and reporting of groundwater conditions. The primary users of the groundwater under this decree include the cities of Colton, Loma Linda, Redlands, and Rialto; East Valley Water District, San Bernardino Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; Riverside-Highland Water Company and 13 private water companies.

In 2002, the City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater in the Beaumont Basin (part of the San Timoteo subbasin), protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013; SBVMWD 2011). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water

District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

The Seven Oaks Accord, a settlement agreement, was signed by the City of Redlands; East Valley Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District; and Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company to recognize prior rights of water users of a portion of the natural flow of the Santa Ana River (SBVMWD 2011). The Seven Oaks Accord requires that San Bernardino Valley Municipal Water District, and Western Municipal Water District develop a groundwater spreading program to recharge the groundwater in cooperation with other parties to the accord to maintain relatively constant groundwater levels.

In 2005, the San Bernardino Valley Municipal Water District entered into an agreement with the San Bernardino Valley Water Conservation District to work cooperatively to develop and implement a groundwater management plan which includes groundwater banking programs (SBVMWD 2011).

The City of Rialto, San Bernardino Valley Municipal Water District, West Valley Water District, and Riverside Highland Water District have jointly constructed the Baseline Feeder to convey groundwater from the Bunker Hill subbasin to the Rialto area and West Valley Water District to be used in an in-lieu program that would reduce reliance on SWP water supplies (City of Rialto 2011; West Valley WD 2014c, 2014d).

West Valley Water District implemented a bioremediation wellhead treatment system (West Valley Water District 2014b).

*San Jacinto Groundwater Basin*

The communities in the San Jacinto Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Hemet 2011; City of San Jacinto 2011; EMWD 2011; LHMWD 2011; MWDSC 2007; RCWD 2011). The Eastern Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the San Jacinto Groundwater Basin. The cities of Hemet and San Jacinto; and Eastern Municipal Water District and Rancho California provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Menifee, Moreno Valley, Murrieta, and Temecula; Lake Hemet Municipal Water District; Nuevo Water Company and numerous private water companies; and the communities of Edgemont, Homeland, Juniper Flats, Lakeview, Mead Valley, North Perris Water System, Romoland, Sunnymead, Valle Vista, and Winchester. The City of Perris overlays a portion of the San Jacinto Groundwater Basin; however, the city does not use groundwater. A substantial portion of the groundwater supplies within the San Jacinto Groundwater Basin are used by agricultural water users.

The 1954 Fruitvale Judgment allows for Eastern Municipal Water District to withdraw water from the San Jacinto Groundwater Basin if the groundwater elevation is greater than a specified elevation (EMWD 2009, 2011, 2014). The judgment includes a maximum withdrawal volume for use outside of the groundwater basin. There are further restrictions within the Canyon Basin subbasin of the San Jacinto Groundwater Basin. DWR worked with the cities of Hemet and San Jacinto, Lake Hemet Municipal Water District, Eastern Municipal Water District, and private groundwater companies to file a stipulated judgment in 2007 to form a Watermaster to develop and implement the Hemet/San Jacinto Water Management Plan, including the Hemet/San Jacinto Integrated Recharge and Recovery Program, Recycled Water In-Lieu Project, and Hemet Filtration Plant. The stipulated judgment also limited groundwater withdrawals to protect the groundwater basin, provide for recharge programs, expand water production, and protect water quality. The program uses SWP water and San Jacinto River runoff to recharge the San Jacinto-Upper Pressure Groundwater Management Zone. In 2013, the judgment was filed with the court to adopt the Hemet/San Jacinto Water Management Plan and create the Watermaster Board.

The stipulated judgment also addressed methods to fulfil the Soboaba Band of Luiseño Indians water rights in accordance with the findings of the Court for the *Soboba Band of Luiseño Indians Water Settlement Agreement* in 2006. In 2008, the Soboba Settlement Act was signed by the President of the United States to provide an annual water supply and provide funds for economic development. The legislation also provides funds to construct recharge facilities and provisions for the Soboba Tribe to participate in restoration efforts.

The Eastern Municipal Water District adopted the West San Jacinto Groundwater Basin Management Plan in 1995. The management plan includes the Nuevo Water Company, City of Moreno Valley, City of Perris, and McCanna Ranch Water Company (MWDSC 2007).

Eastern Municipal Water District operates two desalination plants to treat brackish water within the San Jacinto Groundwater Basin as part of the Groundwater Salinity Management Program (EMWD 2011). Other wells within the Eastern Municipal Water District also include treatment facilities to reduce hydrogen sulfide, iron, and/or manganese.

*Elsinore Groundwater Basin*

The communities in the Elsinore Groundwater Basin use a combination of surface water and groundwater to meet water demands (EVMWD 2011; MWDSC 2007). The Elsinore Valley Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the Elsinore Groundwater Basin. The cities of Lake Elsinore, Canyon Lake, and Wildomar; Elsinore Valley Municipal Water District and Elsinore Water District; and Farm Mutual Water Company provide retail water supplies, including groundwater, to users within their communities and to portions of Cleveland Ranch, Farm, Horsethief Canyon, Lakeland Village, Meadowbrook, Rancho Capistrano – El Cariso Village, and Temescal Canyon.

The Elsinore Groundwater Basin is not adjudicated. The Elsinore Valley Municipal Water District was responsible for over 90 percent of the groundwater withdrawals in mid-2000s (EVMWD 2011). The Elsinore Basin Groundwater

Management Plan, adopted by Elsinore Valley Municipal Water District in 2005, identifies conjunctive use projects, including direct recharge projects. The direct recharge projects use imported water, including SWP water.

*Temecula Valley Groundwater Basin*

The communities in the Temecula Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007; RCSD 2011; WMWD 2011). The Rancho California Water District and Western Municipal Water District (including Murrieta County Water District) provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Temecula Valley Groundwater Basin, including the cities of Murrieta and Temecula. The Pechanga Indian Reservation operates groundwater wells within the Temecula Valley Groundwater Basin (MWDSC 2007).

The Temecula Valley Groundwater Basin is located within the Santa Margarita River watershed. As described above for the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins, the groundwater basins that contribute direct or indirect flows into the Santa Margarita River have been adjudicated and are managed by the Santa Margarita River Watermaster in accordance with the 1940 Stipulated Judgment, the 1966 Modified Final Judgment and Decree, and subsequent court orders (MWDSC 2007; RCWD 2011; SMRW 2011; WMWD 2011). The court-appointed steering committee for the Watermaster includes Eastern Municipal Water District, Fallbrook Public Utility District, Metropolitan Water District of Southern California, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Rancho California Water District, Western Municipal Water District, and Marine Corps Base Camp Pendleton. In accordance with the judgment, the Rancho California Water District prepares the annual Groundwater Audit and Recommended Groundwater Production Report that allocates groundwater withdrawals based upon rainfall, recharge area, and pumping capacity. The subsequent orders adopted following 1966 included the Cooperative Water Resource Management Agreement between Rancho California Water District and the Marine Corps Base Camp Pendleton to manage groundwater levels and surface water flows; water rights to Vail Lake on Temecula Creek; and an agreement between the Rancho California Water District and the Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation.

Rancho California Water District provides imported water, including SWP water, and natural runoff released from Vail Lake to the Valle de Los Caballos Recharge Basins (RCWD 2011). The district also has implemented the Vail Lake Stabilization and Conjunctive Use Project to store imported water in Vail Lake for subsequent groundwater recharge (RCWD et al. 2014).

#### 7.3.6.5 Central Riverside County

The areas within the SWP service area which receive Colorado River water in-lieu of SWP water deliveries are located within the Coachella Valley Groundwater Basin. The Coachella Valley Groundwater Basin includes the

Desert Hot Springs, Indio, Mission Creek, and San Gorgonio Pass subbasins, as shown in Figure 7.12.

#### 7.3.6.5.1 Hydrogeology and Groundwater Conditions

The Coachella Valley Groundwater Basin underlies the entire floor of the Coachella Valley. Primary water-bearing materials in the Coachella Valley Groundwater Basin are unconsolidated alluvial deposits along the valley floor which consist of older alluvium and a thick sequence of poorly bedded coarse sand and gravel; terrace deposits under the surrounding foothills in the Mission Creek subbasin; and partly consolidated fine to coarse sandstone in the surrounding mountains in the San Gorgonio Pass subbasin (DWR 2004cm, 2004cn, 2004co, 2004cp). The movement of groundwater is locally influenced by features such as faults, structural depressions, and constrictions; however, groundwater generally flows to the southeast towards the Salton Sea. Groundwater recharge occurs along stream beds and from groundwater inflows from adjacent subbasins. Within the Indio subbasin, groundwater also is recharged from spreading basins and injection wells.

The groundwater quality is characterized as calcium-sodium bicarbonate. Groundwater quality is adequate for community and agricultural water uses within the San Gorgonio Pass, Mission Creek, and Indio subbasins. There are localized areas with high fluoride near the Banning and San Andreas fault zones. Groundwater quality in the Desert Hot Springs subbasin is poor due to the geothermal activity which results in high sodium sulfate, TDS, and chlorides. The hot springs water is only used by a resort for bathing.

Desert Hot Springs Groundwater Basin was designated by the CASGEM program as low priority. Indio, Mission Creek, and San Gorgonio Pass groundwater basins were designated as medium priority.

#### 7.3.6.5.2 Groundwater Use and Management

*Coachella Valley Groundwater Basin*

The Coachella Valley Groundwater Basin includes the San Gorgonio Pass, Mission Creek, Desert Hot Springs, and Indio subbasins.

*San Gorgonio Pass Subbasin*

The communities in the San Gorgonio Pass subbasin use a combination of surface water and groundwater to meet water demands (BCVWD 2013; City of Banning 2011; SGPWA 2010). The City of Banning, Beaumont-Cherry Valley Water District, Cabazon Water District, and High Valley Water District provide retail water supplies, including groundwater, in the areas that overlay the San Gorgonio Pass subbasin, including the City of Banning and the eastern portion of the City of Beaumont; Banning Heights Mutual Water Company; and the community of Cabazon. The Morongo Band of Mission Indians operates groundwater wells within the San Gorgonio Pass subbasin.

The western portion of the San Gorgonio Pass subbasin is located within the Beaumont Basin (USGS 1974). As described above, the City of Beaumont,

Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater, protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

*Mission Creek, Desert Hot Springs, and Indio Subbasins*

The communities in the Mission Creek, Desert Hot Springs, and Indio subbasins use a combination of surface water and groundwater to meet water demands (City of Coachella 2011; CVWD 2011, 2012; DWA 2011; IWA 2010; MSWD 2011). The City of Coachella, Coachella Valley Water District, Desert Water Agency, Indio Water Authority, and Mission Springs Water District provide retail water supplies, including groundwater, in the areas that overlay the Mission Creek, Desert Hot Springs, and Indio subbasins, including the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage; and the communities of Barton Canyon, Bermuda Dunes, Bombay Beach, Desert Crest, Desert Edge, Indio Hills, Mecca, Mecca Hills, Palm Springs Crest, Salton City, Thermal, and West Palm Springs Village. The Cabazon Band of Mission Indians and the Torres-Martinez Desert Cahuilla Indians operate groundwater wells within the subbasins.

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District all participate in groundwater management programs within the subbasins (CVWD 2011, 2012; DWA 2011; MSWD 2011). These programs include purchasing imported Colorado River water for groundwater recharge and in-lieu programs, conjunctive use programs, and conservation programs. Coachella Valley Water District and Desert Water Agency are SWP water contractors. However, because no conveyance facilities exist to deliver the SWP water, these districts have agreements with the Metropolitan Water District of Southern California to exchange SWP water for Colorado River water (CVWD 2012). Since 1973, these agencies have recharged more than 2.6 million acre-feet of water in the groundwater basin with delivery of Colorado River water to the Whitewater River Recharge Facility. The Metropolitan Water District of Southern California also has an agreement with Coachella Valley Water District and Desert Water Agency to store water in the Coachella Valley Groundwater Basin. The Coachella Valley Water District also operates the Thomas E. Levy Groundwater Replenishment Facility and the Martinez Canyon Pilot Recharge Facility. Coachella Valley Water District and Desert Water Agency also provide recycled water for in-lieu programs. The Coachella Valley Water District has agreed to operate groundwater recharge facilities to store Colorado River water for Imperial Irrigation District (CVWD 2011).

These groundwater recharge programs and broader groundwater management programs for the Indio subbasin have been developed in accordance with the Whitewater Basin Water Management Plan developed by Coachella Valley Water District and Desert Water Agency, and the Coachella Valley Water Management Plan developed by Coachella Valley Water District (CVWD 2011, 2012; DWA 2011).

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District jointly manage the Mission Creek subbasin in accordance with the 2004 Mission Creek Settlement Agreement (DWA 2011; MSWD 2011). The Coachella Valley Water District and Desert Water Agency also manage portions of the subbasin in accordance with the 2003 Mission Creek Groundwater Replenishment Agreement. These agreements provide for the allocation of available Colorado River water under the SWP water exchange agreement with the Metropolitan Water District of Southern California between the Mission Creek and Indio (also known as the Whitewater) subbasins.

#### *7.3.6.6 Antelope Valley and Mojave Valley*

The areas within the SWP service area in the Antelope Valley and Mojave Valley include Salt Wells Valley, Cuddeback Valley, Pilot Knob Valley, Grass Valley, Superior Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Bessemer Valley, Lucerne Valley, Johnson Valley, Means Valley, Deadman Valley, Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, Warren Valley, and Morongo Valley groundwater basins in San Bernardino County; Harper Valley and Fremont Valley groundwater basins in San Bernardino Kern counties; Lost Horse Valley in Riverside and San Bernardino counties; Antelope Valley Groundwater Basin in San Bernardino, Kern, and Los Angeles counties; and Indian Wells and Searles Valley groundwater basin in San Bernardino, Inyo, and Kern counties, as shown in Figure 7.13.

##### 7.3.6.6.1 Hydrogeology and Groundwater Conditions

*Indian Wells Valley Groundwater Basin*

Indian Wells Valley Groundwater Basin is located in Inyo, Kern, and San Bernardino Counties. Water bearing formations consist of unconsolidated lakebed, stream, and alluvial fan deposits with upper and lower aquifers (DWR 2004cn). The lower aquifer is more productive and has a saturated thickness of approximately 1000 feet. The upper aquifer provides low yield and has low quality. The lower aquifer is considered unconfined in most of the valley. There is indication that some faults within the valley could obstruct groundwater flow. Groundwater is recharged from runoff on the southwest to northeast sides of the valley. Groundwater levels have been declining since 1945. Groundwater quality varies throughout the groundwater basin from appropriate for beneficial uses to areas with poor water quality due to wastewater disposal practices. Areas near geothermal activity are characterized by high chloride, boron, and arsenic concentrations.

Indian Wells Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Salt Wells Valley Groundwater Basin*

Salt Wells Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004co). Groundwater is recharged from the Indian Wells Groundwater Basin and percolation of rainfall on the valley floor. The regional groundwater flow direction is towards the east into the Searles Valley Groundwater Basin. The groundwater has extremely high salinity, TDS, and boron.

Salt Wells Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Searles Valley Groundwater Basin*

Searles Valley Groundwater Basin is located in San Bernardino, Inyo, and Kern Counties. Water bearing formations consist of alluvium with unconsolidated to semi-consolidated deposits (DWR 2004cp). The Garlock fault may be a barrier to groundwater flow in the southern part of the basin. Groundwater is recharged from percolation of mountain runoff through the alluvial fan deposits and subsurface inflow from Salt Wells Valley and Pilot Knob Valley groundwater basins. Groundwater flows towards Searles Lake except in the northern portion of the basin where pumping by industrial water users has altered the groundwater flow. Groundwater levels near Searles Lake are close to the lake bed elevations. Groundwater quality is generally appropriate for beneficial uses with localized areas with high levels of fluoride and nitrate. In the vicinity of Searles Lake, the groundwater quality is poor with high levels of fluoride, boron, sodium, chloride, sulfate, and TDS.

Searles Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley, Groundwater Basins*

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley Groundwater basins are located in northern San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004cq, 2004cr, 2004cs, 2004ct). Several fault zones restrict groundwater movement. Groundwater is recharged in the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins primarily through groundwater inflow into the basins and percolation of precipitation at the valley margins. Groundwater within Cuddeback Valley, Grass Valley, and Superior Valley groundwater basins flows towards the Harper Valley Groundwater Basin.

Groundwater in the Cuddeback Valley Groundwater Basin also flows towards Cuddeback Lake. Groundwater in Pilot Knob Valley Groundwater Basin flows towards the Searles Valley and Brown Mountain Valley groundwater basins. Groundwater quality is characterized as sodium chloride-bicarbonate with high salinity and TDS in the Cuddeback Valley Groundwater Basin and high concentrations of sodium and fluoride in the Superior Valley Groundwater Basin.

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins were designated by the CASGEM program as very low priority.

*Harper Valley Groundwater Basin*

Harper Valley Groundwater Basin is located in western San Bernardino County and eastern Kern County. Water bearing formations consist of lacustrine deposits and unconsolidated to semi-consolidated alluvial deposits (DWR 2004cu). The alluvial deposits at the center of the basin are generally more interbedded with lacustrine silty clay. Faults in the Harper Valley Groundwater Basin cause at least partial barriers to groundwater flow. Groundwater is recharged from percolation of rainfall and runoff through alluvial fan material at the valley edges and underflow from Cuddeback Valley, Grass Valley, Superior Valley, and Middle Mojave River Valley groundwater basins. Regional groundwater flows toward the south and Harper Lake. Groundwater quality is characterized as sodium chloride-bicarbonate with high concentrations of boron, fluoride, and sodium.

Harper Valley Groundwater Basin was designated by the CASGEM program as low priority.

*Fremont Valley Groundwater Basin*

The Fremont Valley Groundwater Basin is located in eastern Kern County and in northwestern San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits (DWR 2004cv). The alluvial deposits are generally unconfined and the lacustrine deposits may exhibit locally confined conditions. Fault zones, including the Garlock and El Paso fault zones, are barriers to groundwater flow. Groundwater is recharged along streambeds in the Sierra Nevada Mountains. Groundwater flow is generally toward the center of the valley and Koehn Lake. Groundwater is characterized as sodium bicarbonate with high concentrations of calcium, chloride, fluoride, and sodium.

Fremont Valley Groundwater Basin was designated by the CASGEM program as low priority.

*Antelope Valley Groundwater Basin*

The Antelope Valley Groundwater Basin is located in Kern, Los Angeles, and San Bernardino counties. Water bearing formations consist of unconsolidated alluvial and lacustrine deposits consisting of compact gravels, sand, silt, and clay (DWR 2004cw). Several fault zones restrict groundwater movement. Groundwater is recharged along streams from the surrounding mountains, including Big Rock Creek and Little Rock Creek. The regional groundwater flow direction historically was towards the dry lakebeds of Rosamond, Rogers, and Buckhorn

Lakes. However, extensive groundwater pumping has caused subsidence and reduced the groundwater storage and flow direction. The groundwater is characterized as sodium bicarbonate with localized areas of high nitrate and boron.

Antelope Valley Groundwater Basin was designated by the CASGEM program as high priority.

*El Mirage Valley Groundwater Basin*

The El Mirage Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2003c). Several fault zones restrict groundwater movement. Groundwater is recharged in alluvial deposits at the mouth of Sheep Creek. The regional groundwater flow direction is generally north toward El Mirage Lake. The groundwater is characterized as sodium bicarbonate with localized areas of high levels of fluoride, sulfate, sodium, and TDS.

El Mirage Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley Groundwater Basins*

The Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins are located along the Mojave River in southwestern and central San Bernardino County. The water bearing formations consist of alluvial fan deposits overlain by river channel, floodplain, or lake deposits (DWR 2004cx, 2004cy, 2003d, 2003e). The general groundwater flow direction follows the Mojave River north through the Upper Mojave River Valley Groundwater Basin, and east through the Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation on the valley floor, underflow from the Mojave River, streamflow, and flow between the basins. Treated wastewater and irrigation return flows also provide a source of groundwater recharge in these basins. Groundwater quality in the Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins varies throughout the basins due to geological formations and includes areas dominated by calcium bicarbonate, calcium-sodium bicarbonate, calcium-sodium sulfate, sodium-calcium sulfate, and sodium sulfate-chloride. There are localized areas of high nitrate, iron, and manganese in the Upper Mojave River Valley Groundwater Basin; and areas with high nitrates, fluoride, and boron in the Middle Mojave River Valley and Lower Mojave River Valley groundwater basins. Localized areas with high volatile organic compounds occur in the Upper Mojave River Valley and Lower Mojave River Valley groundwater basins.

Upper Mojave River Valley Groundwater Basin was designated by the CASGEM program as high priority. Lower Mojave River Valley Groundwater Basin was designated as medium priority. Middle Mojave River Valley Groundwater Basin was designated as low priority. Caves Canyon Valley Groundwater Basin was designated as very low priority.

*Langford Valley Groundwater–Langford Well Lake Subbasin, and Cronise Valley and Coyote Lake Valley Groundwater Basins*

The Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins are located in central San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004cz, 2004da, 2004db). Groundwater is recharged from precipitation, stream flows into alluvial deposits along the mountains at the basin boundaries, and subsurface inflow from other groundwater basins including the Superior Valley Groundwater Basin. Groundwater quality is poor due to high concentrations of fluoride, boron, and TDS, and localized areas with high iron in the Langford Well Lake subbasin.

Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins were designated by the CASGEM program as very low priority.

*Kane Wash Area Groundwater Basin*

The Kane Wash Area Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium with undissected coarse gravel to sand in the younger deposits and dissected gravel sand and silt in the older deposits (DWR 2004dc). Groundwater is recharged from precipitation and stream flows. The groundwater is characterized as sodium sulfate-bicarbonate with moderate TDS concentrations.

Kane Wash Area Groundwater Basin was designated by the CASGEM program as very low priority.

*Iron Ridge Area Groundwater Basin*

The Iron Ridge Area Groundwater Basin is located in southern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004dd). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows from the nearby mountains.

Iron Ridge Area Groundwater Basin was designated by the CASGEM program as very low priority.

*Bessemer Valley Groundwater Basin*

The Bessemer Valley Groundwater Basin is located in eastern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits, fanglomerate, and playa lake deposits (DWR 2004de). More recent deposits consist of unconsolidated, undissected coarse gravel to sand. Older deposits consist of gravel, sand, and silt from dissected alluvial fans. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows at the valley margins.

Bessemer Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Lucerne Valley Groundwater Basin*

The Lucerne Valley Groundwater basin is located in San Bernardino County. Water bearing formations consist of unconsolidated or semi-consolidated alluvial deposits and dune sand deposits composed of gravel, sand, silt, clay, and occasional boulders (DWR 2004df). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater levels have declined throughout the basin and caused subsidence. The groundwater is characterized as calcium-magnesium bicarbonate or magnesium-sodium sulfate with TDS and nitrates.

Lucerne Valley Groundwater Basin was designated by the CASGEM program low priority.

*Johnson Valley Groundwater Basin*

The Johnson Valley Groundwater Basin is located in San Bernardino County and includes the Soggy Lake and Upper Johnson Valley subbasins. Water bearing formations in both subbasins consist of alluvial deposits with mainly sand and gravel in the Soggy Lake subbasin and silt, clay, sand, and gravel in the Upper Johnson Valley subbasin (DWR 2004dg, 2004dh). Springs occur throughout the Soggy Lake subbasin. Groundwater flows from Soggy Lake subbasin into the Upper Johnson Valley subbasin. Several fault zones restrict groundwater movement. The groundwater is characterized with moderate to high TDS and localized areas with high fluoride.

Johnson Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Means Valley Groundwater Basin*

The Means Valley Groundwater Basin is located in south central part of San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits with unconsolidated fine to coarse grained sand, pebbles, and boulders; and varying silt and clay deposits throughout the basin (DWR 2004di). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and subsurface inflow from the Johnson Valley Groundwater Basin. The groundwater is characterized as sodium-chloride bicarbonate with high TDS, fluoride, and nitrates.

Means Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Deadman Valley Groundwater Basin*

The Deadman Valley Groundwater Basin is located in San Bernardino County. The Deadman Valley Groundwater Basin includes the Deadman Lake and Surprise Spring subbasins. Water bearing formations consist of unconsolidated to partly consolidated continental deposits including interbedded gravels, conglomerates, clays, and silts in alluvial fan units (DWR 2004dj, 2004dk). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater flows from the Surprise Spring subbasin into the Deadman Lake subbasin, and from Deadman Lake subbasin to the dry Mesquite Lake. Groundwater also flows from the Ames Valley Groundwater Basin into the Surprise Spring subbasin. The groundwater is characterized as sodium bicarbonate with moderate to high TDS and localized areas of high fluoride.

Deadman Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, and Warren Valley Groundwater Basins*

The Twentynine Palms Valley, Ames Valley, and Copper Mountain Valley groundwater basins are located in southern San Bernardino County. The Joshua Tree and Warren Valley groundwater basins are located in southern San Bernardino County and northern Riverside County. Water bearing formations consist of unconfined, unconsolidated to partly consolidated continental deposits with interbedded gravels, conglomerates, lake playa, silts, clays, and sandy-clay deposits (DWR 2004di, 2004dj, 2004dk, 2004dl, 2004dm). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation, stream flows, and wastewater effluent disposal. Groundwater flows from the Joshua Tree Groundwater Basin into the Copper Mountain Valley Groundwater Basin. Groundwater recharge in the Warren Valley Groundwater Basin also occurs at spreading grounds. The groundwater is characterized as calcium-sodium bicarbonate or sodium sulfate with moderate to high TDS in all of the basins except the Copper Mountain Valley Groundwater Basin; and localized areas with high fluoride, nitrate, sulfate, and chloride.

Warren Valley Groundwater Basin was designated by the CASGEM program as medium priority. Twentynine Palms Valley was designated as low priority. Joshua Tree, Ames, and Copper Mountain Valley groundwater basins were designated as very low priority.

*Morongo Valley Groundwater Basin*

The Morongo Valley Groundwater basin is located in southern San Bernardino County. Water bearing formations consist of alluvial deposits composed of sand, gravel, silt, and clay (DWR 2003f). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows in the Big Morongo and Little Morongo creeks. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS.

Morongo Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Lost Horse Valley Groundwater Basin*

The Lost Horse Valley Groundwater Basin is located on the border between southeastern San Bernardino County and northeastern Riverside County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits (DWR 2004dn). Groundwater is recharged from precipitation and stream flows.

Lost Horse Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### 7.3.6.6.2 Groundwater Use and Management

Within the Antelope Valley and Mojave Valley, groundwater management is facilitated by the Antelope Valley-East Kern Water Agency and Mojave Water Agency. These agencies purchase SWP water and other water supplies to be used for groundwater recharge or in-lieu uses to protect groundwater within the Antelope and Mojave valleys.

*Antelope Valley*

The Antelope Valley-East Kern Water Agency (AVEK) provides SWP water to areas that overlay portions of the Antelope Valley, Fremont Valley, and Indian Wells Valley groundwater basins. To maintain groundwater aquifers in the area, the AVEK provides treated SWP water to users through the Domestic-Agricultural Water Network and untreated SWP water to some agricultural users (AVEK 2011a). The AVEK participates in groundwater banking programs. Communities within the AVEK service area also use groundwater, including the cities of California City, Lancaster, and Palmdale; Edwards Air Force Base; County of Los Angeles Waterworks District No. 40; Boron Community Services District, Desert Lake Community Services District, Indian Wells Water District (including the City of Ridgecrest), Mojave Public Utilities District, Palmdale Water District, Palm Ranch Irrigation District, Quartz Hill Water District, and Rosamond Community Services District; and California Water Service Company (Antelope Valley, Lake Hughes, areas outside of the City of Lancaster, and Leona Valley), Edgemont Crest Municipal Water Company, El Dorado Mutual Water Company, Lake Elizabeth Mutual Water Company, Shadow Acres Mutual Water Company, Sunnyside Farm Mutual Water Company, Westside Park Mutual Water Company, and White Fence Farms Mutual Water Company provide retail groundwater supplies (AVEK 2011a; AVRWC 2011; California Water Service Company 2011f; City of California City 2013; IWVWD 2011; Los Angeles County et al. 2011; PWD 2011; Rosamond CSD 2011).

In 2004, the County of Los Angeles Waterworks District No. 40 and Palmdale Water District filed for the adjudication of the Antelope Valley Groundwater Basin (DWR 2014a; Los Angeles County et al. 2011; PWD 2011). The request of the filing is to allocate groundwater rights within the basin to these districts, other municipal and industrial water users, and Overlying Landowners and provide for a program to replace groundwater withdrawals in excess of a specified yield in order to stabilize or reverse groundwater declines.

*Mojave Valley*

Within the Mojave Water Agency service area, most of the water supply is from groundwater (AVRWC 2011; City of Adelanto 2011; Golden State Water Company 2011k; HDWD 2011; Hesperia Water District 2011; JBWD 2011;

MWA 2011; PPHCSD 2011; San Bernardino County 2012; TPWD 2014; Victorville Water District 2011). The Mojave Water Agency uses natural surface water flows, recycled water imported from outside of the agency's service area, SWP water, and return flows from water users of groundwater within the service area to recharge groundwater. These water supplies are provided as wholesale water supplies to retail groundwater users to maintain groundwater levels in the area. The Mojave Water Agency overlays all or portions of all of the groundwater basins described in this subsection. The City of Adelanto; Hesperia Water District, Hi-Desert Water District, Joshua Water District, Twentynine Palms Water District, Victorville Water District, Apple Foothill County Water District, Apple Heights County Water District, Juniper Riviera County Water District, Thunderbird County Water District, Daggett Community Services District, Helendale Community Services District, Phelan Piñon Hills Community Services District, Yermo Community Services District, Bighorn-Desert View Water Agency, and San Bernardino County Service Areas numbers 64 and 70; and Golden State Water Company, Apple Valley Ranchos Water Company, Jubilee Water Company, and Rancheritos Mutual Water Company provide retail groundwater supplies. These entities provide water to the cities of Adelanto, Barstow, Hesperia, Twentynine Palms, Victorville; towns of Apple Valley and Yucca; Joshua Tree National Park; Twentynine Palms Marine Corps Base; and the communities of Apple Heights, Apple Valley, Daggett, Flamingo Heights, Helendale, Johnson Valley, Landers, Lucerne Valley, Newberry Springs, Oak Hills, Spring Valley Lake, Yermo, and users between these communities. The Morongo Band of Mission Indians also rely upon groundwater from this area.

The Mojave Water Agency has implemented 13 groundwater recharge facilities (MWA 2011). The SWP water is delivered to the recharge facilities throughout the Mojave Water Agency service area.

The area known as the Mojave Basin Area has been adjudicated. This area includes all or portions of Cuddeback Valley, Superior Valley, Harper Valley, Antelope Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Lucerne Valley, and Johnson Valley groundwater basins (Golden State Water Company 2011k; MWA 2011). The Mojave Basin Judgment allocated groundwater withdrawals in the area and required groundwater users that withdraw more than the allocated amount to purchase replenishment SWP water from the Watermaster or from another entity within the judgment. The judgment considers local surface water sources, including groundwater recharge near Hesperia with treated wastewater effluent from Lake Arrowhead Community Services District (LACSD 2011). The judgment also provides for carry over storage between water years. The Mojave Water Agency has been appointed as the Watermaster.

The Warren Valley Groundwater Basin was adjudicated in 1977 (MWA 2011). The Hi-Desert Water District was appointed as the Watermaster to manage groundwater withdrawals and groundwater quality; to provide SWP water, captured stormwater, and recycled water; and to encourage conservation.

In 1991, the Bighorn-Desert Water Agency and the Hi-Desert Water District agreed to the court approved Ames Valley Basin Water Management Agreement. In accordance with this agreement, the Hi-Desert Water District implemented the Mainstream Wells and expansion to conveyance and monitoring approaches.

# 7.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in groundwater resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

## 7.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in groundwater conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

### *7.4.1.1 Changes in Groundwater Use and Groundwater Levels*

Changes in availability of CVP and SWP water supplies could result in changes in groundwater use. For example, if CVP and SWP water supplies are decreased, water users may increase the amount of groundwater withdrawals in response.

Historically, groundwater resources were the only source of water supply in the Central Valley. The heavy use of groundwater has caused groundwater quality issues, drainage issues, groundwater overdraft, and land subsidence (as discussed in Section 7.3). Throughout many areas of the San Joaquin Valley, shallow groundwater is characterized by high salinity. Use of this groundwater for irrigation deposited salts along with agricultural chemicals (nutrients and fertilizers) in the upper soil layer. These constituents leached into the underlying shallow groundwater aquifers and caused them to be unsuitable for irrigation. Surface water was provided though the CVP and SWP to provide irrigation water of higher quality than was available in local groundwater. The expanded use of surface water for irrigation has resulted in a reduction in the degree of groundwater overdraft of local groundwater basins.

Generally, when available, agricultural water users in the San Joaquin Valley prefer to use surface water for irrigation because the water quality is better than for groundwater. When adequate surface water is not available, they will use groundwater (USGS 2009).

As previously described in Section 7.2.3, Sustainable Groundwater Management Act, most groundwater users in California must develop Groundwater Sustainability Plans (GSPs) by 2020 or 2022, and meet the sustainable goal within 20 years after adoption of the plan. The timeframe of this EIS analysis is 2030. Therefore, the EIS analysis assumes that groundwater users have developed the

GSPs before that timeframe (by 2020 or 2022), and have begun to plan, design, and possibly construct alternative water supply facilities or implement water conservation measures to achieve full compliance by 2040 or 2042. However, this EIS analysis assumes that the new facilities or conservation measures are not fully implemented by 2030. Therefore, reductions in groundwater use in accordance with the SGMA are not anticipated until after 2030 and are discussed under Section 7.4.39, Cumulative Effects Analysis.

Changes in groundwater use by users of or providers to CVP and SWP water supplies could result in changes in groundwater storage and groundwater levels. For example, if CVP and SWP water supplies are decreased and water users increase the amount of groundwater withdrawals, groundwater levels could decline. Changes in groundwater levels resulting in levels declining could result in a decrease in well yields. Changes in groundwater levels also could result in different groundwater pumping costs, as analyzed in Chapter 12, Agricultural Resources, and Chapter 14, Socioeconomics, for agricultural and municipal water users of CVP and SWP water supplies, respectively.

##### 7.4.1.1.1 Use of Central Valley Hydrologic Model

There are many groundwater models that have been developed for portions of the Central Valley. However, most of these models were not developed in a manner that would allow for analysis of groundwater changes throughout the Central Valley which includes the majority of CVP and SWP agricultural water users. As described in Appendix 7A, Groundwater Model Documentation, changes in groundwater use, and levels in the Central Valley have been evaluated using the Central Valley Hydrologic Model (CVHM) because this model is readily available and covers the entire Central Valley. CVHM is a regional-scale calibrated historical finite-difference, block-centered saturated groundwater flow model application developed by the USGS and uses the MODFLOW-2000 computer code (USGS 2000b). The CVHM model spans a 42-year simulation period between water years 1962 and 2003.

CVHM is used to estimate the changes in groundwater levels and groundwater withdrawals under the alternatives as compared to the No Action Alternative and Second Basis of Comparison. CVHM model output is also used as input files of the State Wide Agricultural Production (SWAP) model to simulate agricultural production changes based on groundwater pumping costs, as described in Chapter 12, Agricultural Resources.

The CVHM domain is subdivided into 21 WBSs, as summarized in Figure 7.14 (USGS 2009). Applied water requirements for each WBS are computed based on crop type and available water from precipitation, shallow groundwater uptake, and surface water, as limited by surface water rights and CVP and SWP water supply deliveries.

CVHM simulates primarily subsurface and limited surface hydrologic processes over the entire Central Valley at a uniform grid-cell spacing of 1 mile. Boundary conditions were modified to reflect anticipated changes in surface water availability, including the effects of climate change.

Surface water inflows from the CalSim II model were used to define boundary conditions for CVHM for each alternative and the Second Basis of Comparison. The CalSim II model simulates the operation of the major SWP and CVP facilities in the Central Valley by calculating river flows; and CVP and SWP reservoir storage, exports, and deliveries (see Appendix 5A for more details on CalSim II). The CalSim II outputs are included in the CVHM input files.

The CVHM uses the FMP process (described in Appendix 7A) to estimate agricultural water supply needs and assumes that when surface water deliveries are available, they are used first, before groundwater is pumped for additional water supplies.

Changes in agricultural groundwater pumping under the alternatives are compared to groundwater pumping under the No Action Alternative and Second Basis of Comparison. The data for these results were processed from the FMP output files, which include the amount of water used from each available source by the farm, based on the computed crop water demand for each WBS.

For the analyses presented in this chapter, changes in groundwater use, elevation, and pumping volumes between the alternatives, No Action Alternative, and Second Basis of Comparison are described for agricultural water users only in the Central Valley Region.

##### 7.4.1.1.2 Analysis of Changes in Municipal and Industrial Groundwater Use

Due to the regional scale of the CVHM model, municipal and industrial groundwater use is a very small portion of total groundwater use due to the predominance of agricultural groundwater use. Therefore, in the CVHM model, municipal and industrial groundwater use in the Central Valley was assumed to continue at the 2003 calibrated volume throughout the predictive simulations.

For municipal and industrial groundwater use in the Central Valley, the CWEST model is a more appropriate model than CVHM. The CWEST model evaluates total water use by municipal and industrial water users in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions based upon economic decisions.

It is recognized that municipal and industrial pumping in urban areas in the Central Valley could cause localized impacts to groundwater levels from increased drawdown. The increased withdrawals could also impact groundwater quality due to the migration of existing plumes, as described in the Affected Environment section.

##### 7.4.1.1.3 Analysis of Changes in Agricultural Groundwater Use Outside of the Central Valley Region

Agricultural groundwater use by CVP and SWP water users located outside of the Central Valley primarily occurs in Santa Clara and San Benito counties in the San Francisco Bay Area Region; San Luis Obispo and Santa Barbara counties in the Central Coast Region; and Ventura, Orange, San Bernardino, and Riverside counties in the Southern California Region. Basin adjudication programs in many portions of these counties will minimize changes in groundwater use and levels as a result of changes in CVP and SWP water supplies. There are no regional groundwater flow models available that uniformly help analyze groundwater use and elevation in these areas linked to CVP and SWP water supply deliveries, in a similar manner as CVHM simulates in the Central Valley, however in some areas local models have been developed to support groundwater management activities. Therefore, changes in groundwater use and related changes in groundwater levels are assumed to be correlated to availability of CVP and SWP water supplies. It is generally assumed that an increase in CVP and SWP water supplies would result in a decrease in groundwater use in these areas. Similarly, a decrease in CVP and SWP water supplies could result in a short-term increase in groundwater use and associated groundwater level decrease. In adjudicated basins, groundwater use restrictions limit the amount of groundwater that can be pumped, even when surface water availability is reduced. In those basins, long-term groundwater use is assumed to not increase, and agricultural production could decrease if CVP and SWP water supplies decrease.

#### *7.4.1.2 Changes in Land Subsidence*

Extensive groundwater withdrawals from confined and unconfined aquifers increases the potential for land subsidence. In aquifers with clay and silt lenses, decreased groundwater levels can result in compaction of fine-grained deposits which could lead to irreversible land subsidence. Subsidence could result in structural damage to roads, railroad tracks, pipelines and associated structures, drainage, buildings, and wells. Subsidence can also result in the permanent loss of groundwater storage potential within an aquifer system.

Subsidence is related to changes in groundwater levels; and a review of simulated changes in groundwater elevation output from the CVHM model as compared between alternatives is used to provide an indication of the potential occurrence of subsidence.

CVHM includes a module known as the SUB package that computes the cumulative compaction of each model layer during the model simulation. The cumulative layer compactions at the end of the simulation are summed into a total subsidence. However, this version of the SUB package does not consider the potential reduction in the rate of subsidence that would occur as the magnitude of compaction approaches the physical thickness of the affected fine-grained interbeds. Thus, subsidence forecasts from the predictive versions of CVHM were not used as they may not accurately depict long-term changes in subsidence using the current version of the SUB package. Therefore, a qualitative approach was used for the estimation of the potential for increased land subsidence in areas of the Central Valley that have historically experienced inelastic subsidence due to the compaction of fine-grained interbeds.

Potential changes in subsidence due to changes in municipal and industrial groundwater use were qualitatively analyzed for regions with historic or existing subsidence issues, such as in Santa Clara County in the San Francisco Bay Area Region.

#### *7.4.1.3 Changes in Groundwater Quality*

Changes in groundwater quality could occur in several ways under implementation of the alternatives as compared to the No Action Alternative and Second Basis of Comparison. Reductions in groundwater levels could change groundwater flow directions, potentially causing poorer quality groundwater to migrate into areas with higher quality groundwater, or cause intrusion of poor water quality (e.g. from aquitards) as water levels decline.

Groundwater quality also could change due to changes in availability of CVP and/or SWP water supplies used by agricultural water users. For example, if reductions in CVP and/or SWP water supplies result in increased use of groundwater with higher salinity than CVP and/or SWP supplies, shallow groundwater could become more saline and soil salinity could increase, as described in Chapter 11, Geology and Soils. In addition, the reduced availability of higher quality surface water for use in recharge facilities may decrease the overall groundwater quality in those localized areas.

Changes in groundwater quality due to changes in CVP and SWP water supply availability could occur under the following mechanisms:

- Migration of reduced quality groundwater towards areas of groundwater withdrawals, including seawater intrusion and migration of contaminant plumes
- Depletion of the freshwater aquifer that overlays poorer quality groundwater, and the upwelling of the poorer quality groundwater into the upper aquifers
- Percolation of applied water with poorer water quality than underlying groundwater

Within the Central Valley, changes in groundwater use and groundwater flow direction are analyzed using the CVHM. The model does not directly simulate changes in groundwater quality. However, in regions with existing poorer quality groundwater, changes in groundwater levels or flow directions can be used to evaluate potential impacts to groundwater quality. For example, declines in groundwater levels that result in seawater intrusion, or the migration of good quality groundwater into areas with poor quality can result in groundwater quality degradation. Further, reduction in groundwater quality could also occur due to migration or upwelling of poorer quality groundwater into areas with good quality groundwater.

Long-term use of poorer quality groundwater due to changes in CVP and SWP water supplies could also result in a reduction in shallow aquifer groundwater quality. Application of poorer quality groundwater also could increase soil salinity, as described in Chapter 11, Geology and Soils Resources.

#### *7.4.1.4 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis.

The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future groundwater conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in groundwater conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 7.4.2 Conditions in Year 2030 without implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

This section of Chapter 7 provides qualitative projections of the No Action Alternative as compared to existing conditions described under the Affected Environment; and qualitative projections of the Second Basis of Comparison as compared to "recent historical conditions." Recent historical conditions are not the same as existing conditions which include implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) biological opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

### *7.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries, as described in Chapter 5, Surface Water Resources and Water Supplies.

#### 7.4.2.1.1 Changes in Conditions due to Climate Change and Sea-Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

Climate change also would reduce groundwater supplies due to reduced groundwater recharge potential and increased groundwater overdraft potential as surface water supplies decline. However, in some locations, sustainable groundwater supplies could remain similar to recent historical conditions or rise due to implementation of groundwater management plans to reduce groundwater overdraft, including the completion of ongoing groundwater recharge and recovery programs.

#### 7.4.2.1.2 General Plan Development in California

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Preparation of general plans includes an environmental evaluation under the California Environmental Quality Act to identify adverse impacts to the physical environment and to provide mitigation measures to reduce those impacts to a level of less than significance. Most of the counties where CVP and SWP water supplies are delivered have adopted general plans following the environmental review of the plans and appropriate alternatives. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and the Second Basis of Comparison assume that land uses will develop through 2030 in accordance with existing general plans.

The assumptions related to 2030 municipal water demands are based upon a review of the 2010 Urban Water Management Plans (UWMPs) prepared by CVP and SWP water users. The No Action Alternative and the Second Basis of Comparison assumptions related to future water supplies presented in the UWMPs were evaluated to determine if the projects were reasonable and certain to occur by 2030. Projects that had undergone environmental review, were under design, or under construction were included in the future water supply assumptions for 2030 in the No Action Alternative and the Second Basis of Comparison. Projects described in the UWMPs that currently were under evaluation were included in the Cumulative Effects analysis for future water supplies.

Under the No Action Alternative and Second Basis of Comparison, it is assumed that water demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, CVP and SWP water supplies, other imported water supplies, groundwater, recycled water, infrastructure improvements, desalination water treatment, and water transfers and exchanges. It is anticipated that individual communities or users could be in a situation that would not allow for affordable water supply options, and that water demands could not be fully met. However, on a regional scale, it is anticipated that water demands would be met.

##### 7.4.2.1.3 Reasonable and Foreseeable Water Resources Management Projects

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of the 2008 USFWS BO and 2009 NMFS BO by 2030, as described in Chapter 3, Description of Alternatives. Many of these future actions could affect groundwater conditions and use of groundwater.

The No Action Alternative and the Second Basis of Comparison assume that groundwater would continue to be used even if groundwater overdraft conditions continue or become worse. It is recognized that SGMA was enacted in September 2014. The SGMA requires the formation of GSPs in groundwater basins or subbasins that DWR designates as medium or high priority based upon groundwater conditions identified using the CASGEM results by 2022. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs. In some areas with adjudicated groundwater basins, sustainable groundwater management could be achieved and/or maintained by 2030. However, to achieve sustainable conditions in many areas, measures could require several years to design and construct water supply facilities to replace groundwater, such as seawater desalination. Therefore, it does not appear to be reasonable and foreseeable that sustainable groundwater management would be achieved by 2030; and it is assumed that groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030.

#### 7.4.2.1.4 Potential Future Groundwater Conditions in 2030 due to Common Changes

*Groundwater Conditions*

In the Central Valley Region, the combination of increased groundwater withdrawals due to reductions in CVP and SWP water deliveries as compared to recent historical long-term deliveries and reduced groundwater recharge due to climate change could result in continued reductions in groundwater levels in the same manner as recent declines of up to 10 feet in the Sacramento Valley and more than 20 feet in the San Joaquin Valley, as described in Section 7.3.4, Central Valley Region. It is also assumed that full implementation of SGMA GSPs would not occur by 2030; and therefore, groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030, as described above.

Under the No Action Alternative and Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded, including ongoing groundwater recharge efforts in the Eastern San Joaquin, Kings, Kaweah, and Kern subbasins in the San Joaquin Valley Groundwater Basin. These programs could result in groundwater levels that are similar or higher as compared to recent groundwater conditions. If local agencies fully implement GSPs in accordance with the state SGMA prior to the regulatory deadline, groundwater levels could remain similar to recent conditions or rise.

Localized groundwater levels in portions of the Central Valley Region could increase due to seepage in lands adjacent to the ecosystem restoration areas in the Yolo Bypass, Cache Slough, and Suisun Marsh areas depending upon local geological and soil conditions.

In the Southern California Region, several SWP water users have purchased transferred water, expanded groundwater storage within their service areas, implemented wastewater recycling and stormwater recycling programs to provide water supplies for groundwater recharge, and participated in groundwater banks outside of their service areas as part of ongoing sustainable groundwater management programs. Under the No Action Alternative and the Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded. Several of the programs include expansion of groundwater storage by Kern County and Antelope Valley-East Kern Water Agency; groundwater recharge programs using recycled stormwater by the Los Angeles Department of Water and Power; groundwater recharge programs using recycled wastewater by the Water Replenishment District; and groundwater treatment by City of Oxnard and Western Municipal Water District (AVEK 2011b; City of Los Angeles 2011; City of Oxnard 2013; Reclamation 2010b; WMWD 2012; WRD 2015). Expansion of these programs could result in maintenance of groundwater levels in accordance with objectives in the current groundwater management plans even with reduced SWP water supplies under the No Action Alternative and Second Basis of Comparison.

*Potential Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin and Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin in the Central Valley Region; Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region; and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region. Under the No Action Alternative, it is anticipated that increased groundwater withdrawals due to reductions in CVP and SWP water supplies and reduced groundwater recharge due to climate change could result in increased irreversible land subsidence in these areas.

*Groundwater Quality*

*Central Valley Region*

As described in Section 7.3, Affected Environment, in the Central Valley, there are localized areas of high salinity related to natural geologic formations and/or historic land uses; high naturally occurring arsenic, calcium, iron, and/or manganese; and high levels of boron, and/or phosphates related to historic land use practices. High concentrations of nitrates due to current anthropogenic sources and legacy sources occur in many locations in the San Joaquin Valley Groundwater Basin, especially in the Eastern San Joaquin, Modesto, Merced, Kings, Kaweah, Tule, and Tulare Lake subbasins. Under the No Action Alternative, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals.

Groundwater quality in the Grasslands Drainage Area and near Mud Slough and the San Joaquin River is anticipated to improve as compared with historic conditions due to the implementation of the Grasslands Bypass project. This program would reduce seepage from unlined canals and capture, treat, and/or reuse drainage flows (Reclamation 2009).

In the Tulare Lake Area of the San Joaquin Valley Groundwater Basin (in the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins within Fresno, Kern, Kings, and Tulare counties) high salinity groundwater occurs in the shallow aquifers due to agricultural drainage issues and naturally occurring high saline soils. Salts are imported into the Tulare Lake Area through the use of CVP and SWP irrigation water supplies and introduced into groundwater from dissolution of salts in the local soil from agricultural land use. Groundwater salinity increases because the Tulare Lake Area is a closed basin.

The CV-SALTS program is preparing a Salinity and Nitrate Management Plan for publication in 2016 (CVRWQCB 2015). The plan will include sustainable salt management alternatives, including treatment and salt recovery technologies, such as, reverse osmosis; and related brine disposal/storage options that could range from deep well injection to dedicated disposal locations to conveyance of brine to locations outside of the San Joaquin Valley. This plan also will address current and legacy sources of nitrates; assimilative capacity of the groundwater subbasins and aquifers; drinking water protection measures, including waste discharge requirements from irrigated lands and dairies; and measurable and enforceable milestones that do not disproportionately impact disadvantaged communities; and measures that minimize costs and maximize benefits to the community and water users. The 2015 CV-SALTS work plan projects completion of Central Valley Basin Plan amendments and Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley updates to incorporate recommendations of CV-SALTS by 2018, including source control strategies and real time management strategies (CVRWQCB 2015; SWRCB 2015). The *2015 CV-SALTS Annual Report* indicated that structural best management practices would not be fully selected until 2018 and may not be implemented until after 2030 (SWRCB 2015). Under the No Action Alternative and Second Basis of Comparison it is assumed that non-structural measures would be implemented by 2030 to reduce salinity and nitrate loadings; however, structural improvements that would reduce total groundwater salinity and nitrate concentrations generally would not be implemented. Therefore, water quality under the No Action Alternative and the Second Basis of Comparison is anticipated to be poorer in some portions of the Central Valley than under recent groundwater quality conditions.

Poor groundwater quality occurs near urban areas in the Central Valley due to contamination from municipal and industrial land use practices. In many of these areas, groundwater quality improvement programs have been implemented, as described above. However, in many areas, groundwater quality is managed by reducing groundwater drawdown near contaminant plumes to avoid transporting the contaminants into other portions of the aquifer. Under the No Action Alternative and the Second Basis of Comparison, it is assumed that these programs would continue. However, as CVP and SWP water supplies become less available in 2030 as compared to recent conditions, increased reliance on groundwater could cause groundwater contamination of portions of the aquifers near existing wells.

*San Francisco Bay Area Region*

In the San Francisco Bay Area Region, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion near San Francisco Bay. High levels of boron due to natural geologic formations and nitrates related to historic land use practices occur in the Livermore Valley and the Gilroy-Hollister- Valley groundwater basins. Under the No Action

Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals, especially in locations with seawater intrusion near the coast.

*Central Coast Region*

In the Central Coast Region, there are localized areas of moderate to high salinity due to seawater intrusion near the coast. High levels of iron and manganese due to natural geologic formations and nitrates related to historic land use practices occur in local areas of the Central Coast Region. Under the No Action Alternative and Second Basis of Comparison, it is anticipated that these conditions would continue to occur. Seawater intrusion could increase and further degrade groundwater quality in groundwater adjacent to the coast if groundwater levels decline in the future.

*Southern California Region*

In the Southern California Region, there are localized areas of moderate to high salinity due to natural geologic formations, percolation of high salinity applied water supplies, and/or seawater intrusion near the coast. High levels of calcium, sulfate, magnesium, iron, manganese, and fluoride due to natural geologic formations, and nitrates and organic compounds related to historic land use practices. Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water or seawater to flow towards the groundwater withdrawals.

#### *7.4.2.2 Changes in Conditions under the No Action Alternative*

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year.

#### *7.4.2.3 Changes in Conditions under the Second Basis of Comparison*

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the availability of CVP and SWP water supplies would be greater under the Second Basis of Comparison as compared to the No Action Alternative because CVP and SWP water operations would not include requirements of the 2008 USFWS BO and 2009 NMFS BO. However, reliance on groundwater in 2030 under the Second Basis of Comparison is anticipated to increase as compared to recent historical conditions due to the climate change and sea-level rise and increased water demands in the Sacramento Valley.

### 7.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

#### *7.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 7.4.3.1.1 Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land subsidence, and groundwater quality under the No Action Alternative would be the same as under the Second Basis of Comparison.

##### 7.4.3.1.2 Central Valley Region

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts water, under the No Action Alternative water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under the No Action Alternative would be the same as under the Second Basis of Comparison.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under the No Action Alternative as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under the No Action Alternative as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley Groundwater Basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.15 through 7.19. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under the No Action Alternative as compared to the Second Basis of Comparison because the long-term reductions in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (or 6 percent) over the long-term condition, up to 8,000 acre-feet per year (or 8 percent) in dry years, and similar (or 5 percent or less) in critical dry years. The water demands are consistent between the No Action Alternative and Second Basis of Comparison; therefore, it is anticipated that reduced surface water supplies would result in increased groundwater use.

Groundwater levels decline under the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison with greater reductions occurring in wet years than in critical dry years. Figures 7.20 and 7.21 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under the No Action Alternative as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under the No Action Alternative as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in all water year types. In critical dry years, groundwater levels decline by up to 100 feet on average in the Westside subbasin. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under the No Action Alternative compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley would result in similar conditions (less than 5 percent change). Therefore, groundwater pumping in the Sacramento Valley is similar under the No Action Alternative compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins would increase by approximately 8 percent under the No Action Alternative as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under the No Action Alternative as compared to the

Second Basis of Comparison occurs in the Westside subbasin, with an average July increase close to 40 thousand acre-feet (TAF).

*Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under the No Action Alternative would be similar as conditions under the Second Basis of Comparison.

Under the No Action Alternative, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under the No Action Alternative, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under the No Action Alternative as compared to the Second Basis of Comparison.

*Groundwater Quality*

Under the No Action Alternative, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under the No Action Alternative could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. For example, potential impacts to groundwater quality may arise from deeper pumping close to the base of freshwater, where higher TDS water exists. Large areas in the San Joaquin Valley also experience impairments due to nitrate and other fertilizers used in agriculture, which could migrate to areas with better quality water due to increased pumping and potential changes in groundwater flow directions.

As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality could decline under the No Action Alternative as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to groundwater were identified as reduced groundwater levels and potentially subsidence in areas that sold water using groundwater substitution practices. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts to other groundwater users, the analysis indicated that water transfers would not result in substantial changes in groundwater because mitigation and monitoring plans would be required. The mitigation measures would require reductions in providing water from groundwater substitutions if the monitoring results indicated substantial declines in groundwater levels. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 7.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

*Groundwater Use and Elevation*

Under the No Action Alternative, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be reduced as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The reduction in surface water supplies could result in increased groundwater withdrawals, decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Increased use of groundwater and reductions in groundwater levels would result in an increased potential for additional land subsidence under the No Action Alternative as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer quality groundwater to flow towards the groundwater withdrawals, especially near the coast. This would result in poorer quality groundwater in some areas under the No Action Alternative as compared to the Second Basis of Comparison.

#### 7.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because groundwater conditions under Alternative 1 are identical to groundwater conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 7.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality degradation under Alternative 1 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 1 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 1 would be the same as under the No Action Alternative.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 1 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 1 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.24 through 7.28. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 1 as compared to the No Action Alternative because the long-term increases in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (or up to 6 percent) over the long-term condition, up to 8,000 acre-feet per year (or up to 8 percent) in dry years, and up to 5,000 acre-feet per year (or up to 7 percent) in critical dry years. The water demands are consistent between Alternative 1 and the No Action Alternative; therefore, it is anticipated that increased surface water supplies would result in reduced groundwater use.

Groundwater levels increase under Alternative 1 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years (up to 100 feet). Figures 7.29 and 7.30 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 1 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 1 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels rise 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in most water year types. In critical dry years, groundwater levels increase by up to 100 feet on average in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley subbasins, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 1 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 1 as compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins would decrease by approximately 8 percent under Alternative 1 as compared to the No Action Alternative. Figure 7.32 shows that the biggest change in groundwater pumping under the Alternative 1 compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease close to 40 TAF.

*Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 1 would be similar as conditions under the No Action Alternative.

Under Alternative 1, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 1 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 1 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 1 as compared to the No Action Alternative.

*Groundwater Quality*

Under Alternative 1, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 1 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 1 as compared to the No Action Alternative.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross

Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions Groundwater Use and Elevation*

Under Alternative 1, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels in areas with CVP and SWP water users.

*Land Subsidence*

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 1 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 1 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

##### 7.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *7.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, the groundwater conditions under Alternative 2 is only compared to the Second Basis of Comparison.

##### 7.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to groundwater resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 7.4.3.1, No Action Alternative.

#### *7.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and

Alternative 1 with modified Old and Middle River flow criteria. Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 7.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the No Action Alternative. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 3 as compared to the No Action Alternative because the long-term increases in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet (up to 7 percent) in dry years, and similar (or 5 percent or less) in long-term conditions and critical dry years. The water demands are consistent between Alternative 3 and the No Action Alternative; therefore, it is anticipated that increased surface water supplies would result in reduced groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 3 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin (changes would be plus/minus 2 feet), as shown in Figures 7.33 through 7.37.

Groundwater levels increase under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years. Figures 7.38 and 7.39 present the simulated changes in groundwater levels over the 42-year CVHM model study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 3 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels increase 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in most water year types. In critical dry years, groundwater levels increase by up to 50 feet on average in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins decreases by approximately 6 percent under Alternative 3 as compared to the No Action Alternative. Figure 7.32 shows that the largest change in groundwater pumping under Alternative 3 as compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease of approximately 35 TAF.

*Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 3 would be similar as conditions under the No Action Alternative.

Under Alternative 3, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 3 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 3 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 3 as compared to the No Action Alternative.

*Groundwater Quality*

Under Alternative 3, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 3 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 3 as compared to the No Action Alternative.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Groundwater Use and Elevation*

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 3 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

**7.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison**

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the Second Basis of Comparison.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the Second Basis of Comparison. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are considered to be similar under Alternative 3 as compared to the Second Basis of Comparison because the CVP municipal water supplies are similar (or 5 percent or less) in long-term conditions, dry years, and critical dry years. The water demands are consistent between Alternative 3 and the Second Basis of Comparison; therefore, it is anticipated that similar surface water supplies would result in similar groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under Alternative 3 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the Second Basis of Comparison. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.40 through 7.44.

Groundwater levels generally decrease under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.45 and 7.46 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 3 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet areas of the western and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline up to 25 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and decline up to 25 feet in Westside subbasin, in most water year types. However, groundwater levels in the Westside subbasin increase by up to 10 feet on average in wet years, due to increased CVP water deliveries to this region in wet years. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 3 as compared to the Second Basis of Comparison, and is therefore considered similar. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 3 compared to the Second Basis of Comparison occurs in WBS 18, with an average July increase close to 10 TAF.

*Land Subsidence*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Groundwater Quality*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Groundwater Use and Elevation*

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users.

*Land Subsidence*

Increased use of groundwater and lower groundwater levels would result in an increased potential for additional land subsidence under Alternative 3 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

#### *7.4.3.5 Alternative 4*

Groundwater conditions under Alternative 4 would be identical to groundwater conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 7.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in groundwater conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 7.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *7.4.3.6 Alternative 5*

CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 7.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the No Action Alternative. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 5 as compared to the No Action Alternative because the CVP municipal water supplies are anticipated to be similar in long-term conditions, dry years, and critical dry years. The water demands are consistent between Alternative 5 and the No Action Alternative; therefore, it is anticipated that similar surface water supplies would result in similar groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be slightly lower under Alternative 5 as compared to the No Action Alternative.

The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the No Action Alternative. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.47 through 7.51.

Groundwater levels decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with the greatest decreases occurring in above normal years. Figures 7.52 and 7.53 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 5 as compared to the No Action Alternative, July average groundwater levels decrease approximately 2 to 10 feet on average in some of the Westside subbasin and the northern portion of the Kern County subbasin in most water year types, and decrease approximately by up to 25 feet in dry and above normal water years in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels usually fluctuate by no more than 50 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 5 as compared to the No Action Alternative, and is therefore considered similar. Figure 7.32 shows that the biggest change in groundwater pumping under Alternative 5 compared to the No Action Alternative occurs in the Western San Joaquin Valley.

*Land Subsidence*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 5 as compared to the No Action Alternative.

*Groundwater Quality*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 5 as compared to the No Action Alternative.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Groundwater Use and Elevation*

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be similar to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. Therefore, groundwater pumping would be similar.

*Land Subsidence*

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, the potential for additional land subsidence would be similar.

*Groundwater Quality*

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, groundwater quality would be similar.

#### 7.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the Second Basis of Comparison.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the Second Basis of

Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the Second Basis of Comparison. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 5 as compared to the Second Basis of Comparison because the long-term reductions in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (up to 6 percent) over the long-term condition, up to 9,000 acre-feet per year (up to 9 percent) in dry years, and up to 6,000 acre-feet per year (up to 8 percent) in critical dry years. The water demands are consistent between Alternative 5 and the Second Basis of Comparison; therefore, it is anticipated that reduced surface water supplies would result in increased groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be lower under Alternative 5 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.54 through 7.58.

Groundwater levels generally decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.59 and 7.60 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 5 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and can decline up to 200 feet in the Westside subbasin, in below normal, above normal and dry water year types. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins increases by approximately 8 percent under the Alternative 5 as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 5 compared to the Second Basis of Comparison occurs in WBS 14, with an average July increase of almost 40 TAF.

*Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 5 would be similar as conditions under the Second Basis of Comparison.

Under Alternative 5, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase under Alternative 5 as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 5, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under Alternative 5 as compared to the Second Basis of Comparison.

*Groundwater Quality*

Under Alternative 5, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 5 could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality may be affected under Alternative 5 as compared to the Second Basis of Comparison.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 5 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions Groundwater Use and Elevation*

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Increased use of groundwater and lower groundwater levels would result in a decreased potential for additional land subsidence would increase under Alternative 5 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 5 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

#### *7.4.3.7 Summary of Impact Analysis*

The results of the impact analysis of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 7.3 and 7.4.

1 **Table 7.3 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Region**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would decrease by approximately 8 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence. | None needed |
| Alternative 2 | No effects on groundwater resources or water supplies. | None needed |
| Alternative 3 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Region**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would decrease by approximately 6 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence. | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar.  July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; and up to 25 feet in the Westside subbasin.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Because the CVP and SWP water deliveries would be similar; groundwater pumping would be similar the potential for land subsidence would be similar. | None needed |

Note:
*Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

1 **Table 7.4 Comparison of No Action Alternative and Alternatives 1 through 5 to**
2 **Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to 200 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |
| Alternative 1 | No effects on groundwater resources or water supplies. | None needed. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the areas of the western and southern San Joaquin Valley; up to 25 feet in the Delta-Mendota, Tulare Lake, Kern County and in Westside subbasins.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 4 | No effects on groundwater resources or water supplies. | None needed |
| Alternative 5 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake and Kern County subbasins; and up to 200 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |

Note:
*Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

#### *7.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

As described above and summarized in Table 7.3, implementation of Alternatives 1 through 5 as compared to the No Action Alternative would result in either similar or less groundwater pumping and potential for land subsidence; and similar groundwater quality conditions. Therefore, there would be no adverse impacts to groundwater; and no mitigation measures are needed.

#### *7.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Groundwater Resources are summarized in Table 7.5.

**Table 7.5 Summary of Cumulative Effects on Groundwater Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g.,Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Nimbus Fish Hatchery Fish Passage Project<br>- Folsom Dam Water Control Manual Update | These effects would be the same in all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies; and therefore, increase groundwater use, reduce groundwater elevations, and increase potential subsidence.<br>Future water supply projects are anticipated to both increase surface water supply reliability due to increased surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability.<br>Developments under the general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect future groundwater resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration | However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to groundwater resources. |
| | - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to groundwater quality. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project | These effects would be the same in all alternatives.<br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the future reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries. |
| | - Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- Westlands Water District v. United States Settlement<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | Developments under the future projects are anticipated to potentially affect groundwater resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to groundwater resources.<br>Some of the future reasonably foreseeable actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to groundwater quality. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS | Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies, and increase groundwater use as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to increased surface water supplies and to accommodate planned growth in the general plans.<br>Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta, and improve groundwater quality. |
| | | Groundwater substitution water transfers could result in reduced groundwater levels and potential subsidence in areas that sell water using groundwater substitution practices.  Because all water transfers would be required to avoid adverse impacts to other water users and biological resources, including impacts to other groundwater users, it is anticipated that water transfers would not result in substantial changes in groundwater conditions |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 2 with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with future reasonably foreseeable would result in similar surface water availability and similar groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with future reasonably foreseeable would result in similar surface water availability and similar groundwater use as compared to the No Action Alternative with the added actions. |

There would be no adverse impacts associated with implementation of the alternatives as compared to the No Action Alternative. Therefore, Alternatives 1 through 5 would not contribute cumulative impacts to groundwater as compared to the No Action Alternative. However, implementation of No Action Alternative and Alternative 5 (in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions) and Alternative 3 (in the San Francisco Bay Area, Central Coast, and Southern California regions) as compared to the Second Basis of Comparison would result in increased groundwater pumping and associated potential for land subsidence and poorer groundwater quality; and could contribute to cumulative impacts related to groundwater conditions as compared to the Second Basis of Comparison conditions.

## 7.5 References

ACWD (Alameda County Water District). 2011. *Urban Water Management Plan 2010-2015*. July.

ACWD (Alameda County Water District). 2012. *Survey Report on Groundwater Conditions*. February.

Alameda County. 2014. *County Codes Title 6: Health and Safety Chapter 6.88: Water Wells.* Site accessed April 24, 2014. https://www.municode.com/library/ca/alameda_county/codes/code_of_ordinances?nodeId=TIT6HESA_CH6.88WAWE.

ALW (Azusa Light and Power). 2011. *2010 Urban Water Management Plan*. July.

Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan, Final, 2013 Update*.

Arroyo Grande (City of Arroyo Grande). 2012. *Urban Water Management Plan, 2010 Update, Final*. January 17.

AVEK (Antelope Valley-East Kern Water Agency). 2011a. *2010 Urban Water Management Plan*. June 20.

AVEK (Antelope Valley-East Kern Water Agency). 2011b. *Water Supply Stabilization Project No. 2 Implementation Grant Proposal*.

AVRWC (Apple Valley Ranchos Water Company). 2011. *2010 Urban Water Management Plan*. June 23.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html.

BCVWD (Beaumont-Cherry Valley Water District). 2013. *2013 Urban Water Management Plan Update*. July.

Beaumont Basin Watermaster. 2013. *Annual Report for Calendar Year 2012*. December.

BSMWC (Bellflower-Somerset Mutual Water Company). 2011. *Urban Water Management Plan*. June 30.

Butte County. 2004. *Butte County Groundwater Management Plan*. September.

Butte County. 2010. *General Plan Draft Environmental Impact Report*. April 8.

Butte County. 2014a. *County Code: Chapter 33A: Basin Management*. Site accessed April 22, 2014. https://www.municode.com/library/ca/butte_county/codes/code_of_ordinances.

Butte County. 2014b. *County Code: Chapter 23B: Water Wells.* Site accessed April 22, 2014.

https://www.municode.com/library/ca/butte_county/codes/code_of_ordinances?nodeId=CH23BWAWE.

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://www.bvh2o.com/James.html

California American Water Company. 2011. *Sacramento District 2010 Urban Water Management Plan*. October 17.

California American Water Company. 2012. *2010 Urban Water Management Plan for the Southern Division – San Diego County District*. February.

California Water Service Company. 2011a. *2010 Urban Water Management Plan, Bakersfield District, Adopted*. June.

California Water Service Company. 2011b. *2010 Urban Water Management Plan, City of Hawthorne, Adopted*. June.

California Water Service Company. 2011c. *2010 Urban Water Management Plan, Hermosa-Redondo District, Adopted*. June.

California Water Service Company. 2011d. *2010 Urban Water Management Plan, Dominguez District, Adopted*. June.

California Water Service Company. 2011e. *2010 Urban Water Management Plan, Palos Verdes District, Adopted*. June.

California Water Service Company. 2011f. *2010 Urban Water Management Plan, Antelope Valley District, Adopted*. June.

California Water Service Company. 2011g. *2010 Urban Water Management Plan, Chico-Hamilton City District, Adopted*. June.

California Water Service Company. 2011h. *2010 Urban Water Management Plan, Livermore District, Adopted*. June.

Calleguas MWD (Calleguas Municipal Water District). 2011. *2010 Urban Water Management Plan, Final*. May.

Camarosa Water District. 2013. *Santa Rosa Basin Groundwater Management Plan*. August.

Carpinteria Valley WD (Carpinteria Valley Water District). 2011. *Final 2010 Urban Water Management Plan Update*. June.

Castro Valley (City of Castro Valley). 2012. *Castro Valley General Plan*. March.

CBMWD (Central Basin Municipal Water District). 2011. *Draft, 2010 Urban Water Management Plan*. March.

CCWA (Central Coastal Water Authority). 2013a. *Central Coast Water Authority fiscal year 2013/14 Budget*. April 25.

_____. 2013b. *Central Coast Water Authority, A California Joint Powers Authority, Comprehensive Annual Financial Report, year ended June 30, 2013*. October 24.

CCWD (Contra Costa Water District). 2011. *Urban Water Management Plan*. June.

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

CGRA (California Groundwater Resource Association). 2012. *Surface Recharge Webinar*. November.

CIC (Covina Irrigating Company). *2010 Urban Water Management Plan*. June.

City of Adelanto. 2011. *2010 Urban Water Management Plan*. June.

City of Alhambra. 2011. *2010 Urban Water Management Plan Update, Final Draft*. June.

City of Anaheim. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Arcadia. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Banning. 2011. *2010 Urban Water Management Plan*. July 22.

City of Beverly Hills. 2011. *2010 Urban Water Management Plan*. August.

City of Brea. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Buena Park. 2011. *2010 Urban Water Management Plan*. June.

City of California City. 2013. *Urban Water Management Plan 2010 Update*. March.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Cerritos. 2011. *2010 Urban Water Management Plan*. June.

City of Chino. 2011. *Urban Water Management Plan*. June 21.

City of Coachella. 2011. *2010 Urban Water Management Plan*. July 13.

City of Compton. 2011. *2010 Urban Water Management Plan*. June 28.

City of Corona. 2011. *2010 Urban Water Management Plan*. June.

City of Downey. 2012. *2010 Urban Water Management Plan*. January.

City of Escondido. 2011. *2010 Urban Water Management Plan*. July.

City of Fountain Valley. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Fresno. 2015. *Groundwater Recharge*. Site accessed April 25, 2015. http://www.fresno.gov/Government/DepartmentDirectory/PublicUtilities/Watermanagement/watersource/groundwaterrecharge.htm.

City of Fullerton. 2011. *2010 Urban Water Management Plan*. July.

City of Garden Grove. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Grover Beach. 2011. *2010 Urban Water Management Plan*. June.

City of Hemet. 2011. *2010 2010 Urban Water Management Plan*. September 13.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Huntington Beach. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Huntington Park. 2011. *2010 Urban Water Management Plan*. July 5.

City of Inglewood. 2011. *2010 Urban Water Management Plan*. June.

City of La Habra. 2011. *2010 Urban Water Management Plan*. May.

City of La Palma. 2011. *Urban Water Management Plan, 2010 Update*. May.

City of Lakewood. 2011. *Urban Water Management Plan Update, 2010*. May 24.

City of La Verne. 2011. *Urban Water Management Plan, 2010*. June.

City of Livermore. 2011. *2010 Urban Water Management Plan*. June.

City of Lomita. 2011. *2010 Urban Water Management Plan*. May.

City of Long Beach. 2011. *2010 Urban Water Management Plan*. September 15.

City of Long Beach. 2012. *Long Beach 90H20*. January.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://lbwater.org/overview-long-beach-seawater-desalination-project.

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

City of Los Angeles (Los Angeles Department of Water and Power). 2010. *Water System Ten-Year Capital Improvement Program for the Fiscal Years 2010-2019*.

City of Los Angeles (Los Angeles Department of Water and Power). 2011. *Urban Water Management Plan, 2010*. May 3.

City of Los Angeles (Los Angeles Department of Water and Power). 2013. *Initial Study, Los Angeles Groundwater Replenishment Project*. September.

City of Lynwood. 2011. *2010 Urban Water Management Plan*. July.

City of Manhattan Beach. 2011. *2010 Urban Water Management Plan*. December.

City of Monterey Park. 2012. *Water System Financial Evaluations and Water Rate Recommendations*. September 17.

City of Newport Beach. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Norco. 2014. *Welcome to the Public Works Department, Water Maintenance Division*. Site accessed July 17, 2014. http://www.ci.norco.ca.us/depts/pw/default.asp

City of Norwalk. 2011. *2010 Urban Water Management Plan*. June.

City of Oceanside. 2011. *2010 Urban Water Management Plan*. July.

City of Oceanside. 2012. *Oceanside Harbor Desalination Testing Project*.

City of Ontario. 2011. *2010 Urban Water Management Plan*. June.

City of Orange. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Oxnard. 2013. *GREAT Program Update, City Council Report, December 10, 2013*. November 22.

City of Paramount. 2011. *2010 Urban Water Management Plan*. July 5.

City of Pico Rivera. 2011. *2010 Urban Water Management Plan*. July 26.

City of Pleasanton. 2011. *2010 Urban Water Management Plan*. June 21.

City of Pomona. 2011. *Final 2010 Urban Water Management Plan*. July.

City of Poway. 2011. *2010 Urban Water Management Plan*. June 7.

City of Rialto. 2011. *Urban Water Management Plan*. August.

City of Riverside. 2011. *Final 2010 Urban Water Management Plan*. July.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2009a. *Mission Valley Basin*. September 11.

City of San Diego. 2009a. *San Pasqual Basin*. September 11.

City of San Diego. 2011. *2010 Urban Water Management Plan*. June 28.

City of San Jacinto. 2011. *2010 Urban Water Management Plan*. December 6.

City of San Juan Capistrano. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Santa Ana. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp

City of Santa Fe Springs. 2011. *Urban Water Management Plan (2010 – 2014)*. June.

City of Seal Beach. 2011. *Urban Water Management Plan, 2010 Update*. July.

City of South Gate. 2011. *2010 Urban Water Management Plan*. June.

City of Torrance. 2011. *2010 Urban Water Management Plan*. July.

City of Tustin. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Upland. 2011. *2010 Urban Water Management Plan*. June.

City of Vernon. 2011. *Final 2010 Urban Water Management Plan*. June.

City of Westminster. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Whittier. 2011. *2010 Urban Water Management Plan*. May.

City of Norwalk. 2011. *2010 Urban Water Management Plan*. June.

City of Santa Barbara. 2011. *Urban Water Management Plan. 2010 Update*. June.

City of Santa Monica. 2011. *2010 Urban Water Management Plan, Draft Copy*. May.

CLWA et al. (Castaic Lake Water Agency, CLWA Santa Clarita Water Division; Los Angeles County Waterworks District 36; Newhall County Water District; and Valencia Water Company). 2012. *14th Annual Santa Clarita Valley Water Report 2011*. June.

CMWD (Carlsbad Municipal Water District). 2011. *2010 Urban Water Management Plan*. June.

Colusa County. 2014a. *County Code: Chapter 43: Groundwater Management.* Site accessed April 22, 2014. http://www.codepublishing.com/ca/colusacounty/.

Colusa County. 2014b. *County Code: Chapter 35: Well Standards.* Site accessed April 22, 2014. http://www.codepublishing.com/ca/colusacounty/.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020*. January.

Contra Costa County. 2014. *County Code Title 4: Health and Safety, Chapter 414: Waterways and Water Supply, Chapter 414-4: Water supply.* Site accessed April 24, 2014. http://library.municode.com/print.aspx?h=&clientID=16286&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f16286%2flevel3

%2fTIT4HESA_DIV414WAWASU_CH414-4WASU.html&HTMTitle=Chapter+414-4+WATER+SUPPLY.

Cucamonga Valley WD (Cucamonga Valley Water District). *2010 Urban Water Management Plan, Final*. June 28.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2011. *Irrigated Lands Regulatory Program, Program Environmental Impact Report*. March.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2014b. *Order R5-2014-0029, Waste Discharge Requirements General Order for Growers within the San Joaquin County and Delta Area That are Members of a Third-Party Group.* March.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2015. *Status of the Central Valley Salt & Nitrate Management Plan, Central Valley Water Board Meeting, Agenda Item #14*. April 16.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2015. *CV-SALTS, Central Valley Salinity Alternatives for Long-Term Sustainability*. Site accessed April 29, 2015. http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/.

CVWD (Coachella Valley Water District). 2011. *2010 Urban Water Management Plan, Final Report*. July.

CVWD (Coachella Valley Water District). 2012. *Coachella Valley Water Management Plan Update, Final Report*. January.

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html.

Del Norte County. 2014. *County Code: Title 7: Health and Welfare, Chapter 32: Regulations of Wells and Preservation of Groundwater.* Site accessed April 21, 2014. http://www.co.del-norte.ca.us/county-code.

DCTRA (Deer Creek & Tule River Authority). 2012. *Groundwater Management Plan Update*. May.

DSRSD (Dublin San Ramon Services District). 2011. *2010 Urban Water Management Plan*. June.

DWA (Desert Water Agency). 2011. *2010 Urban Water Management Plan*. March.

DWD (Diablo Water District). 2011. *Final 2010 Urban Water Management Plan*. June.

DWR (California Department of Water Resources). 1980. *Groundwater Basins in California: A Report to the Legislature in Response to Water Code Section 12924. Bulletin 118-80.*

DWR (California Department of Water Resources). 2003a. *California's Groundwater. Bulletin 118, Update 2003*.

DWR (California Department of Water Resources). 2003b. *Sacramento River Basinwide Water Management Plan. Groundwater Hydrology*. January.

DWR (California Department of Water Resources). 2003c. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, El Mirage Valley Groundwater Basin*. October 1.

DWR (California Department of Water Resources). 2003d. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Middle Mojave River Valley Groundwater Basin*. October 1.

DWR (California Department of Water Resources). 2003e. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Caves Canyon Valley Groundwater Basin*. October 1.

DWR (California Department of Water Resources). 2003f. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Morongo Valley Groundwater Basin*. October 1.

DWR (California Department of Water Resources). 2004a. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Anderson Subbasin*. February 27.

DWR (California Department of Water Resources). 2004b. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Bowman Subbasin*. February 27.

DWR (California Department of Water Resources). 2004c. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Rosewood Subbasin*. February 27.

DWR (California Department of Water Resources). 2004d. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Enterprise Subbasin*. February 27.

DWR (California Department of Water Resources). 2004e. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Millville Subbasin*. February 27.

DWR (California Department of Water Resources). 2004f. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, South Battle Creek Subbasin*. February 27.

DWR (California Department of Water Resources). 2004g. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Red Bluff Subbasin*. February 27.

DWR (California Department of Water Resources). 2004h. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Bend Subbasin*. February 27.

DWR (California Department of Water Resources). 2004i. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Antelope Subbasin*. February 27.

DWR (California Department of Water Resources). 2004j. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Dye Creek Subbasin*. February 27.

DWR (California Department of Water Resources). 2004k. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Los Molinos Subbasin*. February 27.

DWR (California Department of Water Resources). 2004l. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Vina Subbasin*. February 27.

DWR (California Department of Water Resources). 2004m. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Yolo Subbasin*. February 27.

DWR (California Department of Water Resources). 2004n *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Solano Subbasin*. February 27.

DWR (California Department of Water Resources). 2004o. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, West Butte Subbasin*. February 27.

DWR (California Department of Water Resources). 2004p. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, East Butte Subbasin*. February 27.

DWR (California Department of Water Resources). 2004q. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, South American Subbasin*. February 27.

DWR (California Department of Water Resources). 2004r. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Modesto Subbasin*. February 27.

DWR (California Department of Water Resources). 2004s. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Merced Subbasin*. February 27.

DWR (California Department of Water Resources). 2004t. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic*

*Region, San Joaquin Valley Groundwater Basin, Chowchilla Subbasin*. February 27.

DWR (California Department of Water Resources). 2004u. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Madera Subbasin*. February 27.

DWR (California Department of Water Resources). 2004v. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Kaweah Subbasin*. February 27.

DWR (California Department of Water Resources). 2004w. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Tule Subbasin*. February 27.

DWR (California Department of Water Resources). 2004x. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Pittsburg Plain Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004y. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Clayton Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004z. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Ygnacio Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004aa. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Arroyo del Hambre Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ab. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, San Ramon Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ac. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Castro Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ad. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin, East Bay Plain Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ae. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin, Santa Clara Subbasin*. February 27.

DWR (California Department of Water Resources). 2004af. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Gilroy-Hollister Groundwater Basin, Llagas Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ag. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Gilroy-Hollister Groundwater Basin, Bolsa Area Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ah. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Gilroy-Hollister Groundwater Basin, Hollister Area Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ai. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Gilroy-Hollister Groundwater Basin, San Juan Bautista Area Subbasin*. February 27.

DWR (California Department of Water Resources). 2004aj. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Morro Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ak. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Chorro Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004al. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Maria Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004am. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Ynez River Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004an. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Goleta Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ao. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Foothill Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ap. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Barbara Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004aq. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Montecito Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ar. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Carpinteria Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004as. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Acton Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004at. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Piru Subbasin*. February 27.

DWR (California Department of Water Resources). 2004au. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Santa Paula Subbasin*. February 27.

DWR (California Department of Water Resources). 2004av. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Simi Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004aw. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Tierra Rejada Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ax. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Conejo Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ay. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Thousand Oaks Area Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004az. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Russell Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ba. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Fernando Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bb. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Raymond Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bc. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Gabriel Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bd. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Hollywood Subbasin*. February 27.

DWR (California Department of Water Resources). 2004be. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Santa Monica Subbasin*. February 27.

DWR (California Department of Water Resources). 2004bf. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Central Subbasin*. February 27.

DWR (California Department of Water Resources). 2004bg. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, West Coast Subbasin*.

DWR (California Department of Water Resources). 2004bh. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Malibu Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bi. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Orange County Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bj. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Juan Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bk. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Mateo Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bl. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Onofre Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bm. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Margarita Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bn. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Luis Rey Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bo. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Marcos Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bp. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Escondido Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bq. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Pasqual Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004br. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Pamo Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bs. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Maria Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bt. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Poway Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bu *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Batiquitos Lagoon Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bv. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Elijo Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bw. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Dieguito Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bx. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Diego River Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004by. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, El Cajon Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004bz. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Mission Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ca. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Sweetwater Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cb. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Otay Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cc. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Tijuana Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cd. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Cucamonga Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ce. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Riverside-Arlington Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cf. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Cajon Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cg. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Rialto-Colton Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ch. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Bunker Hill Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ci. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Yucaipa Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cj. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, San Timoteo Subbasin*. February 27.

DWR (California Department of Water Resources). 2004ck. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Temecula Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cl. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Hemet Lake Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cm. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, Desert Hot Springs Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cn. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, Indio Subbasin*. February 27.

DWR (California Department of Water Resources). 2004co. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, Mission Creek Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cm. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, San Gorgonio Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cn. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Indian Wells Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004co. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Salt Wells Valley Groundwater Basin*. February 29.

DWR (California Department of Water Resources). 2004cp. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Searles Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cq. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Cuddeback Valley Groundwater Basin, Desert Hot Springs Subbasin*. February 27.

DWR (California Department of Water Resources). 2004cr. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Pilot Knob Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cs. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Grass Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004ct. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Superior Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cu. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Harper Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cv. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Fremont Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cw. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Antelope Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cx. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Upper Mojave River Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cy. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Lower Mojave Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004cz. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Langford Valley Groundwater Basin, Langford Well Lake Subbasin*. February 27.

DWR (California Department of Water Resources). 2004da. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Cronise Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004db. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Coyote Lake Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dc. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Kane Wash Area Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dd. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Iron Ridge Area Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004de. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Bessemer Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004df. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Lucerne Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dg. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Johnson Valley Groundwater Basin, Soggy Lake Subbasin*. February 27.

DWR (California Department of Water Resources). 2004dh. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Johnson Valley Groundwater Basin, Upper Johnson Valley Subbasin*. February 27.

DWR (California Department of Water Resources). 2004di. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Means Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dj. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Deadman Valley Groundwater Basin, Surprise Spring Subbasin*. February 27.

DWR (California Department of Water Resources). 2004dk. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Deadman Valley Groundwater Basin, Deadman Lake Subbasin*. February 27.

DWR (California Department of Water Resources). 2004di. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Twentynine Palms Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dj. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Joshua Tree Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dk. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Ames Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dl. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Copper Mountain Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dm. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Warren Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dn. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Lost Horse Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004do. *California's Groundwater, Bulletin 118 Update, North Coast Hydrologic Region, Hoopa Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dp. *California's Groundwater, Bulletin 118 Update, North Coast Hydrologic Region, Lower Klamath River Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2004dq. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, San Antonio Creek Valley Groundwater Basin*. February 27.

DWR (California Department of Water Resources). 2006a. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Corning Subbasin*. January 20.

DWR (California Department of Water Resources). 2006b. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Colusa Subbasin*. January 20.

DWR (California Department of Water Resources). 2006c. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, North Yuba Subbasin*. January 20.

DWR (California Department of Water Resources). 2006d. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, South Yuba Subbasin*. January 20.

DWR (California Department of Water Resources). 2006e. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Sutter Subbasin*. January 20.

DWR (California Department of Water Resources). 2006f. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, North American Subbasin*. January 20.

DWR (California Department of Water Resources). 2006g. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Tracy Subbasin*. January 20.

DWR (California Department of Water Resources). 2006h. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Delta-Mendota Subbasin*. January 20.

DWR (California Department of Water Resources). 2006i. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Cosumnes Subbasin*. February 3.

DWR (California Department of Water Resources). 2006j. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, East San Joaquin Subbasin*. January 20.

DWR (California Department of Water Resources). 2006k. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Turlock Subbasin*. January 20.

DWR (California Department of Water Resources). 2006l. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Westside Subbasin*. January 20.

DWR (California Department of Water Resources). 2006m. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Tulare Lake Subbasin*. January 20.

DWR (California Department of Water Resources). 2006n. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Kings Subbasin*. January 20.

DWR (California Department of Water Resources). 2006o. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Kern County Subbasin*. January 20.

DWR (California Department of Water Resources). 2006p. *California's Groundwater, Bulletin 118 Update, Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Pleasant Valley Subbasin*. January 20.

DWR (California Department of Water Resources). 2006q. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Livermore Valley Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2006r. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin*, *Niles Cone Subbasin.* January 20.

DWR (California Department of Water Resources). 2006s. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Santa Clara River Valley East Subbasin*. January 20.

DWR (California Department of Water Resources). 2006t. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Fillmore Subbasin*. January 20.

DWR (California Department of Water Resources). 2006u. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Mound Subbasin*. January 20.

DWR (California Department of Water Resources). 2006v. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Oxnard Subbasin*. January 20.

DWR (California Department of Water Resources). 2006w. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Las Posas Valley Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2006x. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Pleasant Valley Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2006y. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Arroyo Santa Rosa Valley Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2006z. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Chino Subbasin*. January 20.

DWR (California Department of Water Resources). 2006aa. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Temescal Subbasin*. January 20.

DWR (California Department of Water Resources). 2006ab. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Jacinto Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2006ac. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Elsinore Groundwater Basin*. January 20.

DWR (California Department of Water Resources). 2011. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

DWR (California Department of Water Resources). 2012. *Report to the Legislature, Senate Bill X7 6, (Chapter 1, Statutes of 2009) California Statewide Groundwater Elevation Monitoring (CASGEM) Status Report*. February 23.

DWR (California Department of Water Resources). 2013a. *Hydrologic Regions of California: Sacramento River–Basins and Subbasins of the Sacramento River Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/sacramento_river.cfm.

DWR (California Department of Water Resources). 2013b. *Hydrologic Regions of California: San Joaquin River–Basins and Subbasins of the San Joaquin River Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/san_joaquin_river.cfm.

DWR (California Department of Water Resources). 2013c. *Hydrologic Regions of California: Tulare Lake–Basins and Subbasins of the Tulare Lake Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/tulare_lake.cfm.

DWR (California Department of Water Resources). 2013d. *Hydrologic Regions of California: San Francisco Bay–Basins and Subbasins of the San Francisco Bay Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/san_francisco_bay.cfm.

DWR (California Department of Water Resources). 2013e. *Hydrologic Regions of California: Central Coast–Basins and Subbasins of the Central Coast Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/central_coast.cfm.

DWR (California Department of Water Resources). 2013f. *Hydrologic Regions of California: South Coast–Basins and Subbasins of the South Coast Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed March 11, 2013. http://www.water.ca.gov/groundwater/bulletin118/south_coast.cfm.

DWR (California Department of Water Resources). 2013i. *California Water Plan Update 2013*.

DWR (California Department of Water Resources). 2013j. *San Joaquin Valley Drainage Monitoring Program 2006- 2010. Region Report*. September.

DWR (California Department of Water Resources). 2013k. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR (California Department of Water Resources). 2014a. *Groundwater Management: Court Adjudications*. Site accessed April 22, 2014. http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm.

DWR (California Department of Water Resources). 2014b. *Hydrologic Regions of California: North Coast–Basins and Subbasins of the North Coast Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Site accessed April 22, 2014. http://www.water.ca.gov/groundwater/bulletin118/north_coast.cfm.

DWR (California Department of Water Resources). 2014c. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring*. April 30.

DWR (California Department of Water Resources). 2014d. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages, Gaps in Groundwater Monitoring, Monitoring of Land Subsidence, and Agricultural Land Fallowing*. November.

DWR (California Department of Water Resources). 2014e. *CASGEM Groundwater Basin Prioritization Results – Abridged Sorted by Overall Basin Score; Run Version 05262014C.* May 26.

DWR (California Department of Water Resources). 2015. *Draft List of Critically Overdrafted Basins.* August 6, 2015. Site accessed October 26, 2015. http://www.water.ca.gov/groundwater/sgm/cod.cfm

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper) Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact*

*Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

EBMUD (East Bay Municipal Utility District). 2013. *South East Bay Plain Basin Groundwater Management Plan*. March.

EBMUD (East Bay Municipal Utility District). 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

EGWD (Elk Grove Water District). 2011. *2010 Urban Water Management Plan*. June 22.

El Dorado County. 2014. *County Code: Title 8: Health and Safety, Chapter 8.39: Well Standards.* Site accessed April 21, 2014. http://library.municode.com/index.aspx?clientID=15095&stateID=5&statename=California.

EMWD (Eastern Municipal Water District). 2009. *Executive Summary Substitute Environmental Document Basin Plan Amendment San Jacinto–Upper Pressure Groundwater Management Zone Total Dissolved Solids and Total Inorganic Nitrogen Objectives*. November.

EMWD (Eastern Municipal Water District). 2011. *2010 Urban Water Management Plan*. June.

EMWD (Eastern Municipal Water District). 2014a. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

EMWD (Eastern Municipal Water District). 2014b. *Indirect Potable Reuse Program*. January 8.

ENCSD (East Niles Community Services District). 2011. *East Niles Community Services District 2010 Urban Water Management Plan*. June.

EVMWD (Elsinore Valley Municipal Water District). 2011. *Urban Water Management Plan, Final*. July.

Farmington Program. 2012. *Overview*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/about.html.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp.

FID (Fresno Irrigation District). 2010. *Fresno Irrigation District Waterways*. September.

FID (Fresno Irrigation District). 2015. *Boswell Banking Facility*. Site accessed February 13, 2015. http://www.fresnoirrigation.com/index.php?c=36.

Firebaugh (City of Firebaugh). 2015. *2030 Firebaugh General Plan*. Site accessed April 25, 2015. http://www.ci.firebaugh.ca.us/general-plan.shtml.

Fox Canyon GMA (Fox Canyon Groundwater Management Agency). 2013. *Annual Report for Calendar Year 2012*.

FPUD (Fallbrook Public Utility District). 2011. *Draft 2010 Urban Water Management Plan*. June.

Frame Surveying and Mapping. 2006. *The Yolo County GPS Subsidence Network Recommendations and Continued Monitoring*. March.

Fresno County. 2000. *Fresno County General Plan Background Report*. October.

Fresno County. 2014. *County Code: Title 14: Waters and Sewers, Chapter 14.03 Groundwater Management; Chapter 14.04: Well Regulations – General Provisions; and Chapter 14.08: Well Construction, Pump Installation and Well, Destruction Standards.* Site accessed April 24, 2014. http://library.municode.com/print.aspx?h=&clientID=14972&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f14972%2flevel1%2fTIT14WASE.html&HTMTitle=Title+14+WATER+AND+SEWAGE.

FWC (Fontana Water Company). 2011. *2010 Urban Water Management Plan*. July.

GLCIRWMR (Greater Los Angeles County Integrated Regional Water Management Region). 2014. *The Greater Los Angeles County Integrated Regional Water Management Plan*. February

Glenn County. 2014. *County Code: Title 20: Water.* Site accessed April 22, 2014. http://www.countyofglenn.net/govt/county_code/?cc_t_id=22&cc_c_id=184&division_id=0&part_id=0.

Golden State Water Company. 2011a. *Final Report, 2010 Urban Water Management Plan, Orcutt*. August.

Golden State Water Company. 2011b. *Final Report, 2010 Urban Water Management Plan, Simi Valley*. August.

Golden State Water Company. 2011c. *Final Report, 2010 Urban Water Management Plan, South San Gabriel*. August.

Golden State Water Company. 2011d. *Final Report, 2010 Urban Water Management Plan, Artesia*. September.

Golden State Water Company. 2011e. *Final Report, 2010 Urban Water Management Plan, Bell/Bell Gardens*. September.

Golden State Water Company. 2011f. *Final Report, 2010 Urban Water Management Plan, Florence-Graham*. September.

Golden State Water Company. 2011g. *Final Report, 2010 Urban Water Management Plan, Norwalk*. September.

Golden State Water Company. 2011h. *Final Report, 2010 Urban Water Management Plan, Southwest*. July.

Golden State Water Company. 2011i. *Final Report, 2010 Urban Water Management Plan, Placentia*. August.

Golden State Water Company. 2011j. *Final Report, 2010 Urban Water Management Plan, West Orange*. August.

Golden State Water Company. 2011k. *Final Report, 2010 Urban Water Management Plan, Barstow*. July.

Golden State Water Company. 2011l. *Final Report, 2010 Urban Water Management Plan, Cordova*. July.

GWD (Goleta Water District). 2011. *Final 2010 Urban Water Management Plan Update*. November.

GWD and LCMWC (Goleta Water District and La Cumbre Mutual Water Company). 2010. *Groundwater Management Plan–Goleta Groundwater Basin – Final*. May.

GWRS (Groundwater Recharge System). 2011. The Process. Site accessed March 24, 2011. http://www.gwrsystem.com/the-process.html.

HDWD (Hi-Desert Water District). 2011. *2010 Urban Water Management Plan*. June 27.

Hesperia Water District. 2011. *2010 Urban Water Management Plan*. August 16.

Hoopa Valley Tribe. 2008. *Water Quality Control Plan, Hoopa Valley Indian Reservation*. February.

Humboldt County. 2012. *Humboldt 21st Century General Plan Update, Draft Environmental Impact Report*. April 2.

Humboldt County. 2014. *County Code: Title VI – Water and Sewage, Division 3: Wells*. Site accessed April 22, 2014.

HWD (Helix Water District). 2011. *2010 Urban Water Management Plan*. July.

IEUA (Inland Empire Utilities Agency). 2011. *2010 Regional Urban Water Management Plan*. June.

IEUA (Inland Empire Utilities Agency). 2014. *Inland Empire Utilities Agency, 2013/14 Recycled Water Annual Report*.

Ikehara, M. E. 1994. *Global Positioning System Surveying to Monitor Land Subsidence in Sacramento Valley, California, USA*. Hydrological Sciences Journal. Volume 29 (5)

IRWD (Irvine Ranch Water District). 2011. *2010 Urban Water Management Plan*. June.

IWA (Indio Water Authority). 2010. *2010 Urban Water Management Plan*. May.

IWVWD (Indian Wells Valley Water District). 2011. *2010 Urban Water Management Plan*. June.

JBWD (Joshua Basin Water District). 2011. *2010 Urban Water Management Plan*. June.

JCSD (Jurupa Community Services District). 2011. *2010 Urban Water Management Plan*. May.

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

KBWA (Kings Basin Water Authority). 2014. *Kings Basin IRWMP Project List*. May 30.

KCWA (Kern County Water Agency). 2011. *Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan Final Update*. November.

KCWA (Kern County Water Agency). No Date (n.d.). *Kern County Groundwater Banking Projects*.

KCWA and NORMWD (Kern County Water Agency Improvement District No. 4 and North of the River Municipal Water District). 2011. *2010 Urban Water Management Plan*. June.

KDWCD (Kaweah Delta Water Conservation District). 2006. *Groundwater Management Plan*. November 7.

Kern County. 2014. *County Code Title 14: Utilities, Chapter 14.08: Water Supply Systems, Article III: Well Standards.* Site accessed April 24, 2014. http://library.municode.com/print.aspx?h=&clientID=16251&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f16251%2flevel3%2fTIT14UT_CH14.08WASUSY_ARTIIIWEST.html&HTMTitle=Article+III.+Well+Standards.

Kings County. 2014. *County Code Chapter 14A: Water Wells*. http://library.municode.com/print.aspx?h=&clientID=12257&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f12257%2flevel2%2fCOOR_CH14AWAWE.html&HTMTitle=Chapter+14A+WATER+WELLS.

KRCD (Kings River Conservation District). 2012a. *Kings River Service Area Annual Groundwater Report for the Period covering 2009-2011*.

KRCD (Kings River Conservation District). 2012b. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP)*.

KRCD (Kings River Conservation District). 2013. *Recharge Groups*. Site accessed March 20, 2013. http://www.krcd.org/water/groundwater_management/recharge_groups.html.

KWBA (Kern Water Bank Authority). 2011. *Infrastructure*. Site accessed February 14, 2011. http://www.kwb.org/index.cfm/fuseaction/Pages.Page/id/369.

LACSD (Lake Arrowhead Community Services District). 2011 *Final 2010 Urban Water Management Plan*. June 7.

LHHCWD (La Habra Heights County Water District). 2012. *2011 Water Master Plan Update*. March.

LHMWD (Lake Hemet Municipal Water District). 2011. *Urban Water Management Plan, 2010*. June.

*Lockheed Martin Corporation v. United States, Civil Action No. 2008-1160*. 2014. District Court, District of Columbia. April 24.

Los Angeles County (County of Los Angeles Department of Public Works). 2011. *Waterworks District No. 29, Malibu and the Marina del Rey Water System, 2010 Urban Water Management Plan*. July.

Los Angeles County (County of Los Angeles). 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

Los Angeles County (County of Los Angeles). 2014a. *County Code Title 11: Health and Safety, Chapter: 11.38 Water and Sewers, Part 2: Water and Water Wells*. Site accessed April 24, 2014. https://library.municode.com/print.aspx?h=&clientID=16274&HTMRequest=https%3a%2f%2flibrary.municode.com%2fHTML%2f16274%2flevel4%2fTIT11HESA_DIV1HECO_CH11.38WASE_PT2WAWAWE.html&HTMTitle=Part+2+WATER+AND+WATER+WELLS.

Los Angeles County (County of Los Angeles). 2014b. *Los Angeles County Waterworks Districts*. Site accessed May 23, 2014. http://dpw.lacounty.gov/wwd/web/About/Overview.aspx.

Los Angeles County (Los Angeles County Department of Public Works). 2015. *San Gabriel River and Montebello Forebay Water Conservation System*. Site accessed April 25, 2015. http://ladpw.org/wrd/publication/system/downstream.cfm.

Los Angeles County et al. (Los Angeles County, Department of Public Works, Waterworks District No. 40 and Quartz Hill Water District). *2010 Integrated Regional Urban Water Management Plan for the Antelope Valley*. June.

LOCSD et al. (Los Osos Community Services District, Golden State Water Company, S&T Mutual Water Company, and County of San Luis Obispo). 2013a. *Public Review Draft Basin Plan for the Los Osos Groundwater Basin*. August 1.

Madera County. 2002. *AB3030 Groundwater Management Plan, Madera County, Final Draft*. January.

Madera County. 2008. *Integrated Regional Water Management Plan*. April.

Madera County. 2014a. *County Code Title 13: Waters and Sewers, I: Water, Chapter 13.52: Well Standards*

Madera County. 2014b. *County Code Title 13: Waters and Sewers, V Groundwater Exportation, Groundwater Banking, and Importation of Foreign Water, for Purposes of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands Within their Boundaries; Chapter 13.1: Rules and Regulations Pertaining to Groundwater Banking—Importation of Foreign Water, for the Purpose of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands within their Boundaries—Exportation of Groundwater Outside the County*.

Martinez (City of Martinez). 2011. *Urban Water Management Plan 2010 Update*. June.

MCWD (Mesa Consolidated Water District). 2011. *2010 Urban Water Management Plan*. June.

Mendota (City of Mendota). 2009. *City of Mendota General Plan Update 2005-2025*. August 11.

Merced County. 2012. *Merced County General Plan Revised Background Report*. November.

Merced County. 2014. County Code Title 9: General Health and Safety, Chapter 9.28: Wells. Site Accessed April 21, 2014. http://www.qcode.us/codes/mercedcounty.

MNWD (Moulton Niguel Water District). 2011. *2010 Urban Water Management District*. June.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html.

Morro Bay (City of Morro Bay). 2011. *Final Report, 2010 Urban Water Management Plan*. June.

MSWD (Mission Springs Water District). 2011. *2010 Urban Water Management Plan*. June 28.

MVWD (Monte Vista Water District). 2011. *2010 Urban Water Management Plan*. April.

MWA (Mojave Water Agency). 2011. *Final 2010 Urban Water Management Plan*. June 9.

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome.

MWDSC (Metropolitan Water District of Southern California). 2005. *The Regional Urban Water Management Plan*. November.

MWDSC (Metropolitan Water District of Southern California). 2007. *Groundwater Assessment Study*. September.

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

Napa County. 2014. *County Codes: Chapter 13.12: Wells and Chapter 13.15: Groundwater Conservation*. Site accessed April 23, 2014. http://library.municode.com/index.aspx?clientId=16513&stateId=5&stateName=California.

NCRWQCB (North Coast Regional Water Quality Control Board). 2005. *Integrated Plan for Implementation of the Watershed Management Initiative–Watershed Planning Chapter*. February.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NCSD (Nipomo Community Services District). 2011. *2010 Urban Water Management Plan*. June 29.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2004. *Eastern San Joaquin Groundwater Basin Groundwater Management Plan*. September.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2009. *Eastern San Joaquin Basin Integrated Conjunctive Use Draft Program Programmatic Environmental Impact Report*. September.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2011. *Eastern San Joaquin Basin Integrated Conjunctive Use Program Programmatic Environmental Impact Report*. February.

OCWD (Orange County Water District). 2011. *Groundwater Recharge Operations*. Site accessed July 10, 2014. http://www.ocwd.com/Groundwater-Recharge/ca-34.aspx.

OCWD (Orange County Water District). n.d. (No Date). *Groundwater Replenishment System*.

OMWD (Olivenhain Municipal Water District). 2011. *2010 Urban Water Management Plan*. June 22.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

Orange County. 2014. *County Code Title 4: Health and Sanitation and Animal Regulations, Division 5: Water Conservation, Article 2 Construction and Abandonment of Water Wells*. Site accessed April 24, 2014. https://www.municode.com/library/ca/orange_county/codes/code_of_ordinances?nodeId=TIT4HESAANRE_DIV5WACO_ART2COABWAWE.

Orange County. 2009. *Nitrogen and Selenium Management Program. Conceptual Model for Selenium–Newport Bay Watershed*. May.

OWD (Otay Water District). 2011. 2010 Urban Water Management Plan. June 1.

Pacific Institute. 2011. *The Human Costs of Nitrate-contaminated Drinking Water in the San Joaquin Valley*. March.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

PWD (Palmdale Water District). 2011. *2010 Urban Water Management Plan*. June.

Patterson (City of Patterson). 2014. *The City of Patterson, Water Operations, 2012 Annual CCR Report*. Site accessed May 6, 2014.

PDMWD (Padre Dam Municipal Water District). 2011. *2010 Urban Water Management Plan*. June 28.

Pittsburg (City of Pittsburg). 2011. *City of Pittsburg 2010 Urban Water Management Plan*. August.

Pismo Beach (City of Pismo Beach). 2011. *2010 Urban Water Management Plan*. September.

Placer County. 2014. *County Code: Chapter 13: Public Services, Article 13.08: Water Wells*. Site accessed April 21, 2014. http://qcode.us/codes/placercounty/view.php?topic=13-13_08&showAll=1&frames=on.

Plumas County. 2014. *County Code Title 6: Sanitation and Health, Chapter 8: Water Wells*. Site accessed April 21, 2014. http://library.municode.com/index.aspx?clientId=13824.

PPHCSD (Phelan Piñon Hills Community Services District). 2011. *2010 Urban Water Management Plan*. June.

Ramona MWD (Ramona Municipal Water District). *2010 Urban Water Management Plan*. December.

RBMB (Raymond Basin Management Board). 2014. *About Us*. Site accessed June 30, 2014. http://raymondbasin.org/?page_id=25.

RCSD (Rubidoux Community Services District). 2011. *2010 Urban Water Management Plan*. November.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

RCWD (Rancho California Water District). 2012. *Agricultural Water Management Plan*. December 13.

RCWD et al. (Rancho California Water District, Riverside County Flood Control and Water Conservation District, County of Riverside, Stakeholder Advisory Committee). 2014. *Upper Santa Margarita Watershed, Integrated Regional Water Management Plan Update, Final*. April.

RDDMWD (Rincon del Diablo Municipal Water District). 2011. *2010 Urban Water Management Plan*. June 14.

Reclamation (Bureau of Reclamation). 2006. *San Luis Drainage Feature Re-evaluation. Final Environmental Impact Statement*. May.

Reclamation (Bureau of Reclamation). 2009. *Record of Decision, Grassland Bypass Project, 2010-2019*. December.

Reclamation (Bureau of Reclamation). 2010a. *Resighini Rancheria Water Resources Development Project, Environmental Assessment*. July.

Reclamation (Bureau of Reclamation). 2010b. *Draft Environmental Assessment Antelope Valley Water Bank Initial Recharge and Recovery Facilities Improvement Project*. January.

Reclamation (Bureau of Reclamation). 2011a. *Finding of No Significant Impact, Fresno Irrigation District Oleander Basin Banking Project*. February 28.

Reclamation (Bureau of Reclamation). 2011b. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

Reclamation (Bureau of Reclamation). 2012a. *Draft Finding of No Significant Impact, Central Valley Project Interim Renewal Contracts for the Cities of Avenal, Coalinga, Huron and the California Department of Fish and Game 2013-2015*. October.

Reclamation (Bureau of Reclamation). 2012b. *Record of Decision San Joaquin River Restoration Program*. September 28.

Reclamation (Bureau of Reclamation). 2013a. *Exchange Agreements and/or Warren Act Contracts for Conveyance of Groundwater in the Delta Mendota Canal – Contract Years 2013 through 2023 (March 1, 2013 – February 29, 2024). Final EA 12 – 061*. January.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2013c. *Shasta Lake Water Resources Investigation, California, Draft Environmental Impact Report*. June.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation (Bureau of Reclamation). 2014e. *Santa Clara Valley Water District California Aqueduct Reverse Flow Project*. October.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2011. *San Joaquin River Restoration Program, Draft Program Environmental Impact Statement/ Environmental Impact Report*. April.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, Bureau of Land Management, Trinity County Planning Department). 2006a. *Indian Creek Rehabilitation Site: Trinity River Mile 93.7 to 96.5, Environmental Assessment/Draft Environmental Impact Report*. July.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

Riverside County. 2014. *County Code Title 13: Public Services, Chapter 13.20: Water Wells.* Site accessed April 24, 2014. http://library.municode.com/print.aspx?h=&clientID=16320&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f16320%2flevel2%2fTIT13PUSE_CH13.20WAWE.html&HTMTitle=Chapter+13.20+WATER+WELLS.

RMWD (Rainbow Municipal Water District). 2011. *2010 Urban Water Management Plan*. June 28.

Rosamond CSD (Rosamond Community Service District). 2011. *Urban Water Management Plan 2010*. June.

Roseville et al. (City of Roseville, Placer County Water Agency, City of Lincoln, California American Water Company). 2007. *Western Placer County Groundwater Management Plan*. November.

RWA (Regional Water Authority). 2013. *American River Basin Integrated Regional Water Management Plan 2013 Update.*

RWD (Rowland Water District). 2011. *2010 Urban Water Management Plan*. July.

Sacramento County. 2010. *Final Environmental Impact Report, Sacramento County General Plan Update*. April.

Sacramento County. 2014. *County Code: Title 6: Health and Sanitation, Chapter 6.28: Wells and Pumps.* Site accessed April 23, 2014. http://qcode.us/codes/sacramentocounty/view.php?topic=6-6_28&showAll=1&frames=on.

Sacramento County Water Agency. 2011. *2010 Zone 41 Urban Water Management Plan*. July.

San Benito County Water District. 2012. *Draft Technical Memorandum 1, Hydrogeologic Conceptual Model for Northern San Benito County Salt and Nutrient Management Plan*. July.

San Benito County (County of San Benito). 2014. *County Codes Title 15: Public Works, Chapter 15.05: Water, Article I: Groundwater Aquifer Protections and Article III: Well Standards.*

San Bernardino County (County of San Bernardino, Special Districts County Service Area 64). 2012. *Urban Water Management Plan–2010*. July.

San Bernardino County (County of San Bernardino). 2014. *County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 3: Water Wells and Article 5: Desert Groundwater Management.* Site accessed April 24, 2014. http://www.amlegal.com/nxt/gateway.dll/California/sanbernardinocounty_ca/sanbernardinocountycaliforniacodeofordin?f=templates$fn=default.htm$3.0$vid=amlegal:sanbernardinocounty_ca.

San Diego (City of San Diego). 2011. *2010 Urban Water Management Plan*. July.

San Diego (County of San Diego). 2010. *General Plan Update Groundwater Study*. April.

San Diego County (County of San Diego). 2014. *County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 4: Wells and Chapter 7: Groundwater.*

San Joaquin County. 2009. *General Plan Update Background Report*. July.

San Joaquin County. 2014. *County Codes Title 5: Health and Sanitation, Division 4: Wells and Well Drilling, and Division 8: Groundwater*. Site accessed April 23, 2014. https://www.municode.com/library/ca/san_joaquin_county/codes/code_of_ordinances

San Luis Obispo County. 2012. *San Luis Obispo County Master Water Report*. May.

San Luis Obispo County (County of San Luis Obispo). 2014a. *County Code 8: Health and Sanitation, 8.40: Construction, Repair, Modification and Destruction of Wells.*

San Luis Obispo County. 2014b. *2014 Integrated Regional Water Management Plan*. July.

Santa Barbara (City of Santa Barbara). 2011. *Urban Water Management Plan, 2010 Update, Adopted June 2011*. June.

Santa Barbara County (County of Santa Barbara). 2007. *Santa Barbara Countywide Integrated Regional Water Management Plan*. May.

Santa Barbara County (County of Santa Barbara). 2013. *Santa Barbara Countywide Integrated Regional Water Management Plan 2013*. December.

Santa Barbara County (County of Santa Barbara). 2014. *County Code Chapter 34A: Wells*. Site accessed April 24, 2014. https://library.municode.com/print.aspx?h=&clientID=16322&HTMRequest=https%3a%2f%2flibrary.municode.com%2fHTML%2f16322%2flevel1%2fCH34AWE.html&HTMTitle=CHAPTER+34A+WELLS.

Santa Maria (City of Santa Maria). 2011. *2010 Urban Water Management Plan*. July.

SAWC (San Antonio Water Company). 2011. *2010 Urban Water Management Plan*. June.

SAWCO (San Antonio Water Company). 2011. *2010 Urban Water Management Plan*. June.

SBVMWD (San Bernardino Municipal Valley Water District). 2011. *2010 San Bernardino Valley Regional Urban Water Management Plan*. June.

SCGA (Sacramento Central Groundwater Authority). 2010. *Basin Management Report 2009-2010.*

SCVWD (Santa Clara Valley Water District). 2001. *Santa Clara Valley Water District Groundwater Management Plan*. July.

SCVWD (Santa Clara Valley Water District). 2010. *Revised Final Groundwater Vulnerability Study, Santa Clara County, California*. October.

SCVWD (Santa Clara Valley Water District). 2011. *Urban Water Management Plan*. May

SCVWD (Santa Clara Valley Water District). 2012a. *Annual Groundwater Report for Calendar Year 2012*.

SCVWD (Santa Clara Valley Water District). 2012b. *Groundwater Quality Summary Report for testing performed in 2012*.

SCVWD (Santa Clara Valley Water District). 2014a. *Santa Clara Valley Water District Act*. Site accessed April 21, 2014. http://www.valleywater.org/About/DistrictActText.aspx.

SCVWD (Santa Clara Valley Water District). 2014b. *Santa Clara Valley Water District Well Ordinance 90-1*. Site accessed April 21, 2014. http://www.valleywater.org/Programs/DistrictWellOrdinance901.aspx.

SCWA et al. (Solano County Water Agencies and Solano Agencies). 2005. *Integrated Water Resources Water Management Plan and Strategic Plan*. February.

SCWD (South Coast Water District). 2011. *2010 Urban Water Management Plan*. July.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

SDCWA (San Diego County Water Authority). 2015. *Seawater Desalination*. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination.

SDCWA et al. (San Diego County Water Authority, City of San Diego, County of San Diego). 2013. *2013 San Diego Integrated Regional Water Management Plan, An Update of the 2007 IRWM Plan, Final*. September.

SDLAFCO (San Diego Local Agency Formation Commission). 2011. *Directory of Special Districts in San Diego County*.

SDWD (San Dieguito Water District). 2011. *2010 Urban Water Management Plan*. June.

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html.

SFID (Santa Fe Irrigation District). 2011. *2010 Urban Water Management Plan*. June.

SGA (Sacramento Groundwater Authority). 2013. *Basin Management Report Update 2013*.

SGA (Sacramento Groundwater Authority). 2014. *Groundwater Management Plan*. December.

SGCWD (San Gabriel County Water District). 2011. *2010 Urban Water Management Plan*. May.

SGPWA (San Gorgonio Pass Water Agency). 2010. *2010 Urban Water Management Plan for the San Gorgonio Pass Water Agency*. December.

SGVWC (San Gabriel Valley Water Company). 2011. *2010 Urban Water Management Plan*. July.

Shasta County. 2014a. *County Code: Title 8: Health and Safety*. Site accessed April 22, 2014. http://www.co.shasta.ca.us/docs/COB/county-codes/Title_8.pdf?sfvrsn=0.

Shasta County. 2014b. *County Code: Title 18: Environment*. Site accessed April 22, 2014. http://www.co.shasta.ca.us/docs/COB/county-codes/Title_18.pdf?sfvrsn=0.

SJBA (San Juan Basin Authority). 2013. *San Juan Basin Groundwater and Facilities Management Plan*. November.

SJCFCWCD (San Joaquin County Flood Control and Water Conservation District). 2008. *Groundwater Report: Fall 1999–Spring 2007*.

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011. *Friant-Kern Canal Capacity Restoration, Draft*. June.

SJRRP (San Joaquin River Restoration Program). 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://restoresjr.net/activities/site_specific/madera-canal/index.html

SMRW (Santa Margarita River Watershed Watermaster). 2011. *Santa Margarita River Watershed Annual Watermaster Report, Water Year 2009-10*. September.

SMRW (Santa Margarita River Watershed Watermaster). 2014. *Water Rights Framework Murrieta-Temecula Groundwater Basin, Groundwater Management Workshop*. July 22.

SMVMA (Santa Maria Valley Management Area). 2012. 2011 *Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition*. April.

SMWD (Santa Margarita Water District). 2011. *2010 Urban Water Management Plan*. July.

Solano County. 2008. *Solano County General Plan, Draft Environmental Impact Report*. April.

Solano County. 2014. *County Codes Chapter 13.6: Injection Wells and Chapter 13.10: Well Standards*. Site accessed April 23, 2014. http://www.codepublishing.com/ca/solanocounty/.

South Area Water Council. 2011. *South Basin Groundwater Management Plan. Working Draft*. April.

Stanislaus County (County of Stanislaus County). 2010. *Stanislaus County General Plan Support Documentation, Revised April 2010*. April.

Stanislaus County. 2014. County Code: Title 9: Health and Safety, Chapter 9.36: Water Wells. Site accessed April 21, 2014. http://qcode.us/codes/stanislauscounty.

Stanislaus County. 2014. County Code: Title 9: Health and Safety, Chapter 9.37: Groundwater Mining and Export Prevention. Site accessed April 21, 2014. http://qcode.us/codes/stanislauscounty/view.php?topic=9-9_37&showAll=1&frames=on.

Suburban Water Systems. 2011. *2010 Urban Water Management Plan*. June.

Sutter County. 2011. *Draft Groundwater Management Plan*. October.

Sutter County. 2014. *County Code: Section 700: Health and Sanitation, Chapter 765: Water Wells*. Site accessed April 22, 2014. https://www.co.sutter.ca.us/doc/government/bos/ordinance.

SWD (Serrano Water District). 2011. *2010 Urban Water Management Plan*. June.

Sweetwater Authority. 2011. *2010 Urban Water Management Plan*. June 8.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWRCB (State Water Resources Control Board) 2015. *CV-SALTS Annual Report, State Water Board Meeting, Agenda Item #5*. January 20.

SWSD (Semitropic Water Storage District). 2011a. *About Us*. Site accessed February 14, 2011. http://www.semitropic.com/AboutUs.htm.

SWSD (Semitropic Water Storage District). 2011b. *Storing Water Supplies for our Future (brochure)*. Site accessed February 10, 2011. http://www.semitropic.com/PubsArchive.htm.

SWSD (Semitropic Water Storage District). 2011c. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

SWSD (Semitropic Water Storage District). 2014. *Banking Partners and Allocation of 1.65 Million Acre-feet of Total Storage Capacity*. Site accessed May 12, 2014. http://www.semitropic.com/BankingPartners.htm.

Tehama County Flood Control and Water Conservation District. 1996. *Coordinated AB 3030 Groundwater Management Plan*. November.

Tehama County Flood Control and Water Conservation District. 2008. *Tehama County AB-3030 Groundwater Management Plan. Background Document. Proposing Groundwater Trigger levels for Awareness Actions for Tehama County*. July.

Tehama County. 2014. *County Code: Title 9: Health and Safety: Chapters 9.40: Aquifer Protection and 9.42: Well Construction, Rehabilitation, Repair and Destruction*. Site accessed April 22, 2014. https://www.municode.com/library/ca/tehama_county/codes/code_of_ordinances.

Thousand Oaks (City of Thousand Oaks). 2011. *2010 Urban Water Management Plan*. June.

TPWD (Twentynine Palms Water District). 2014. *Mission History*. Site accessed July 22, 2014. http://www.29palmswater.net/mission-history.html.

Travis AFB (Travis Air Force Base). 1997. *North/East/West Industrial Operable Unit Groundwater Interim Record of Decision Part II, Decision Summary*.

Travis AFB (Travis Air Force Base). 2005. *Groundwater Sampling and Analysis Program 2003–2004 Annual Report*.

Trinity County. 2014. *County Code: Title 15: Buildings and Construction, Chapter 15.20: Water Wells*. Site accessed April 22, 2014. https://www.municode.com/library/ca/trinity_county/codes/code_of_ordinances.

Tulare County. 2010. *Tulare County General Plan 2030 Update, Recirculated Draft Environmental Impact Report.* February.

Tulare County. 2014. *County Codes Part IV: Health, Safety, and Sanitation, Chapter 13: Wells*. Site accessed April 24, 2014. http://www.codepublishing.com/ca/tularecounty/html/tulare04/Tulare0413.html.

TVMWD (Three Valleys Municipal Water District). *Urban Water Management Plan, 2010*. June 16.

ULARAW (Upper Los Angeles River Area Watermaster). 2013. *Annual Report, Upper Los Angeles River Area Watermaster, 2011-12 Water Year, October 1, 2011 – September 30, 2012*. May.

USFWS (U.S. Fish and Wildlife Service). 2012. *Proposed Expansion San Joaquin River National Wildlife Refuge. Environmental Assessment, Land Protection Plan, and Conceptual Management Plan*.

USGS (U.S. Geological Survey). 1960. *Geology, Water Resources and Usable Ground‑Water Storage Capacity of Part of Solano County, California. USGS Water‑Supply Paper 1464. Prepared in cooperation with the Bureau of Reclamation. U.S. Government Printing Office, Washington, D.C.*

USGS (U.S. Geological Survey). 1974. *Analog Model Study of the Ground-Water Basin of the Upper Coachella Valley, California*.

USGS (U.S. Geological Survey). 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections: Regional Aquifer-System Analysis. USGS Professional Paper 1401-C. U.S. Government Printing Office, Washington, D.C.*

USGS (U.S. Geological Survey). 2000a. *Delta Subsidence in California – The Sinking Heart of the State. USGS Fact Sheet 005-00*. April.

USGS (U.S. Geological Survey). 2000b. MODFLOW-2000: The U.S. Geological Survey Modular Ground-Water Model–User Guide to Modularization Concepts and the Ground-Water Flow Process. U.S. Geological Survey Open-File Report 00 92. Reston, Virginia.

USGS (U.S. Geological Survey). 2006. *Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California. USGS Open File Report 2006-1309. Prepared in cooperation with Northeastern San Joaquin Groundwater Banking Authority and California Department of Water Resources*. November.

USGS (U.S. Geological Survey). 2008. *Ground-Water Quality Data in the Southern Sacramento Valley, California, 2005—Results from the California GAMA Program. U.S. Geological Survey Data Series 285*.

USGS (U.S. Geological Survey). 2009. *Groundwater Availability of the Central Valley Aquifer, California. U.S. Geological Survey Professional Paper 1766. Groundwater Resources Program.*

USGS (U.S. Geological Survey). 2012. *Subsidence along the Delta-Mendota Canal*. Site accessed November 30, 2012. http://ca.water.usgs.gov/projects/central-valley/delta-mendota-canal-subsidence.html.

USGS (U.S. Geological Survey). 2013a. *Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-10. Scientific Investigations Report 2013-5142*.

USGS (U.S. Geological Survey). 2013b. *A Geochemical Approach to Determine Sources and Movement of Saline Groundwater in a Coastal Aquifer*. Published by National Ground Water Association. July.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2011. *Urban Water Management Plan*. June.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

UWCD (United Water Conservation District). 2012. *Groundwater and Surface Water Conditions Report – 2011, Open File Report 2012-02*. May.

Vaughn Water Company, Inc. 2011. *2010 Urban Water Management Plan*. July 29.

VCMWD (Valley Center Municipal Water District). 2011. *Urban Water Management Plan 2010 Update*. July.

VCWD (Ventura County Waterworks District No. 8). 2011. *2010 Urban Water Management Plan, City of Simi Valley*. May.

Ventura County. 2011. *2011 Groundwater Section Annual Report*.

Ventura County (County of Ventura). 2014. *County Code Division 4: Public Health, Chapter 8: Water, Article 1: Groundwater Conservation.* Site accessed April 24, 2014. https://library.municode.com/print.aspx?h=&clientID=16749&HTMRequest=http%3a%2f%2flibrary.municode.com%2fHTML%2f16749%2flevel3%2fDIV4PUHE_CH8WA_ART1GRCO.html&HTMTitle=Article+1.+Groundwater+Conservation.

Victorville Water District. 2011. *2010 Urban Water Management Plan*. June.

VID (Vista Irrigation District). 2011. *2010 Urban Water Management Plan*. June 28.

VWD (Vallecitos Water District). 2011. *2010 Urban Water Management Plan*. June 15.

Water Resources Association of Yolo County. 2007. *Final Integrated Regional Water Management Plan*. April

WBMWD (West Basin Municipal Water District). 2011a. *2010 Urban Water Management Plan*. May.

WBMWD (West Basin Municipal Water District). 2011b. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

WBMWD (West Basin Municipal Water District). 2015a. *Water Recycling Satellite Facilities*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/recycled-water/satellite-facilities.

WBMWD (West Basin Municipal Water District). 2015b. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview.

West Valley WD (West Valley Water District). 2014a. *History of West Valley Water District*. Site accessed August 7, 2014. https://www.wvwd.org/index.aspx?nid=92.

West Valley WD (West Valley Water District). 2014b. *Groundwater Wellhead Treatment System Project*. Site accessed August 7, 2014. https://www.wvwd.org/index.aspx?NID=169.

West Valley WD (West Valley Water District). 2014c. *Baseline Feeder Water Supply Project*. Site accessed August 7, 2014. http://www.wvwd.org/index.aspx?NID=197.

WICC (Watershed Information Center and Conservancy of Napa County). 2005. *Napa County Baseline Data Report*. November.

WMWD (Western Municipal Water District). 2011. *2010 Urban Water Management Plan Update*. June.

WMWD (Western Municipal Water District). 2012. *Arlington Basin Groundwater Management Plan*. September.

WRD (Water Replenishment District of Southern California). 2007. *Battling Seawater Intrusion in the Central & West Coast Basins. Technical Bulletin. Volume 13*. Fall.

WRD (Water Replenishment District of Southern California). 2013a. *Engineering Survey and Report*. May 10.

WRD (Water Replenishment District of Southern California). 2013b. *Moving Towards 100% Recycled Water at the Seawater Intrusion Barrier Wells, Central Basin and West Coast Basin. Volume 25*. Spring.

WRD (Water Replenishment District of Southern California). 2015. *Recirculated Draft Environmental Impact Report, Groundwater Reliability Improvement Program (GRIP) Recycled Water Project*. April.

WVWD (Walnut Valley Water District). 2011. *2010 Urban Water Management Plan*. July.

WWD (Westlands Water District). 2008. *Water Management Plan, 2007*. March 3.

WWD (Westlands Water District). 2011. *Deep Groundwater Conditions Report December 2010*. March.

WWD (Westlands Water District). 2013. *Deep Groundwater Conditions Report December 2012*. April 1.

YCFCWCD (Yolo County Flood Control and Water Conservation District). 2012. *Regional Conjunctive Use Enhancement: Nitrate Fingerprinting and Groundwater Age Determination*. December.

YCWA (Yuba County Water Agency). 2010. *Groundwater Management Plan*. December.

YLWD (Yorba Linda Water District). 2011. *2010 Urban Water Management Plan*. May.

YMWD (Yuima Municipal Water District). 2014a. *Yuima Municipal Water District, History*. Site accessed July 11, 2014. http://www.yuimamwd.com/content.php?ID=19.

YMWD (Yuima Municipal Water District). 2014b. *2013 Consumer Confidence Report*. June 1.

Yolo County (County of Yolo). 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report*. April.

Yolo County. 2014. *County Codes: Title 6: Sanitation and Health, Chapter 8: Water Quality and Title 10: Environment, Chapter 7: Groundwater.* Site accessed April 23, 2014. http://www.yolocounty.org/general-government/board-of-supervisors/county-codes.

Yuba County. 2014. *County Code: Title VII: Health and Sanitation, Chapter 7.03: Water Wells*. Site accessed April 22, 2014. https://www.municode.com/library/ca/yuba_county/codes/code_of_ordinances?nodeId=TITVIIHESA_CH7.03WAWE.

Yurok Tribe. 2012. *NPS Assessment and Management Program Plan*. December.

YVWD (Yucaipa Valley Water District). 2011. *2010 Urban Water Management Plan*. July.

Zone 7 (Zone 7 Water Agency). 2005. *Groundwater Management Plan for the Livermore-Amador Valley Groundwater Basin*. September.

Zone 7 (Zone 7 Water Agency). 2010. *2010 Urban Water Management Plan*. December.

Zone 7 (Zone 7 Water Agency). 2013. *Annual Report for the Groundwater Management Program 2012 Water Year Livermore Valley Groundwater Basin*. May.

This page left blank intentionally.


**Figure 7.1 California Groundwater Basins and Subbasins Defined in DWR Bulletin 118**

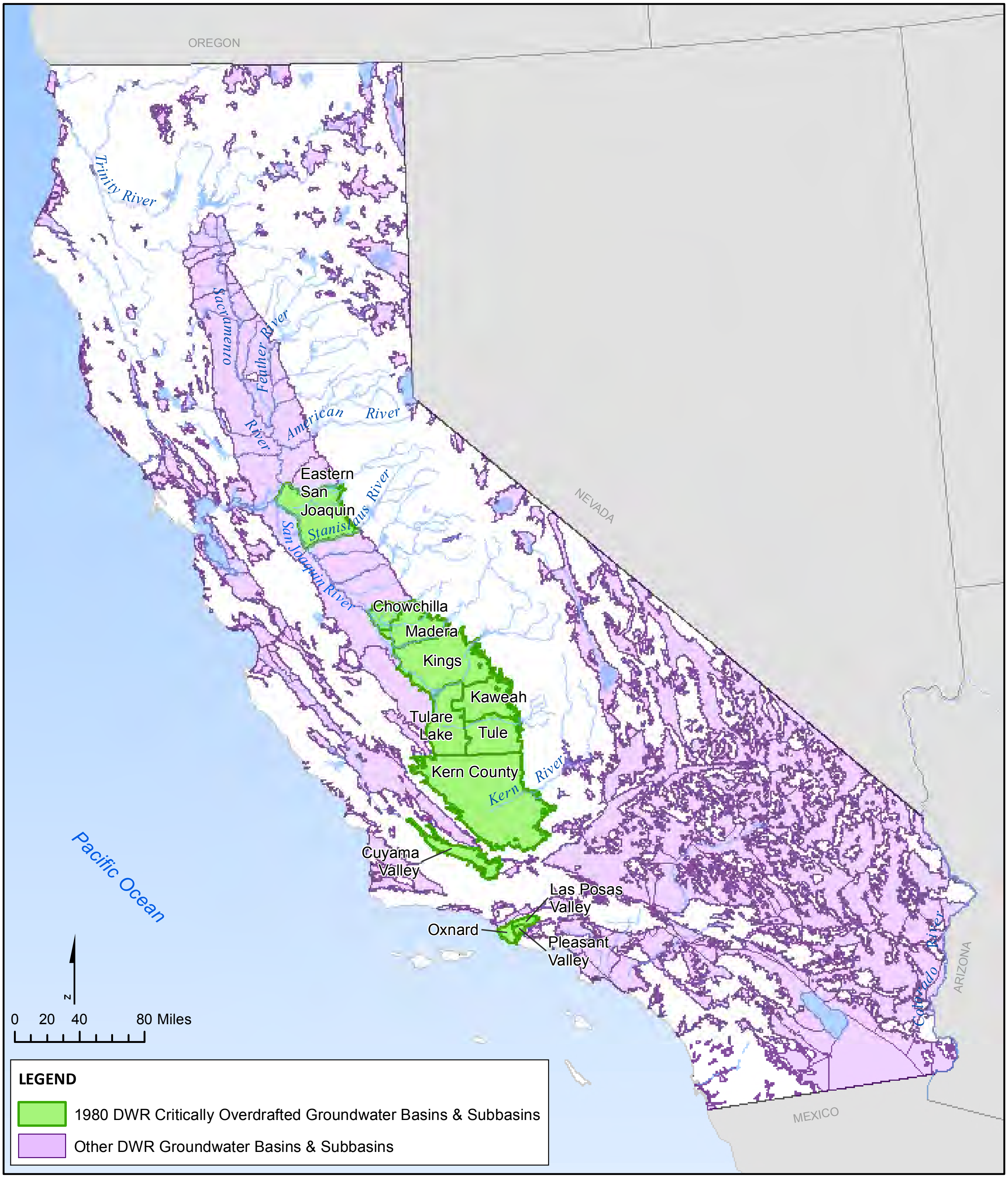



**Figure 7.2 Overdrafted Groundwater Basins Defined in DWR Bulletin 118**

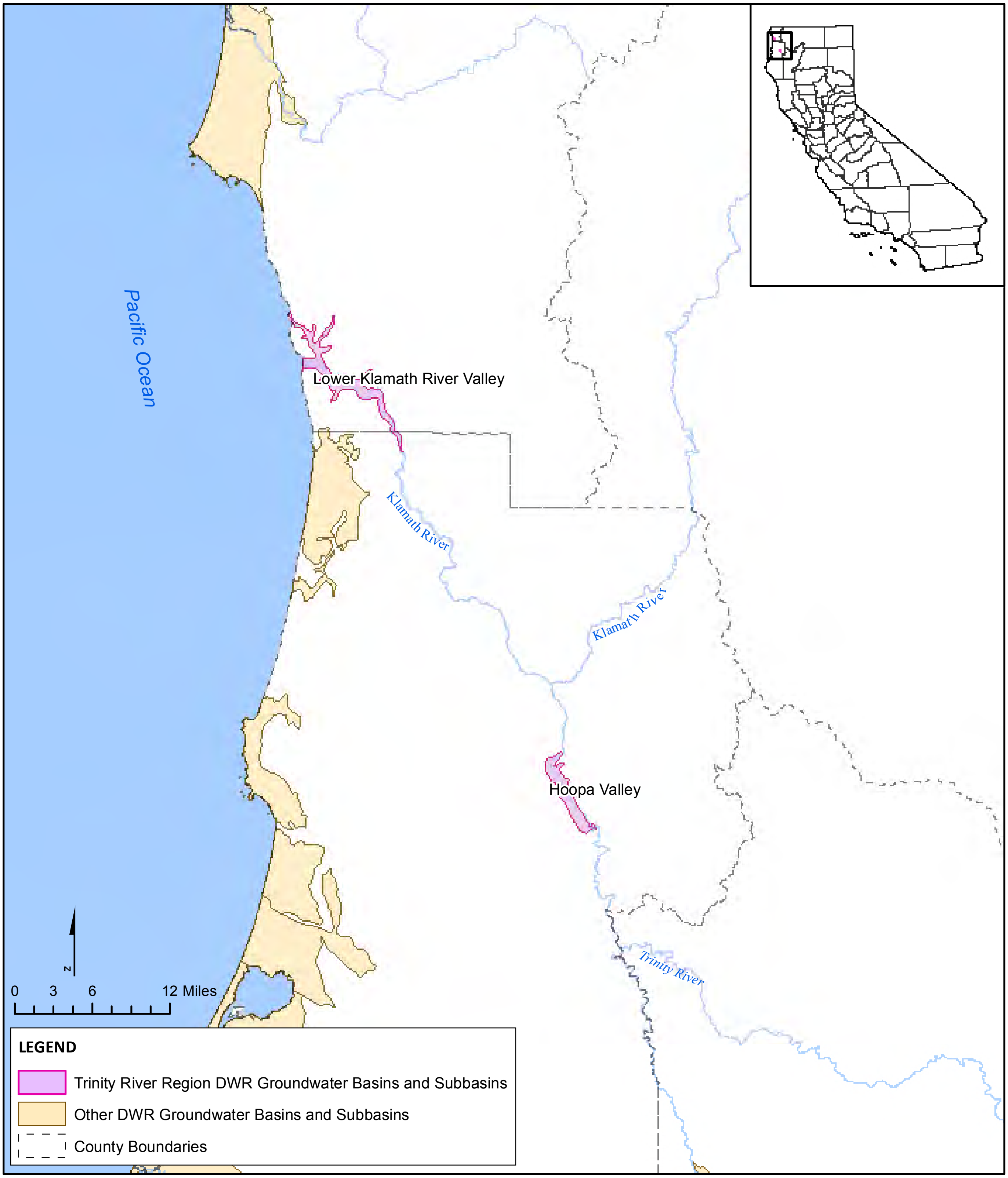



**Figure 7.3 North Coast Groundwater Basins Defined in DWR Bulletin 118**

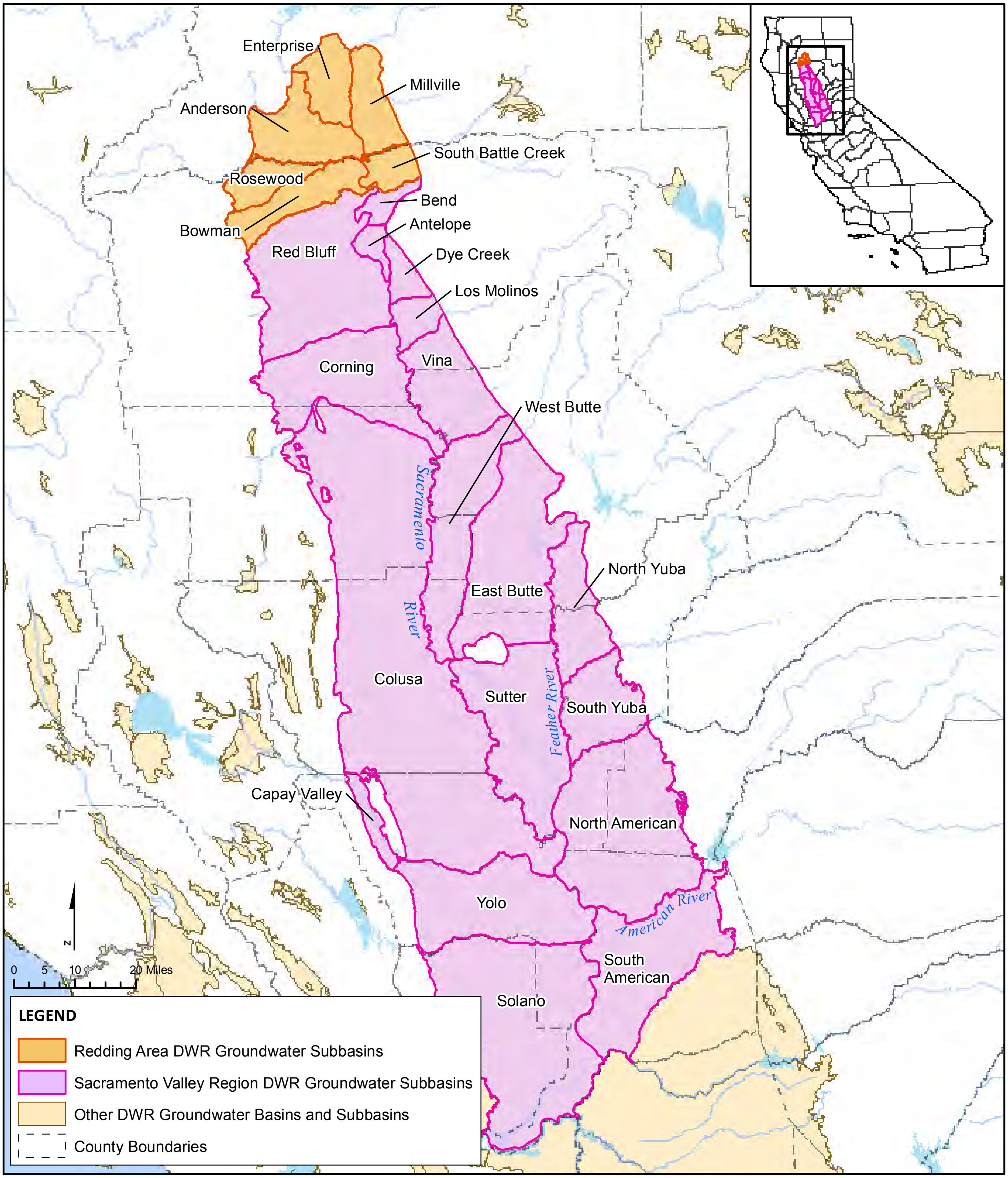



**Figure 7.4 Sacramento Valley Groundwater Basin Defined in DWR Bulletin 118**

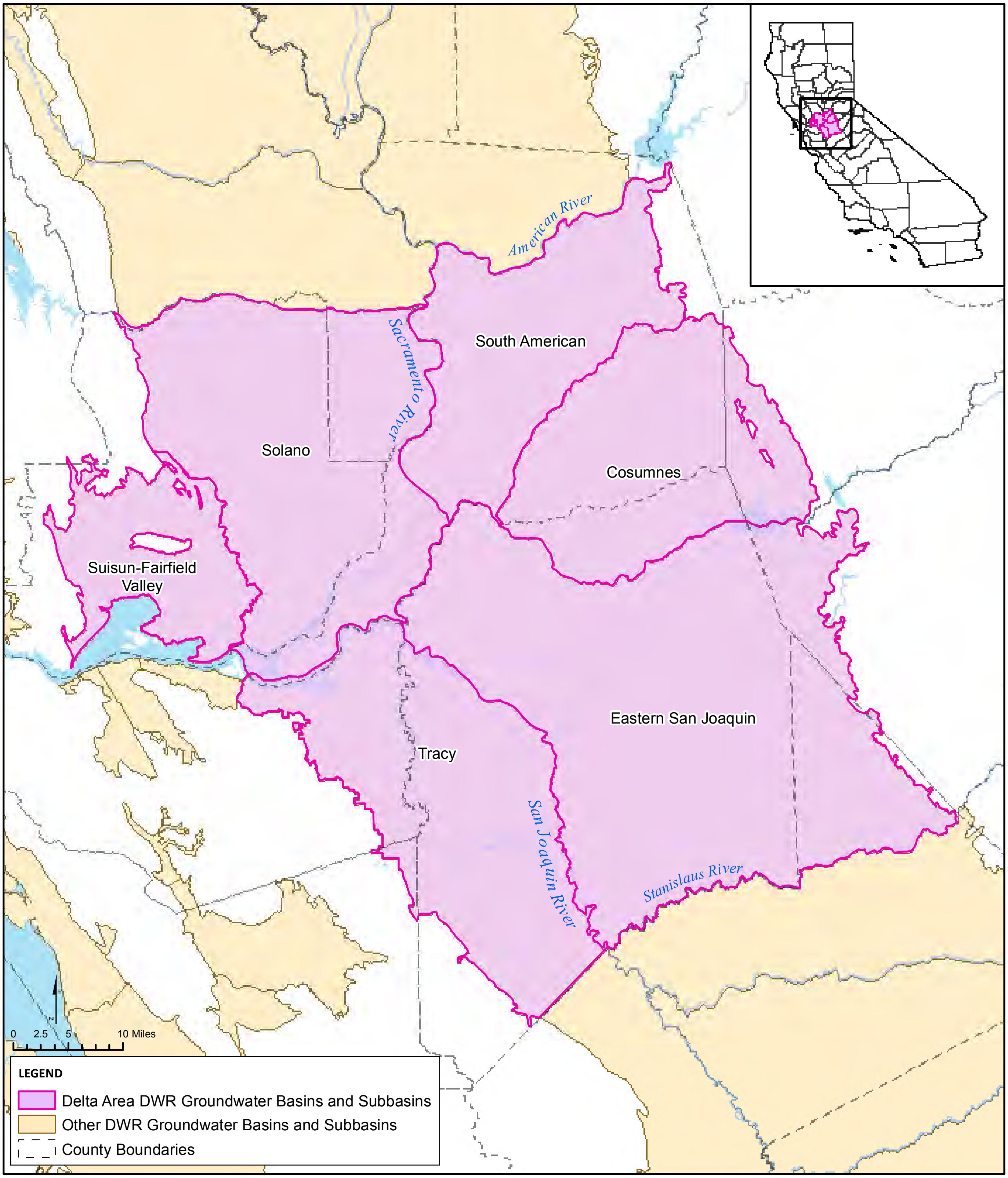



**Figure 7.5 Groundwater Subbasins in the Delta Area Defined in DWR Bulletin 118**

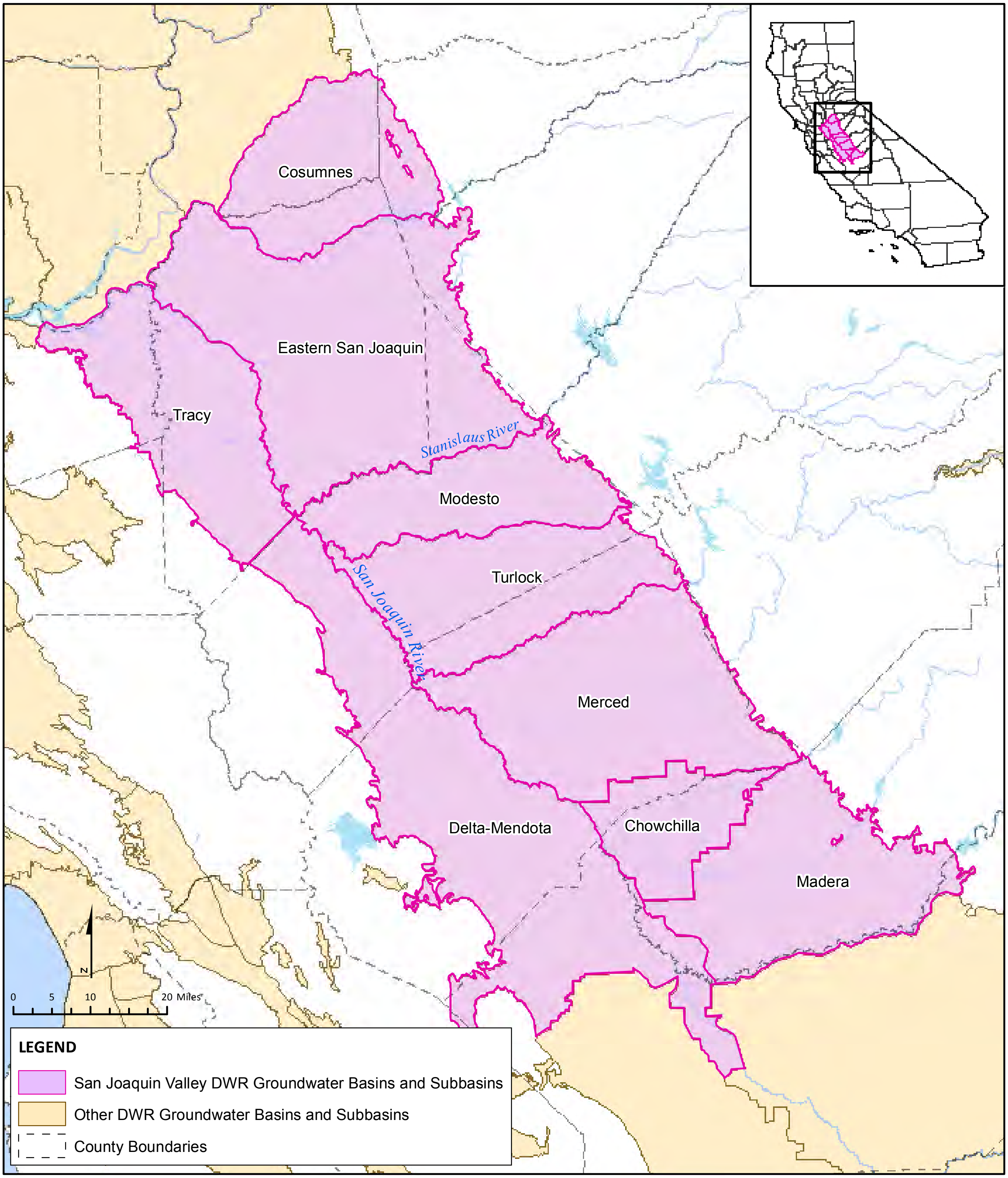



**Figure 7.6 San Joaquin Valley Region Groundwater Basin Defined in DWR Bulletin 118**

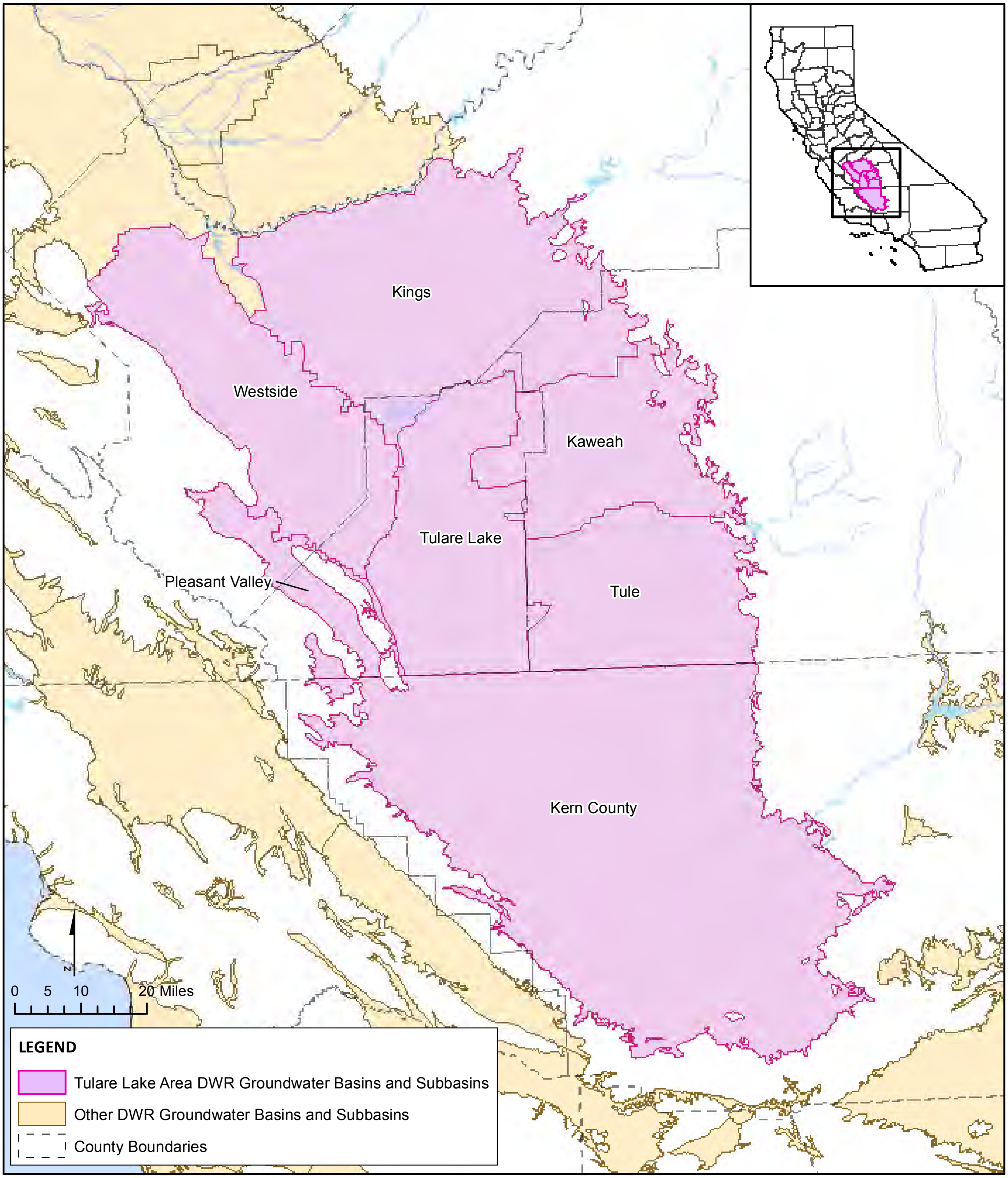



**Figure 7.7 Tulare Lake Area Groundwater Basin Defined in DWR Bulletin 118**

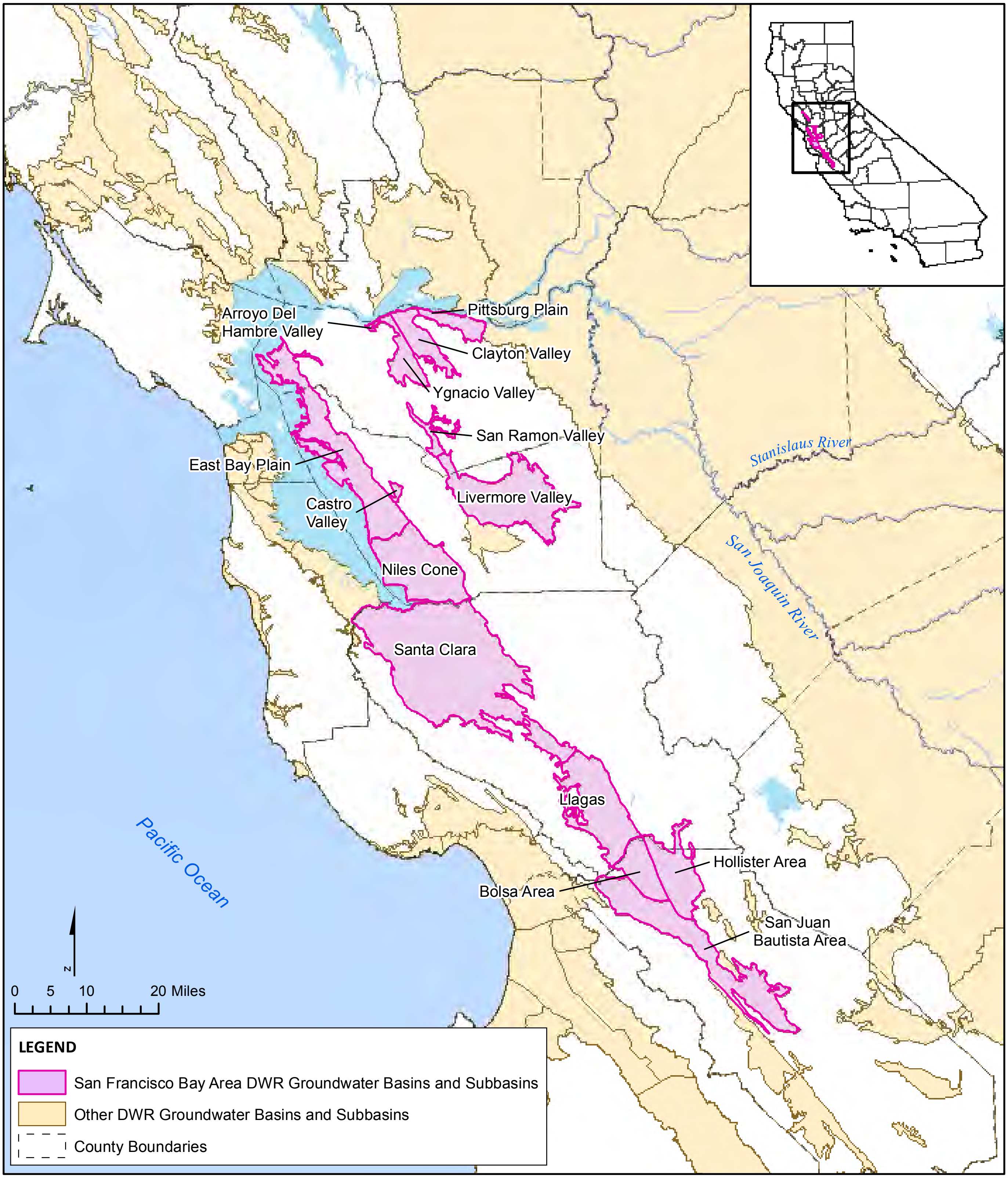



**Figure 7.8 San Francisco Bay Area Groundwater Basins Defined in DWR Bulletin 118**

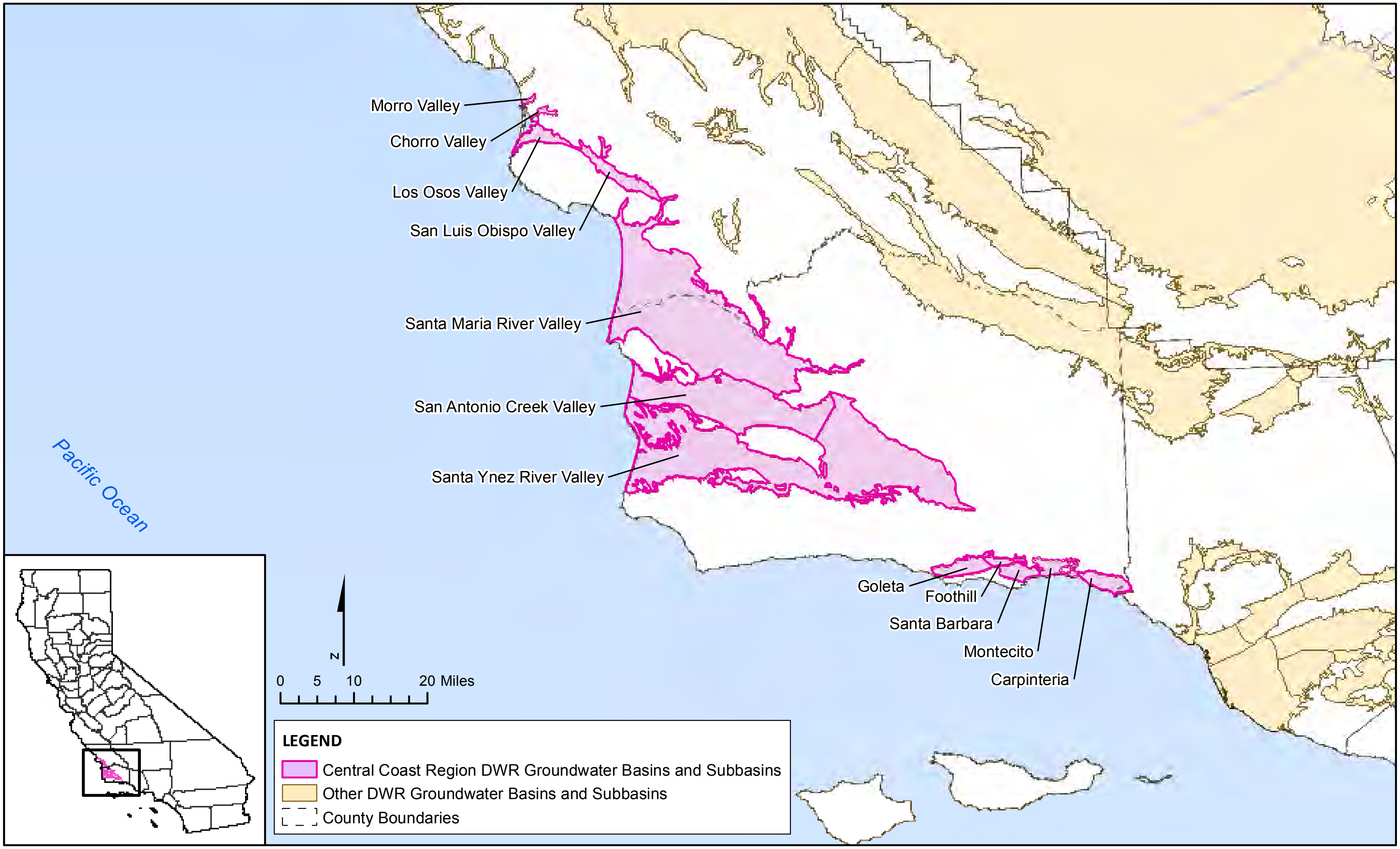



**Figure 7.9 Central Coast Region Groundwater Basins defined in DWR Bulletin 118**

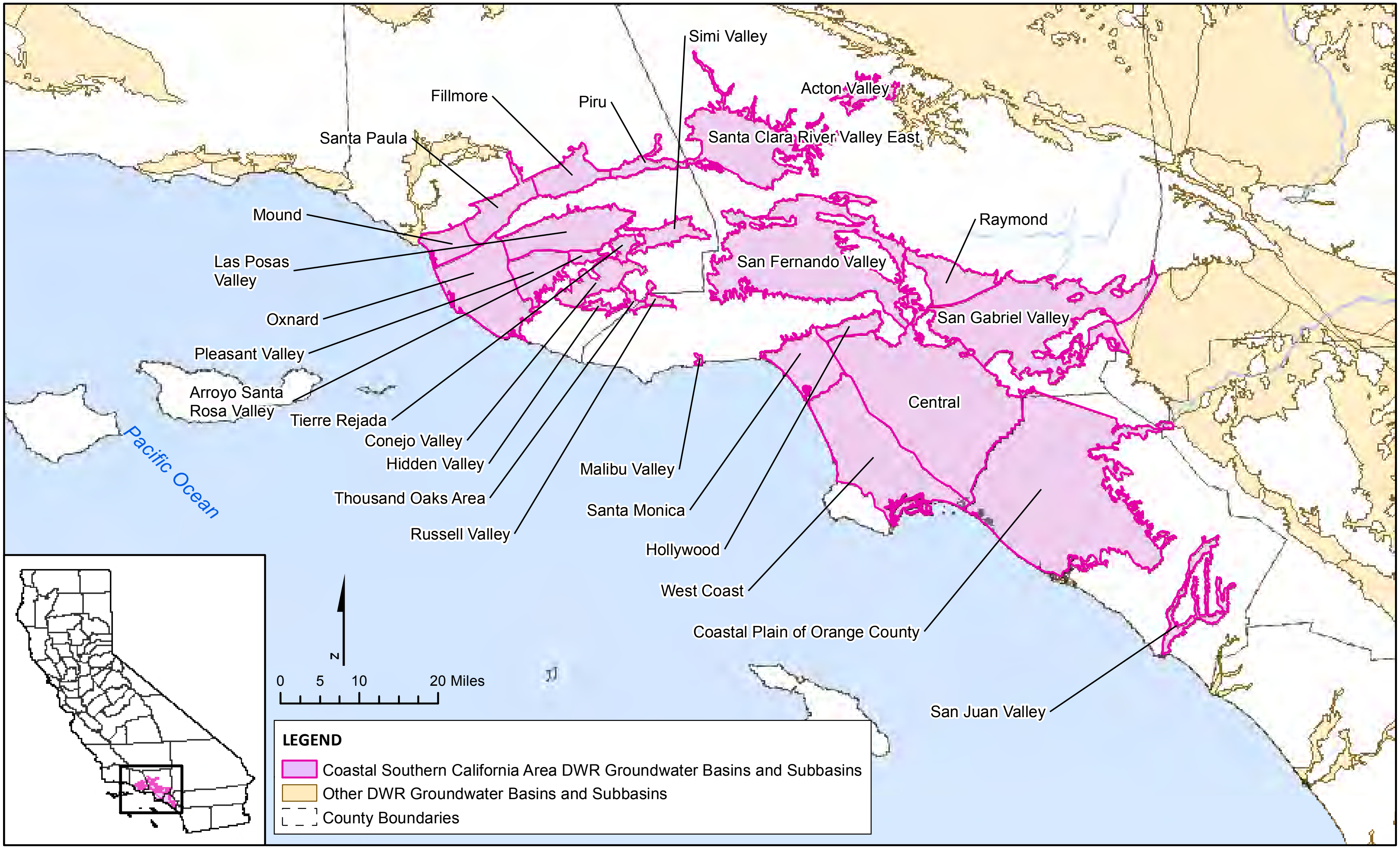



**Figure 7.10 Coastal Southern California Area Groundwater Basins Defined in DWR Bulletin 118**

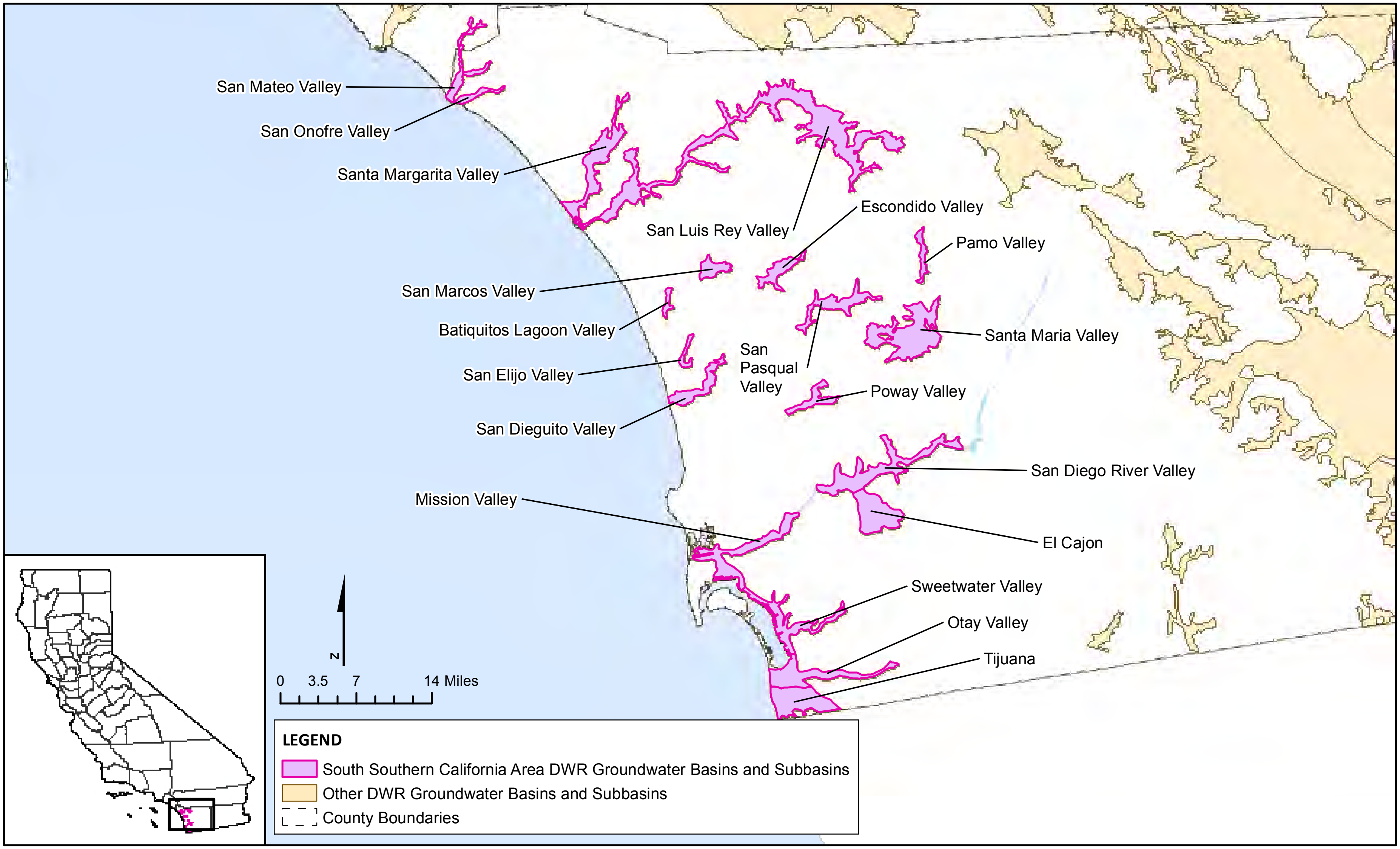



**Figure 7.11 San Diego Area Groundwater Basins Defined in DWR Bulletin 118**

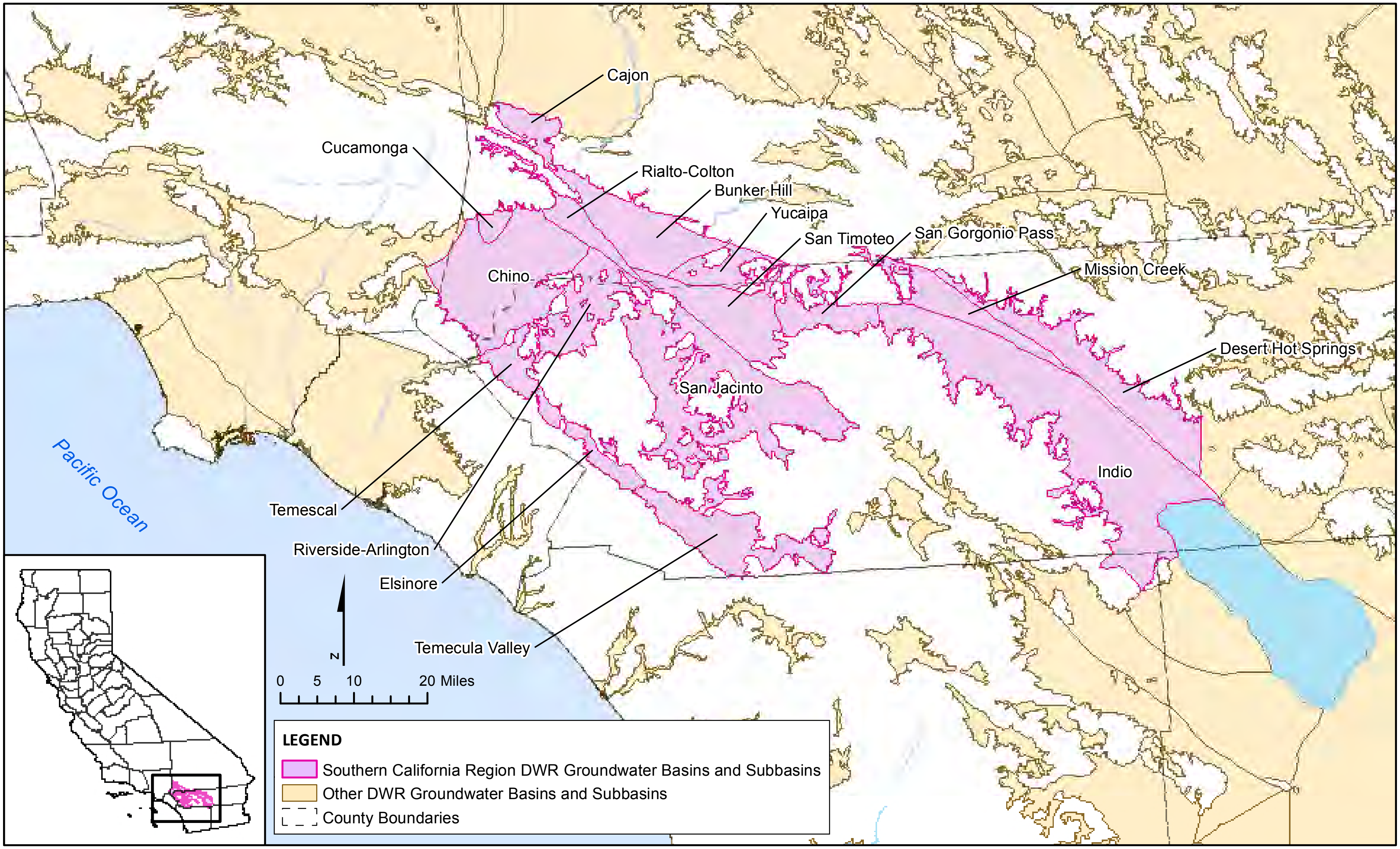



**Figure 7.12 Southern California Region Groundwater Basins Defined in DWR Bulletin 118**

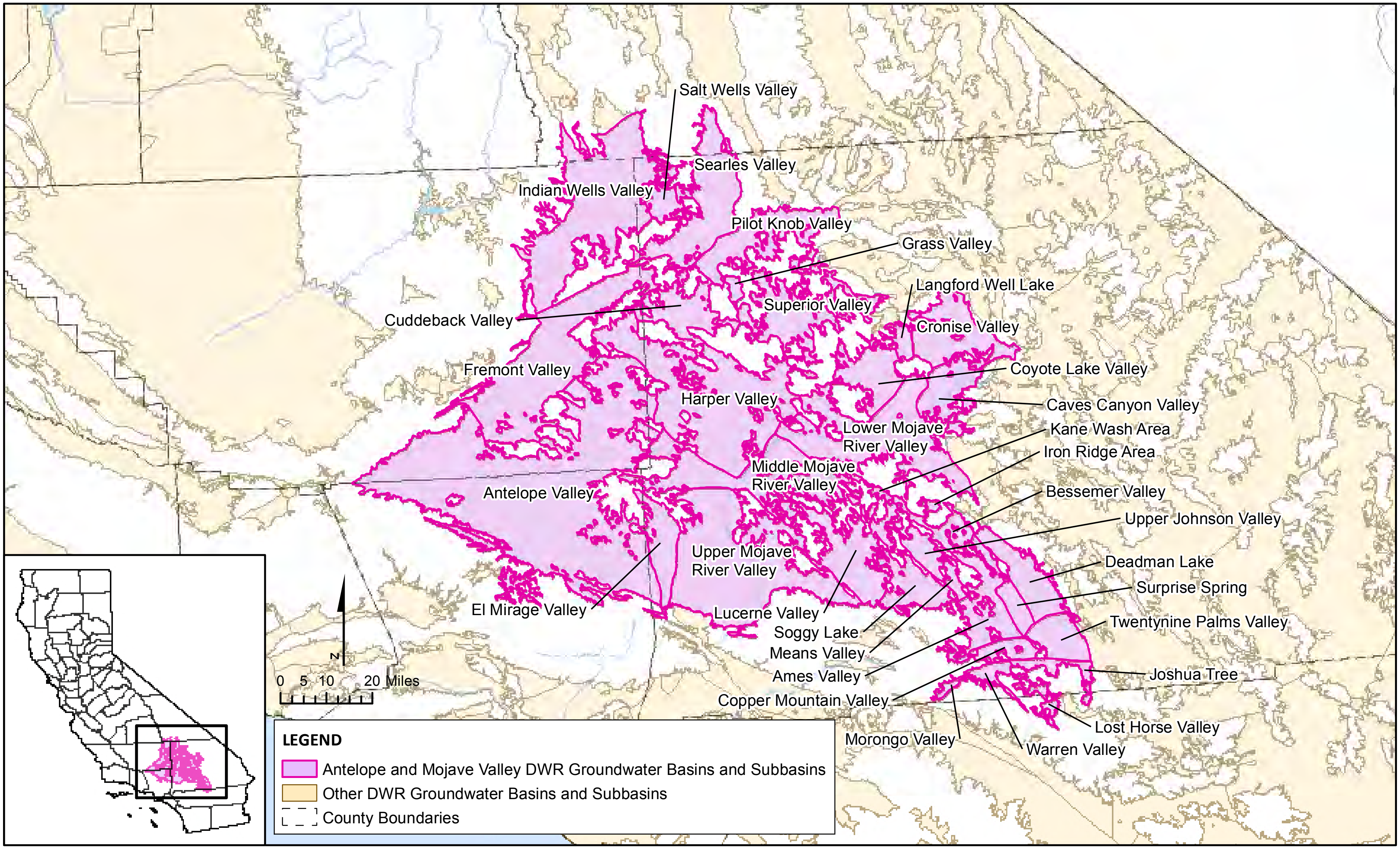
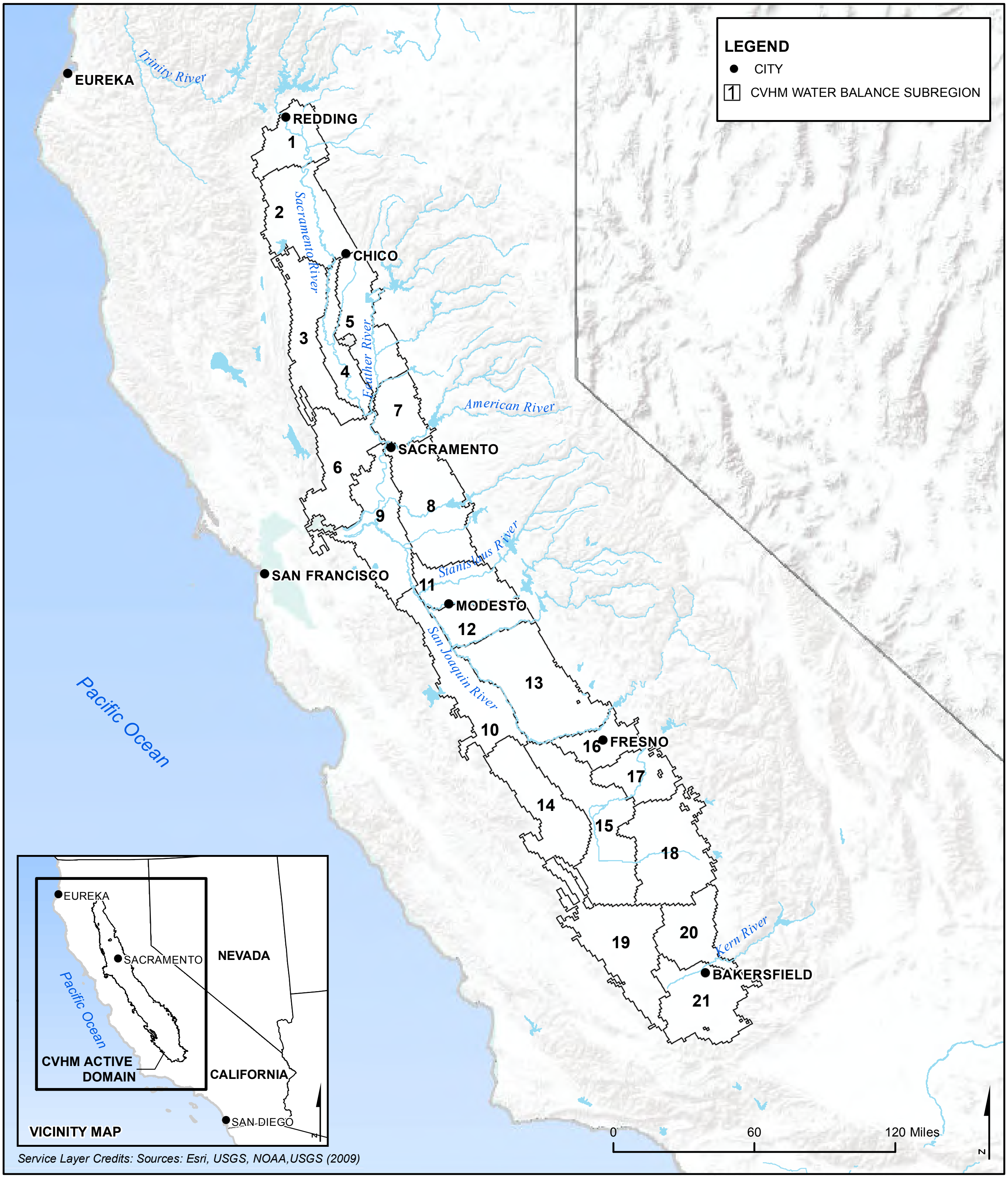



**Figure 7.13 Antelope Valley and Mojave Valley Groundwater Basins Defined in DWR Bulletin 118**




YOSEMITE Z:\MODELING\3\WORKSPACE\TOOLKIT_DEVELOPMENT\CVHM\CVHM_2010\GIS\MAPFILES\APPENDIX_FIGURES\FIG_7.14_MODEL_WBS.MXD 5/28/2015

**Figure 7.14 Groundwater Model Domain and Water Balance Subregions in the Central Valley**

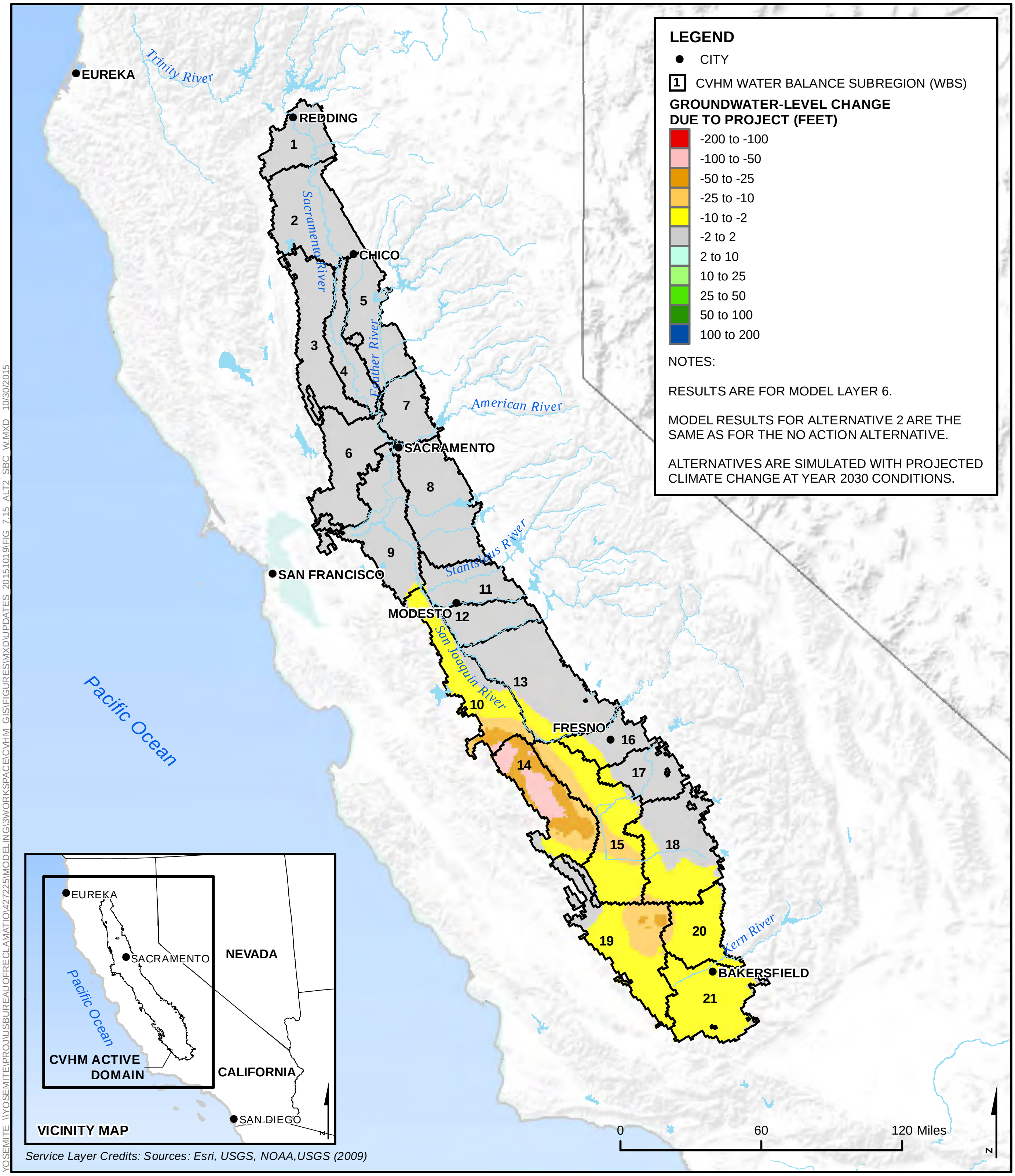



**Figure 7.15 Forecast Groundwater-Level Changes for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison for Average July in a Future Wet Year**

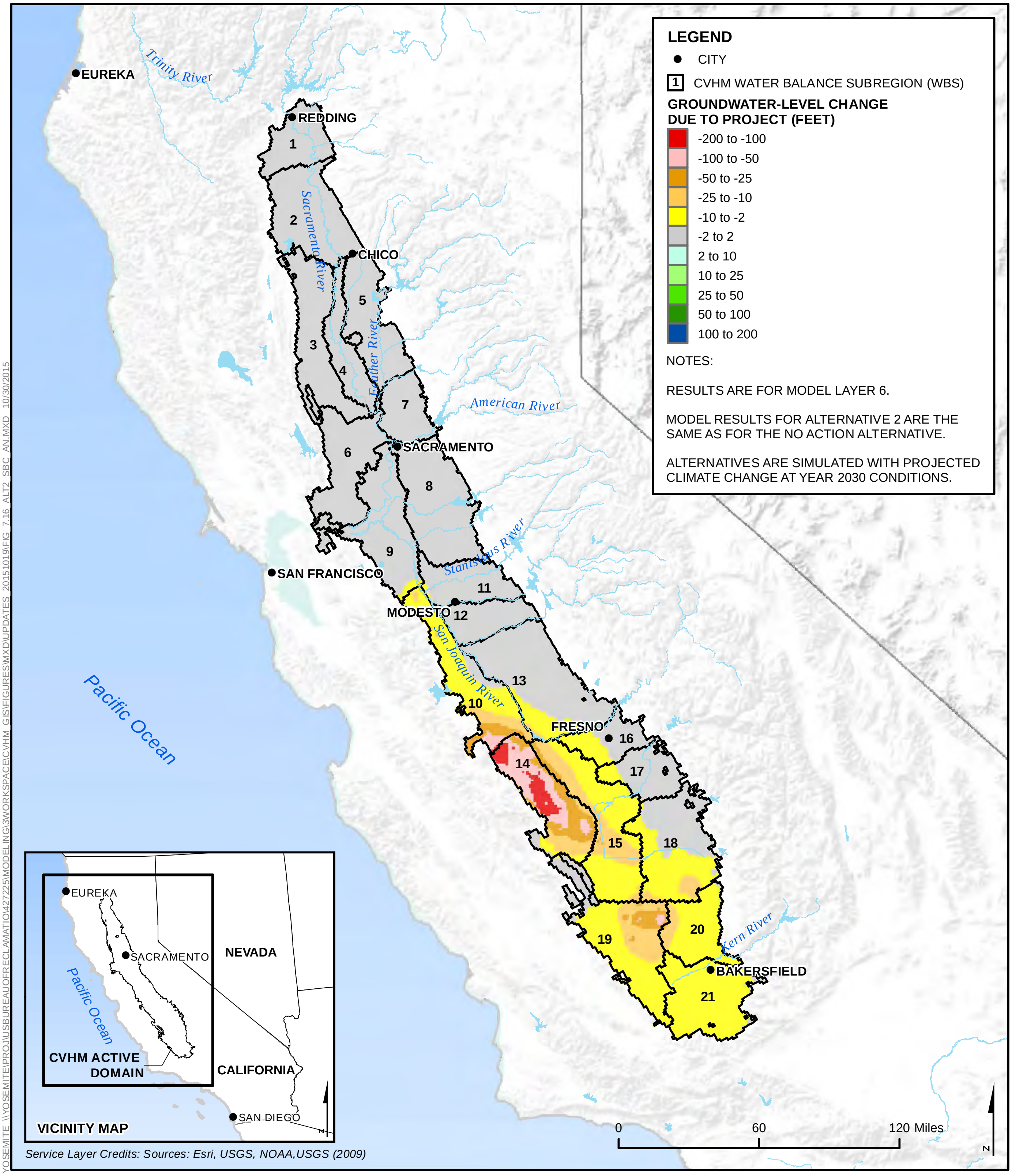



**Figure 7.16 Forecast Groundwater-Level Changes for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison for Average July in a Future Above-Normal Year**

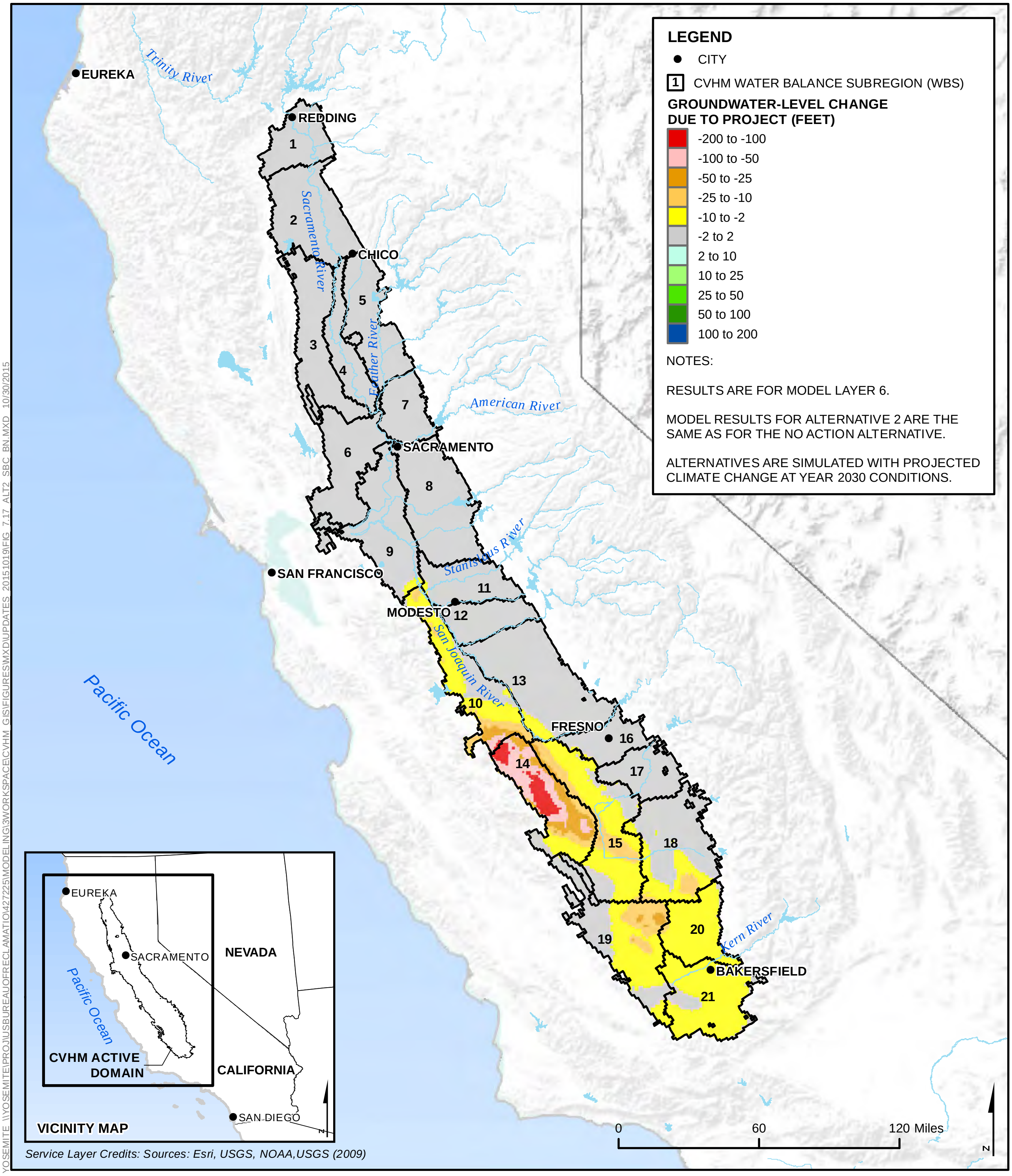



**Figure 7.17 Forecast Groundwater-Level Changes for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison for Average July in a Future Below-Normal Year**

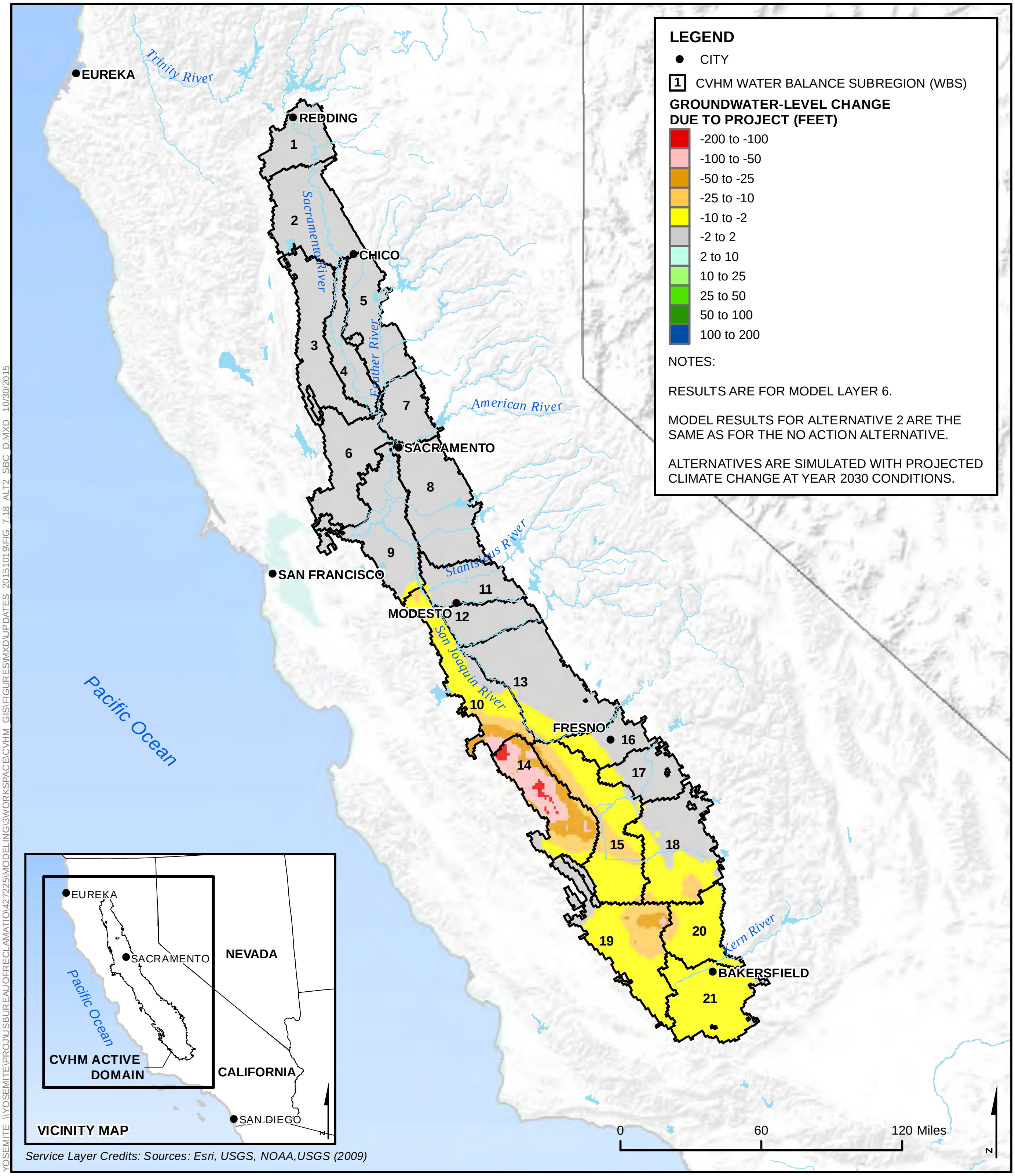
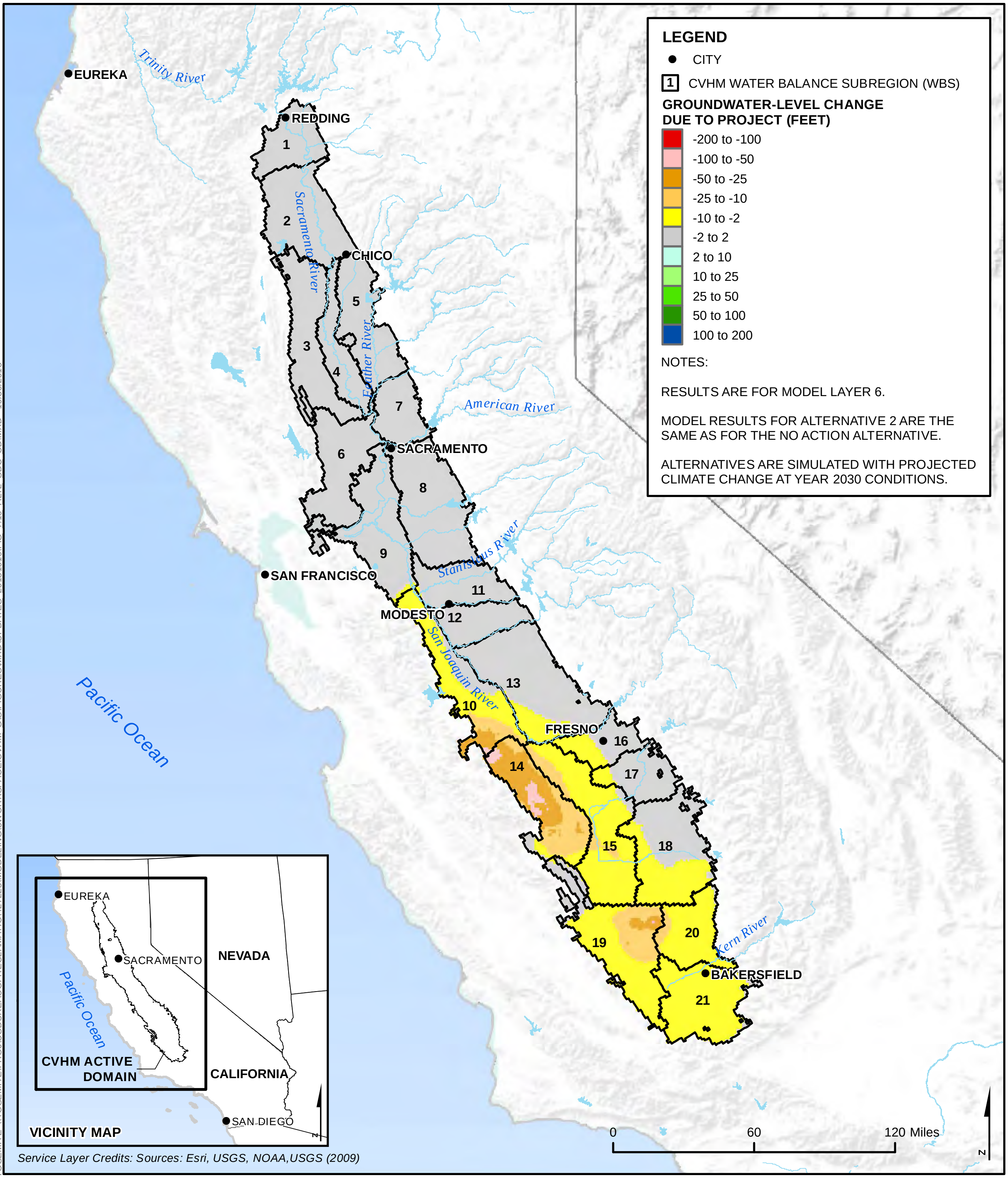



**Figure 7.18 Forecast Groundwater-Level Changes for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison for Average July in a Future Dry Year**




YOSEMITE \\YOSEMITE\PROJ\USBUREAUOFRECLAMATION\427225\MODELING\3\WORKSPACE\CVHM GIS\FIGURES\MXD\UPDATES 20151019\FIG 7.19 ALT2 SBC CD.MXD 10/30/2015

**Figure 7.19 Forecast Groundwater-Level Changes for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison for Average July in a Future Critically-Dry Year**

This page left blank intentionally.

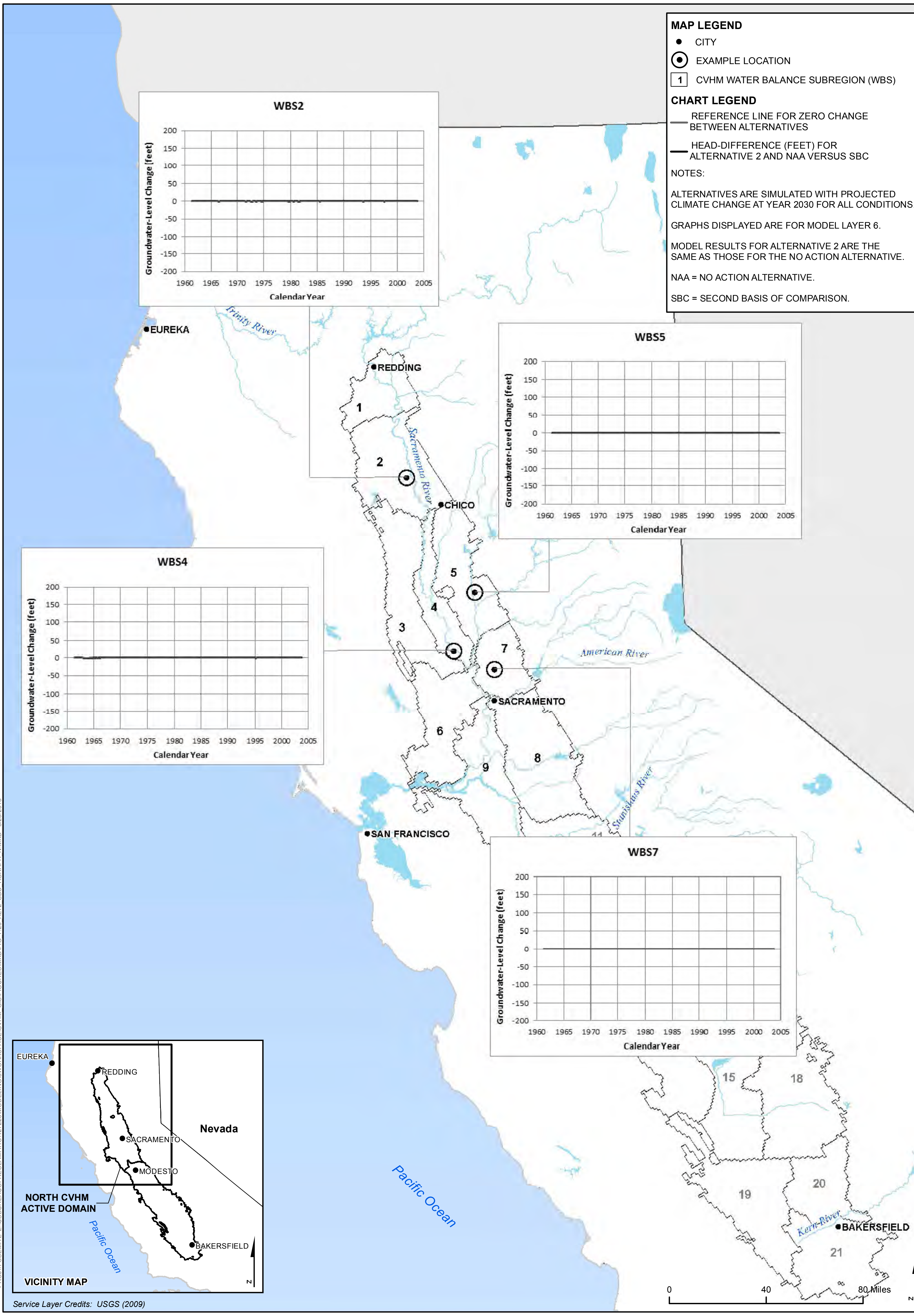



**Figure 7.20 Forecast Groundwater-Level Change Hydrographs for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison at Example Locations in the Sacramento Valley**

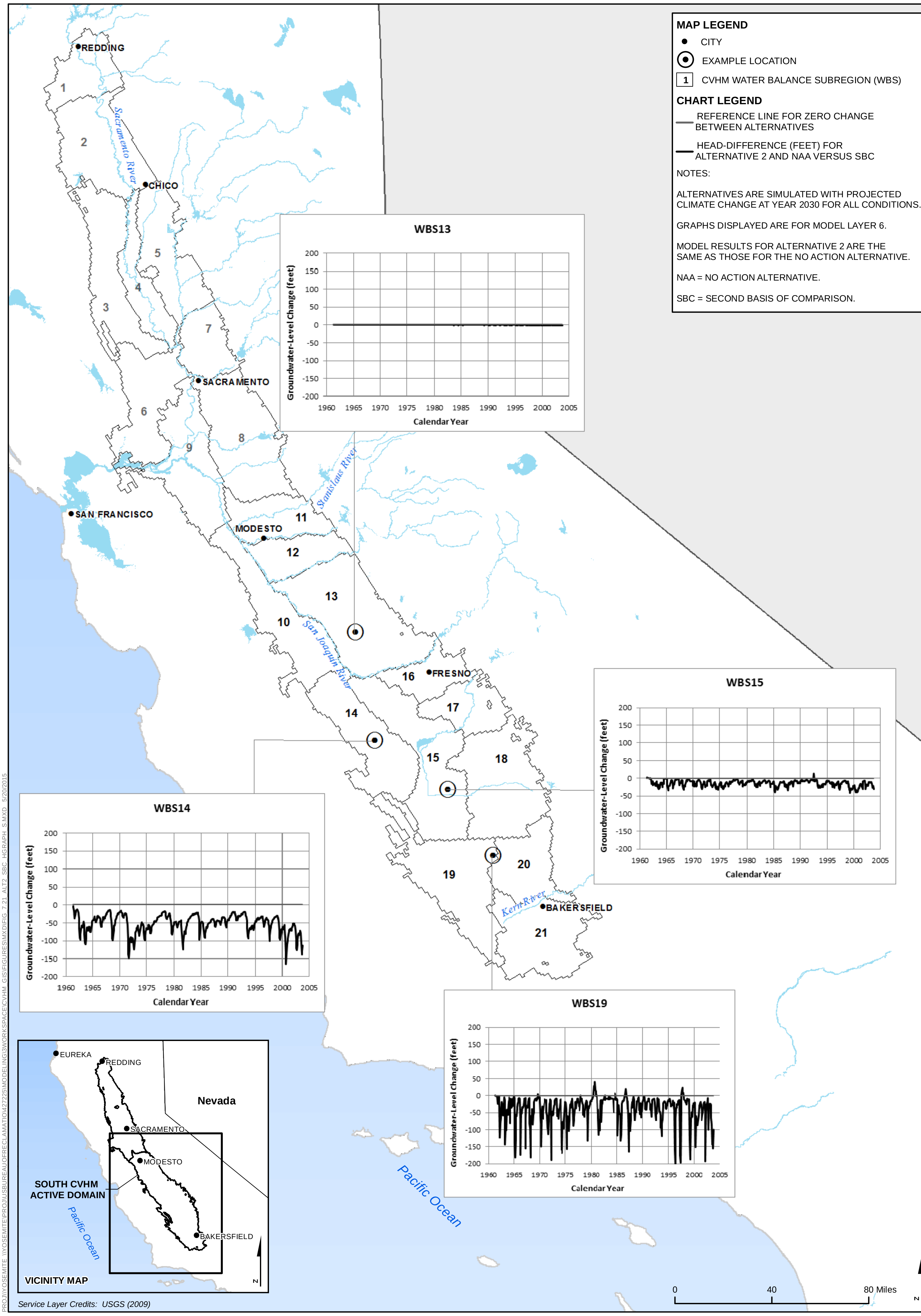



**Figure 7.21 Forecast Groundwater-Level Change Hydrographs for Alternative 2 and No Action Alternative Compared to Second Basis of Comparison at Example Locations in the San Joaquin Valley**

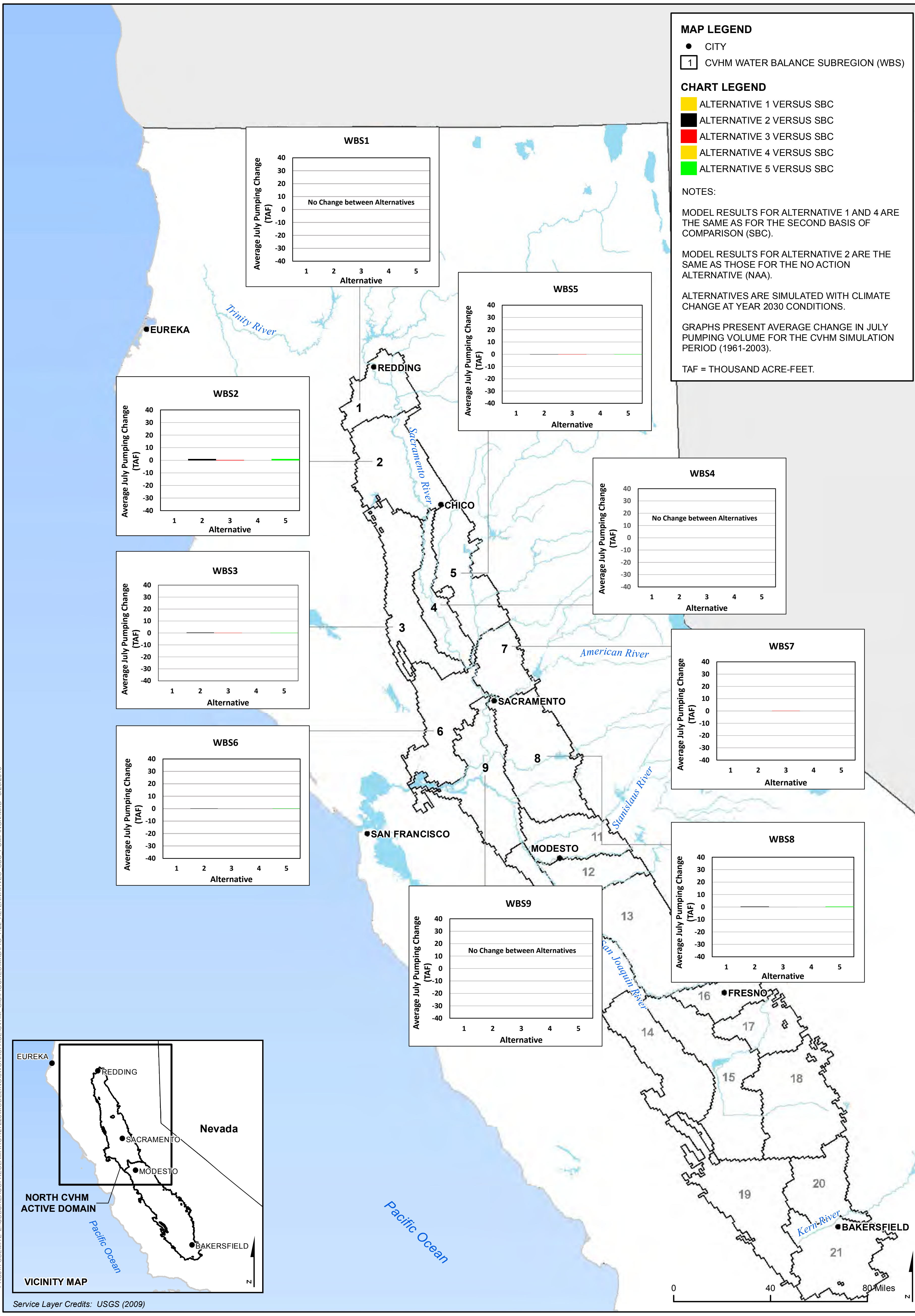



**Figure 7.22 Long-term Average Change in July Agricultural Groundwater Pumping for Alternatives Compared to the Second Basis of Comparison in the Sacramento Valley**

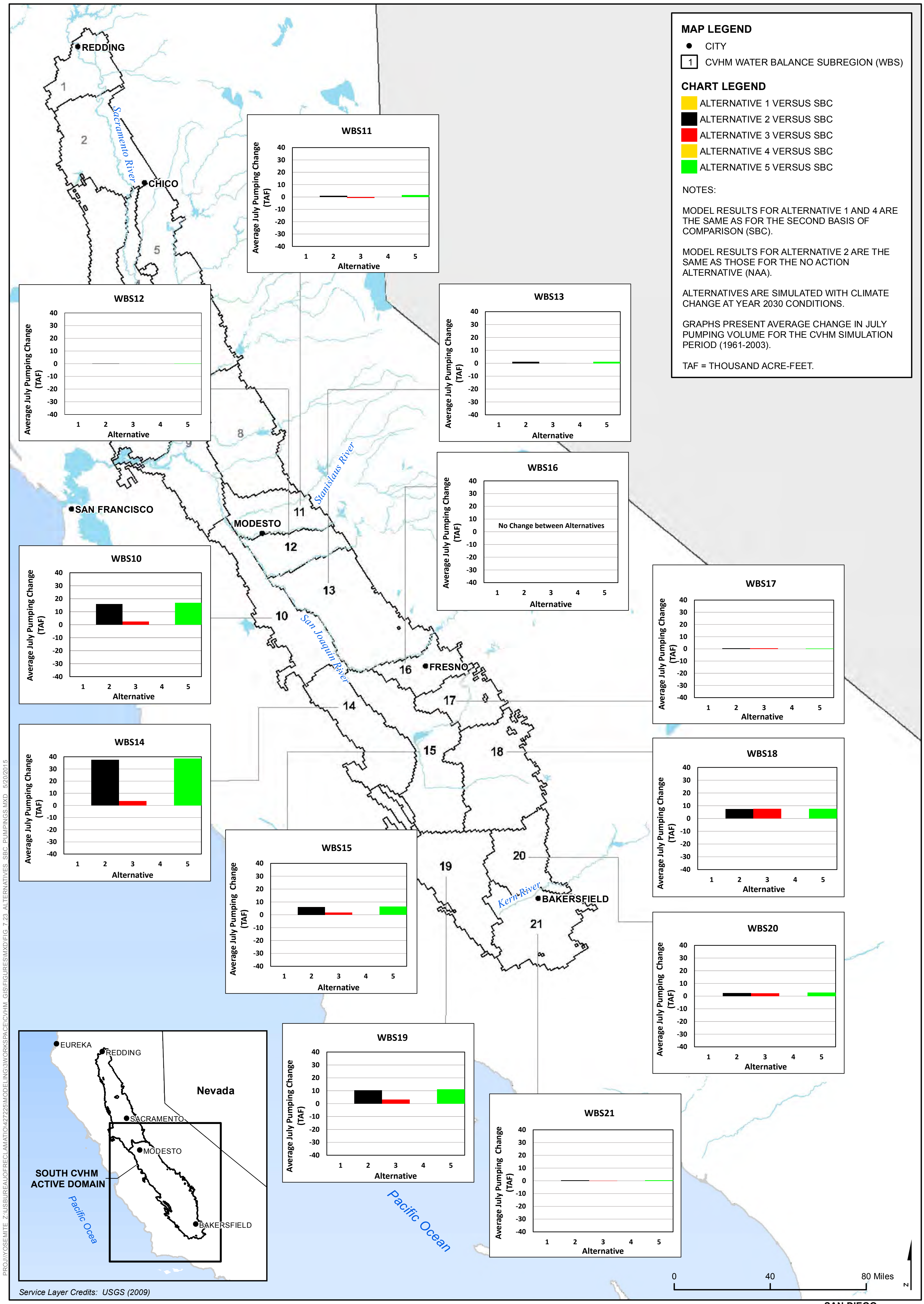



**Figure 7.23 Long-term Average Change in July Agricultural Groundwater Pumping for Alternatives Compared to the Second Basis of Comparison in the San Joaquin Valley**

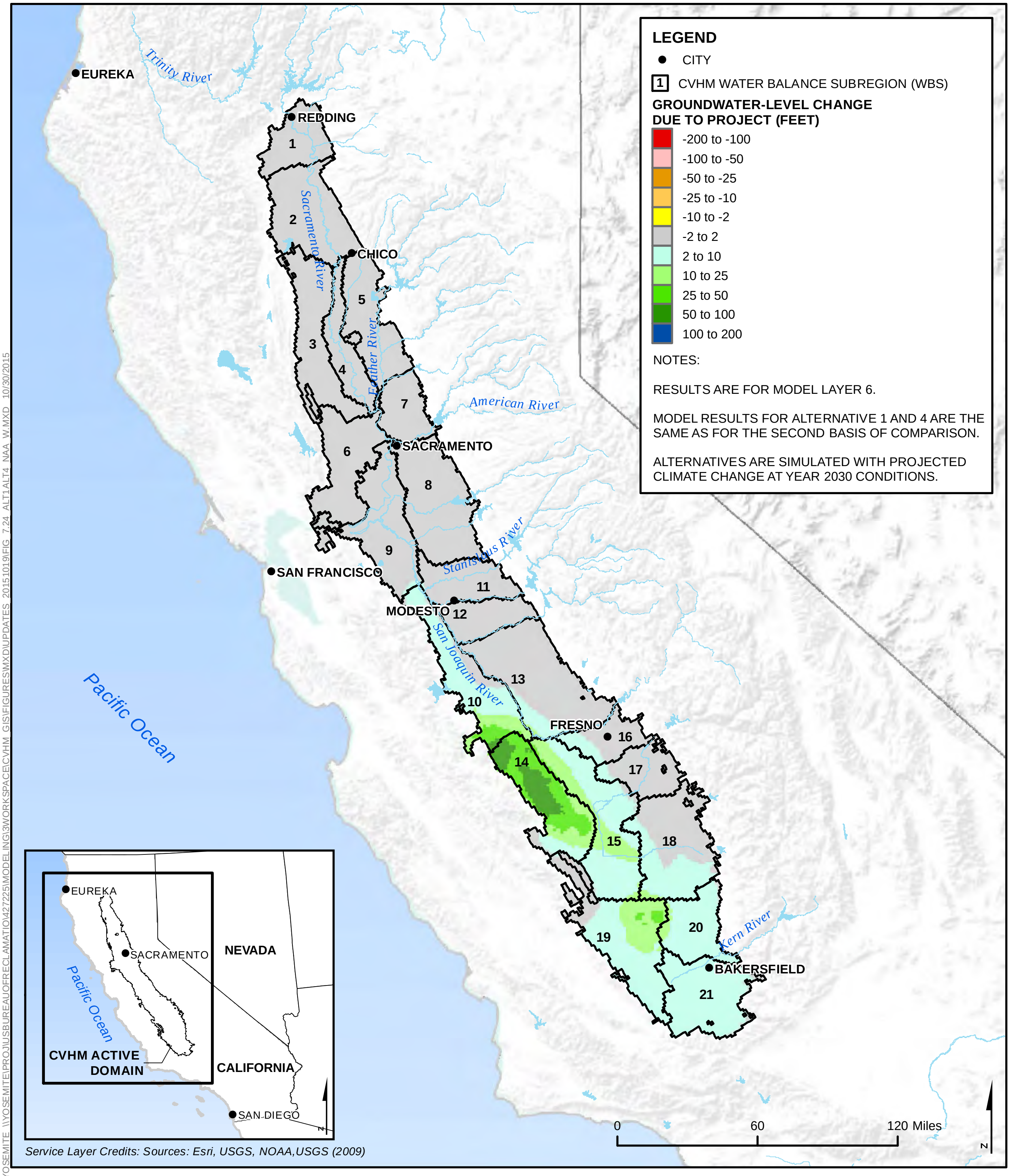



**Figure 7.24 Forecast Groundwater-Level Changes for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative For Average July in a Future Wet Year**

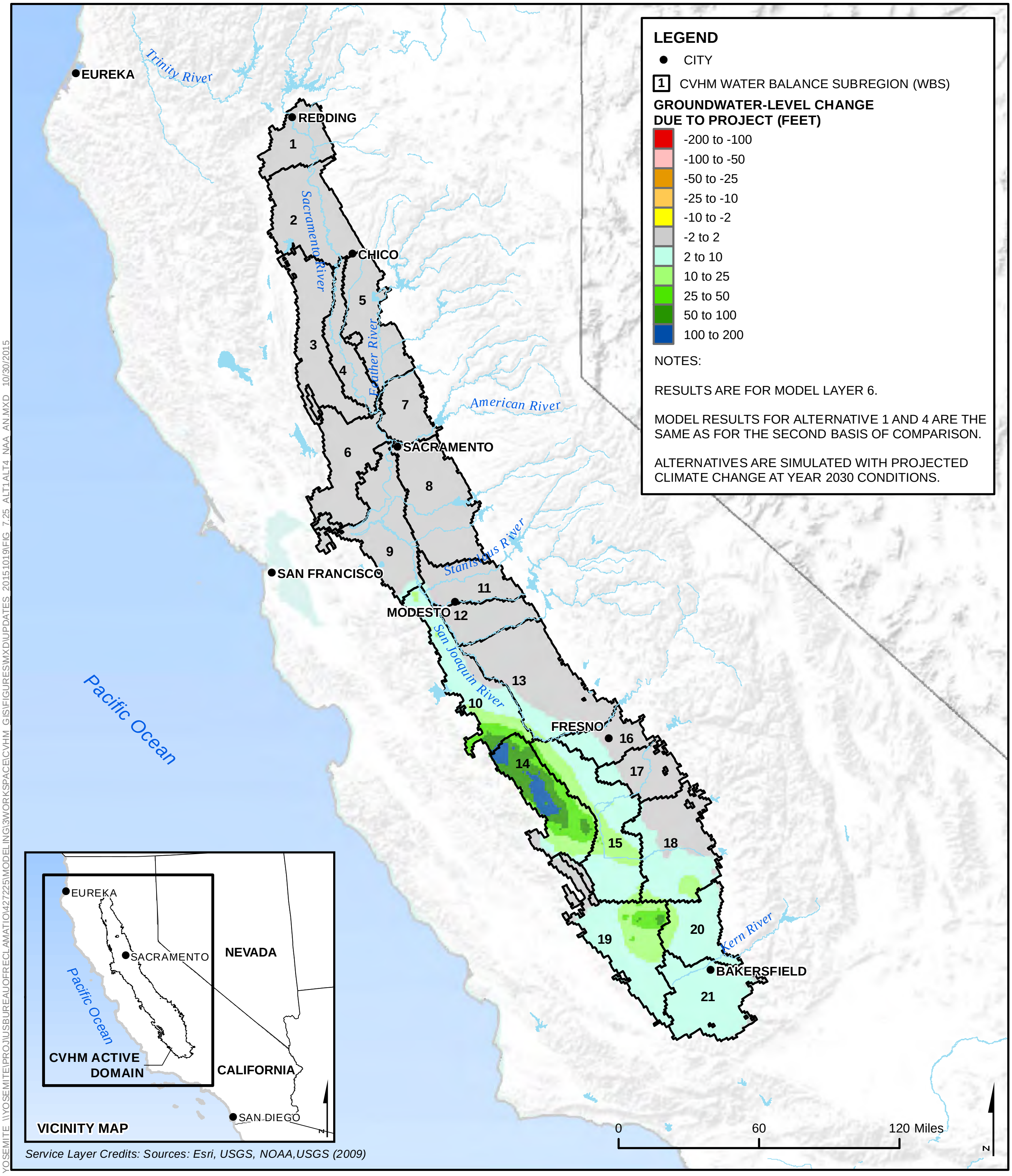



**Figure 7.25 Forecast Groundwater-Level Changes for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative for Average July in a Future Above-Normal Year**

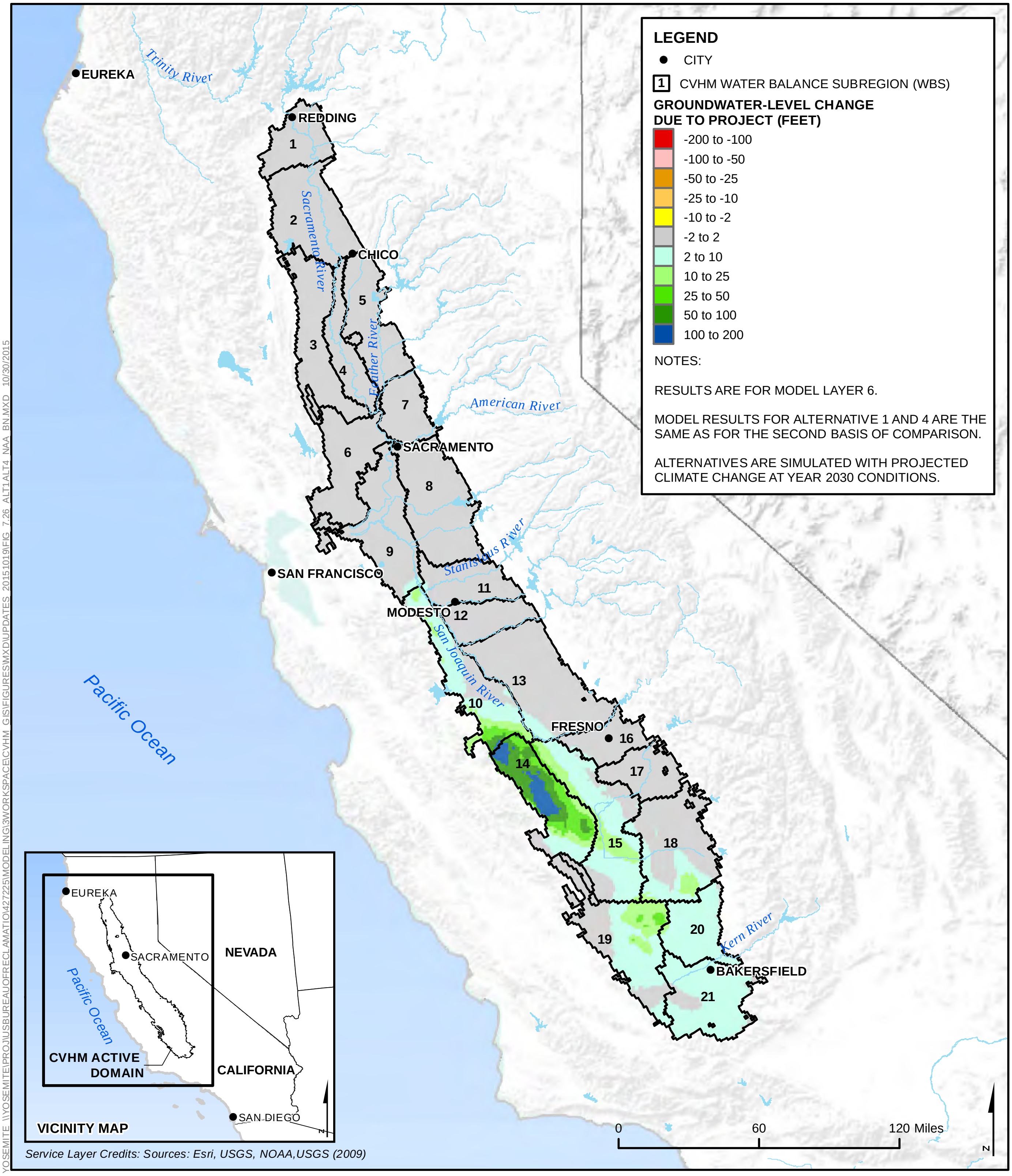



**Figure 7.26 Forecast Groundwater-Level Changes for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative For Average July in a Future Below-Normal Year**

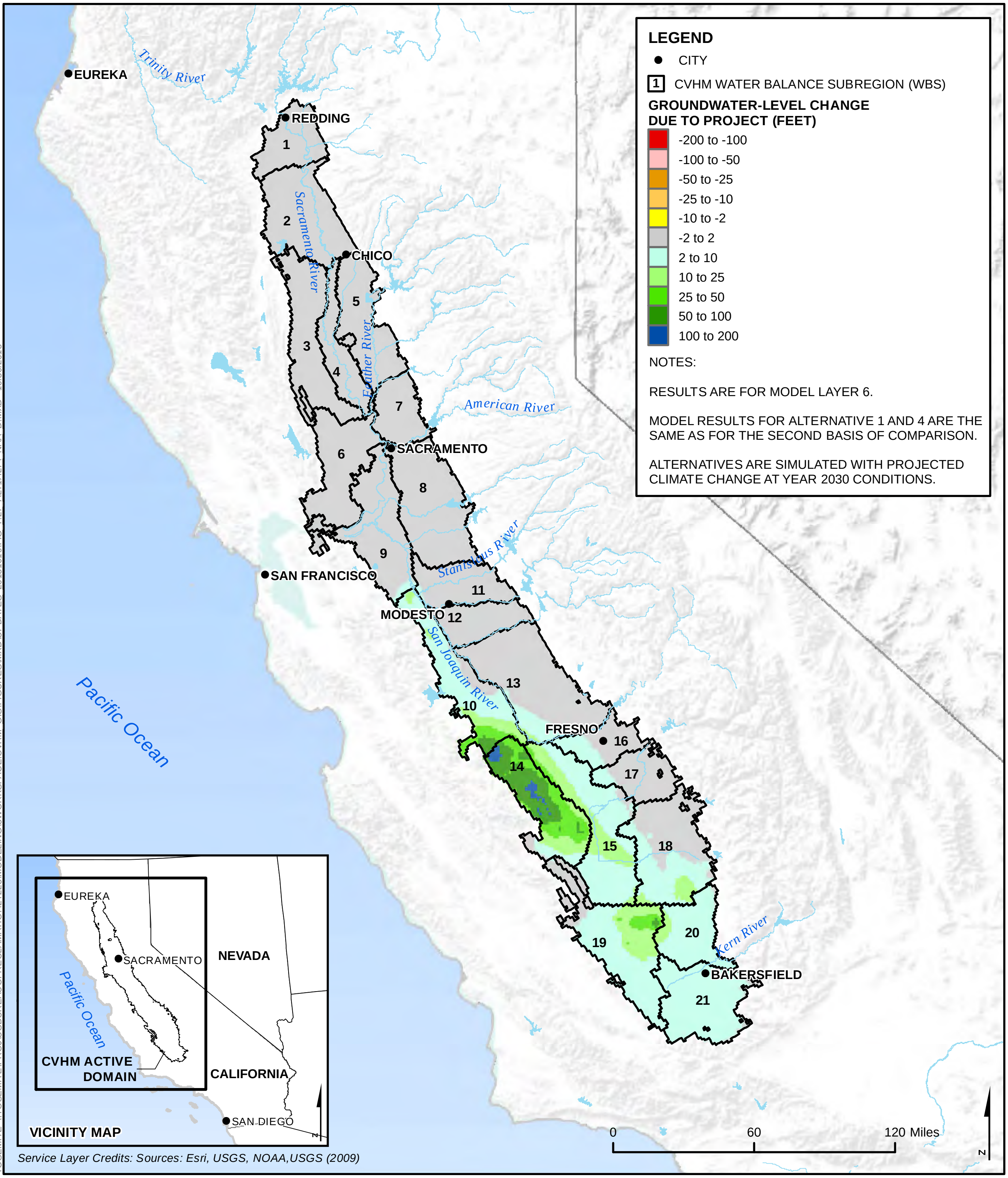



**Figure 7.27 Forecast Groundwater-Level Changes for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative For Average July in a Future Dry Year**

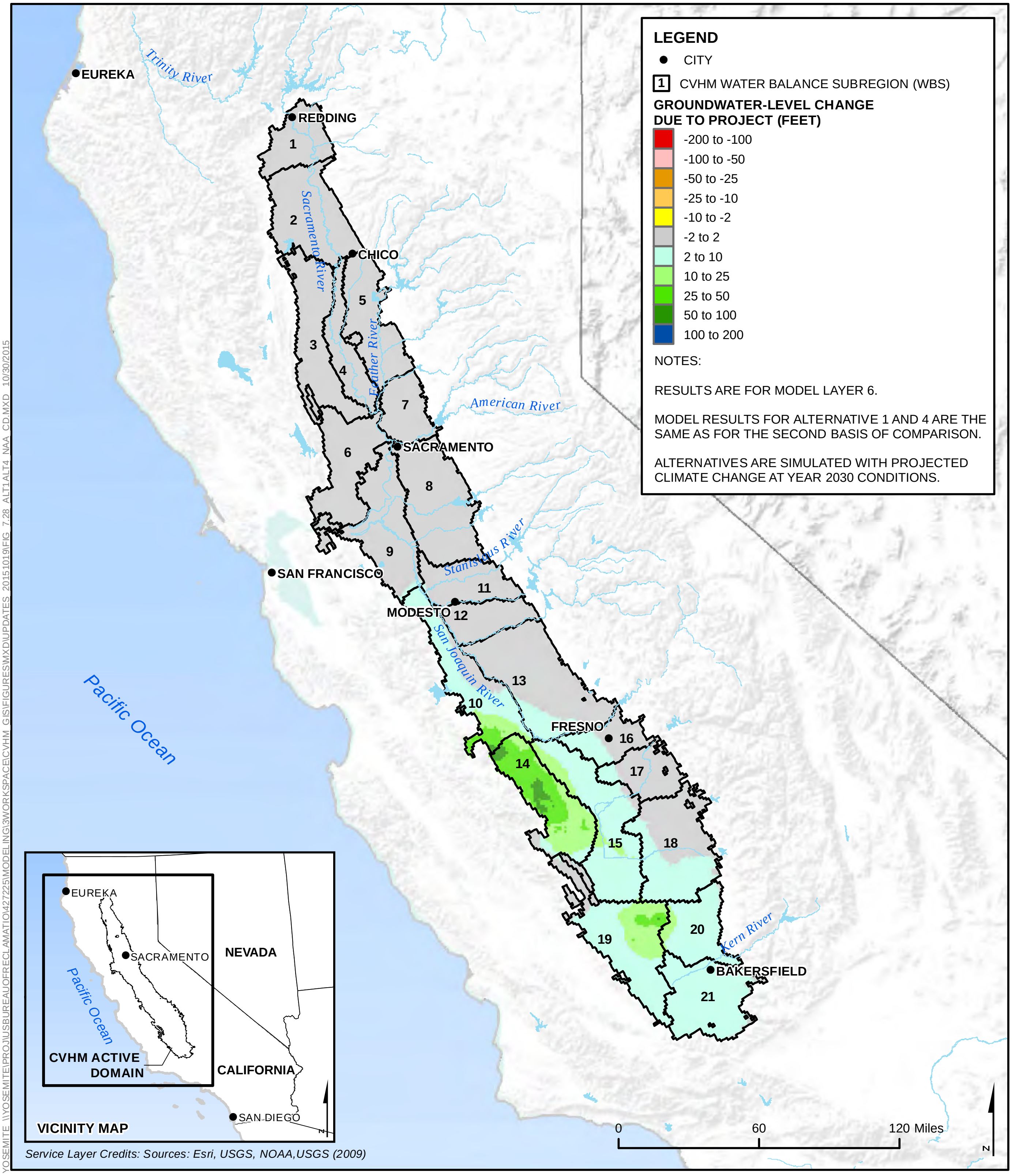



**Figure 7.28 Forecast Groundwater-Level Changes for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative For Average July in a Future Critically-Dry Year**

This page left blank intentionally.

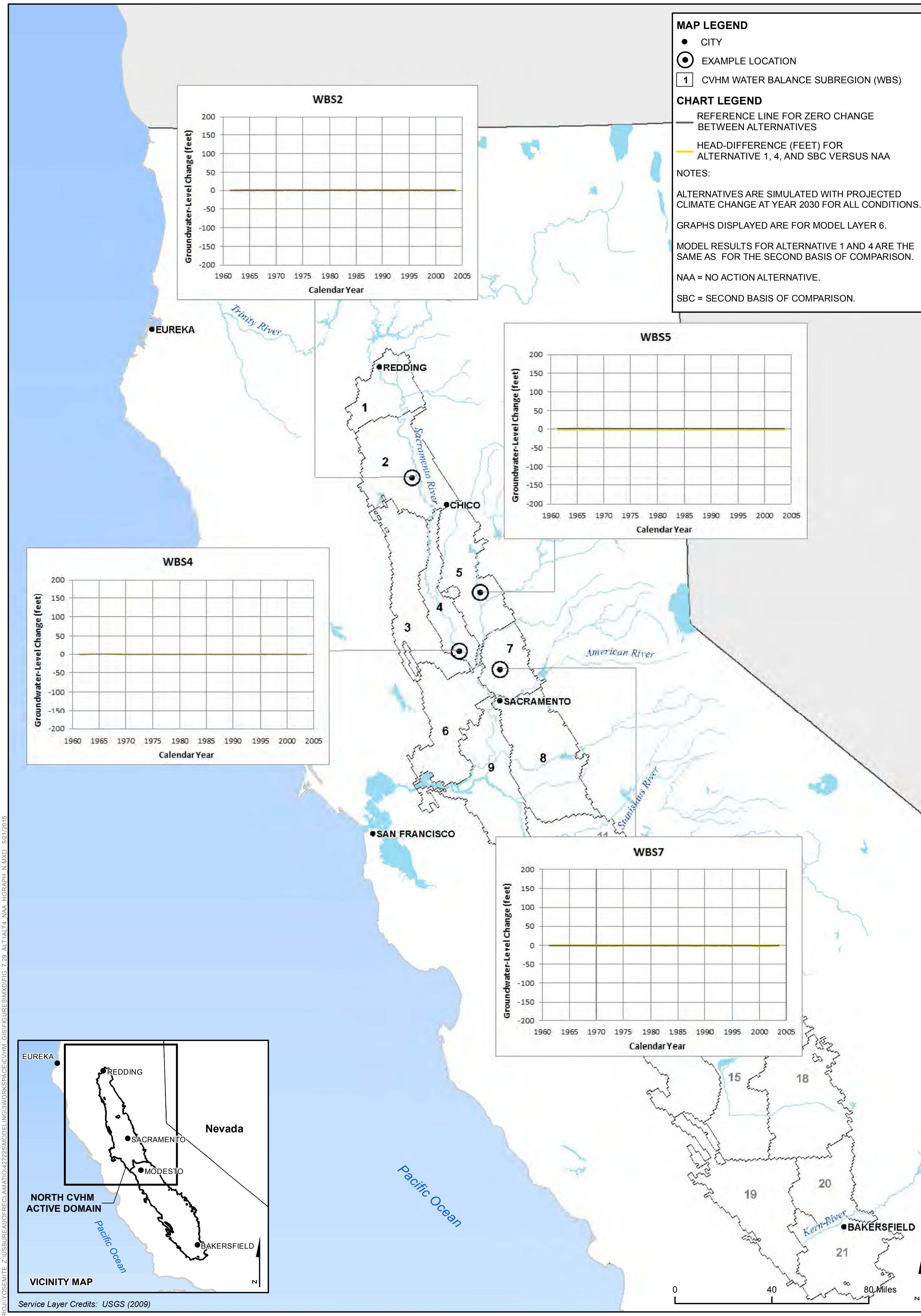



**Figure 7.29 Forecast Groundwater-Level Change Hydrographs for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative at Example Locations in the Sacramento Valley**

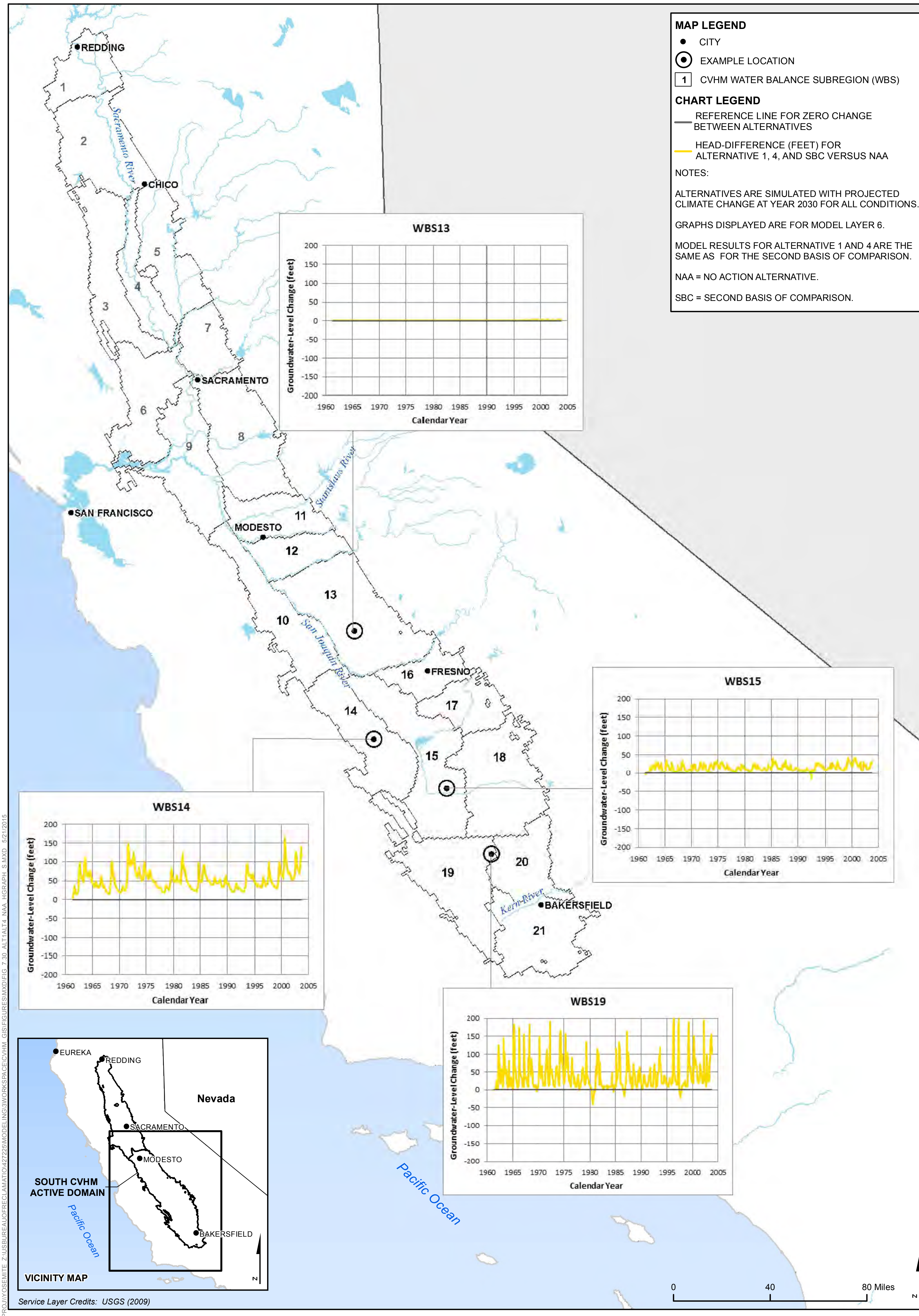



**Figure 7.30 Forecast Groundwater-Level Change Hydrographs for Alternative 1, Alternative 4, and Second Basis of Comparison Compared to No Action Alternative at Example Locations in the San Joaquin Valley**

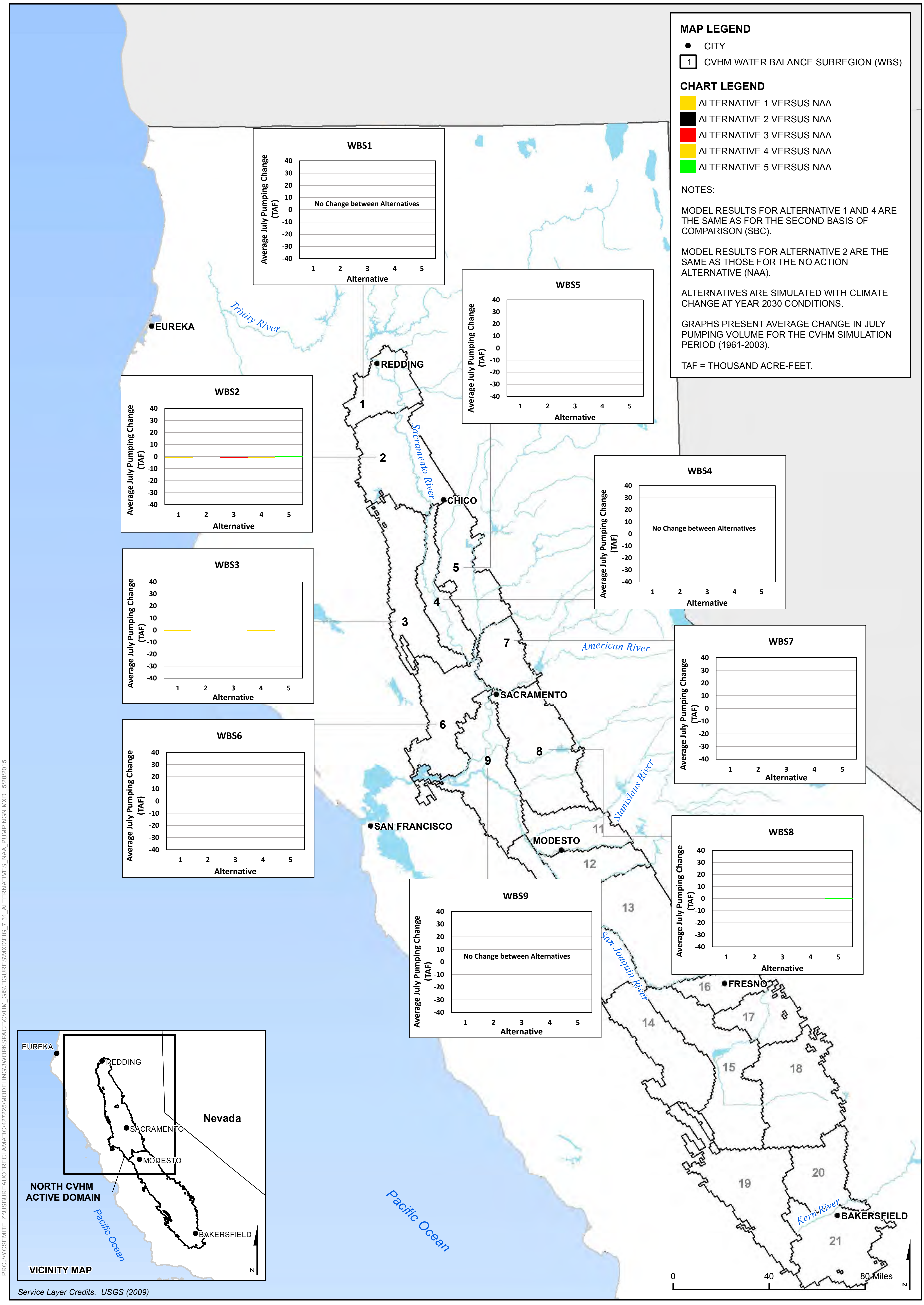



**Figure 7.31 Long-term Average Change in July Agricultural Groundwater Pumping for Alternatives Compared to the No Action Alternative in the Sacramento Valley**

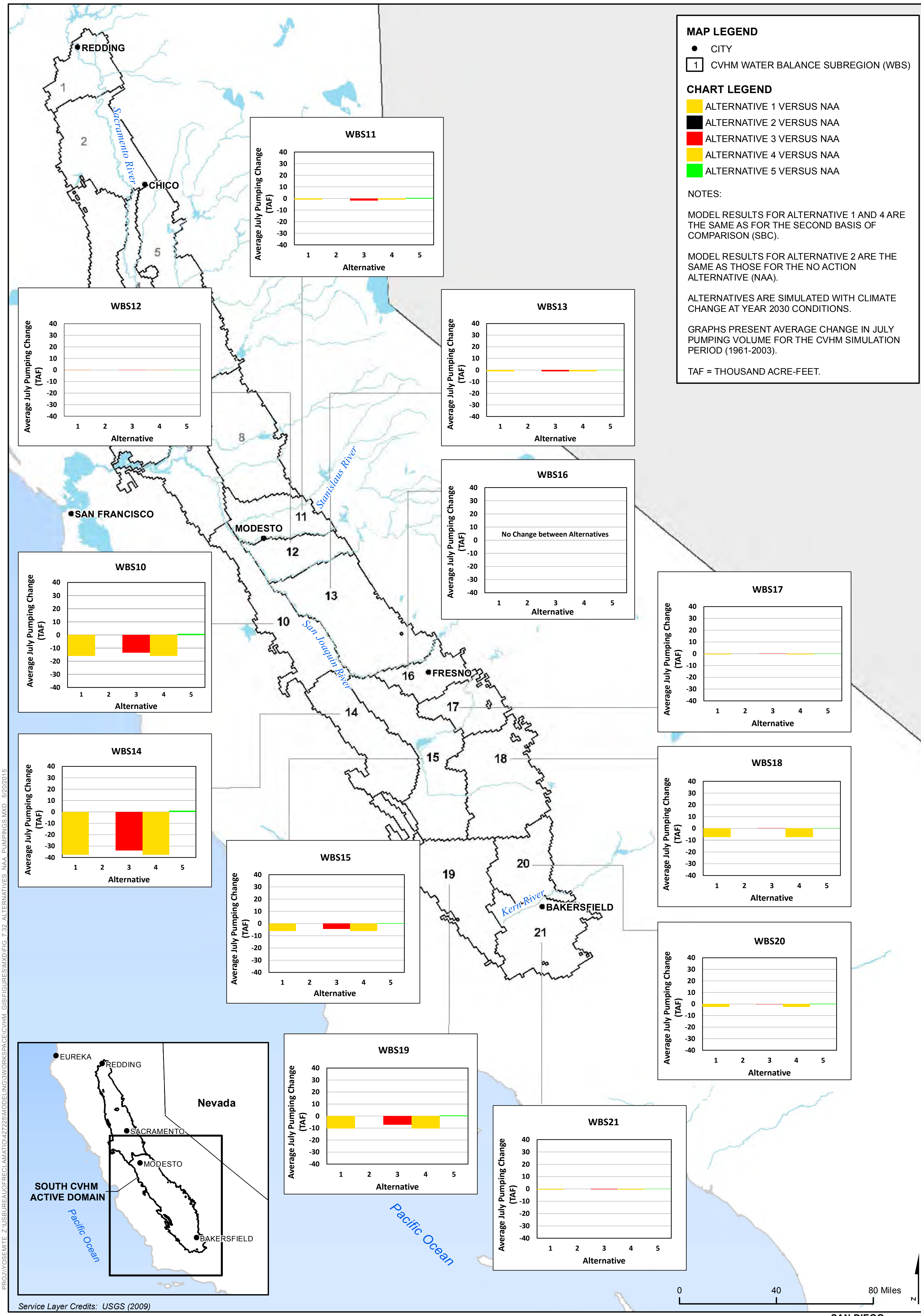



**Figure 7.32 Long-term Average Change in July Agricultural Groundwater Pumping for Alternatives Compared to the No Action Alternative in the San Joaquin Valley**

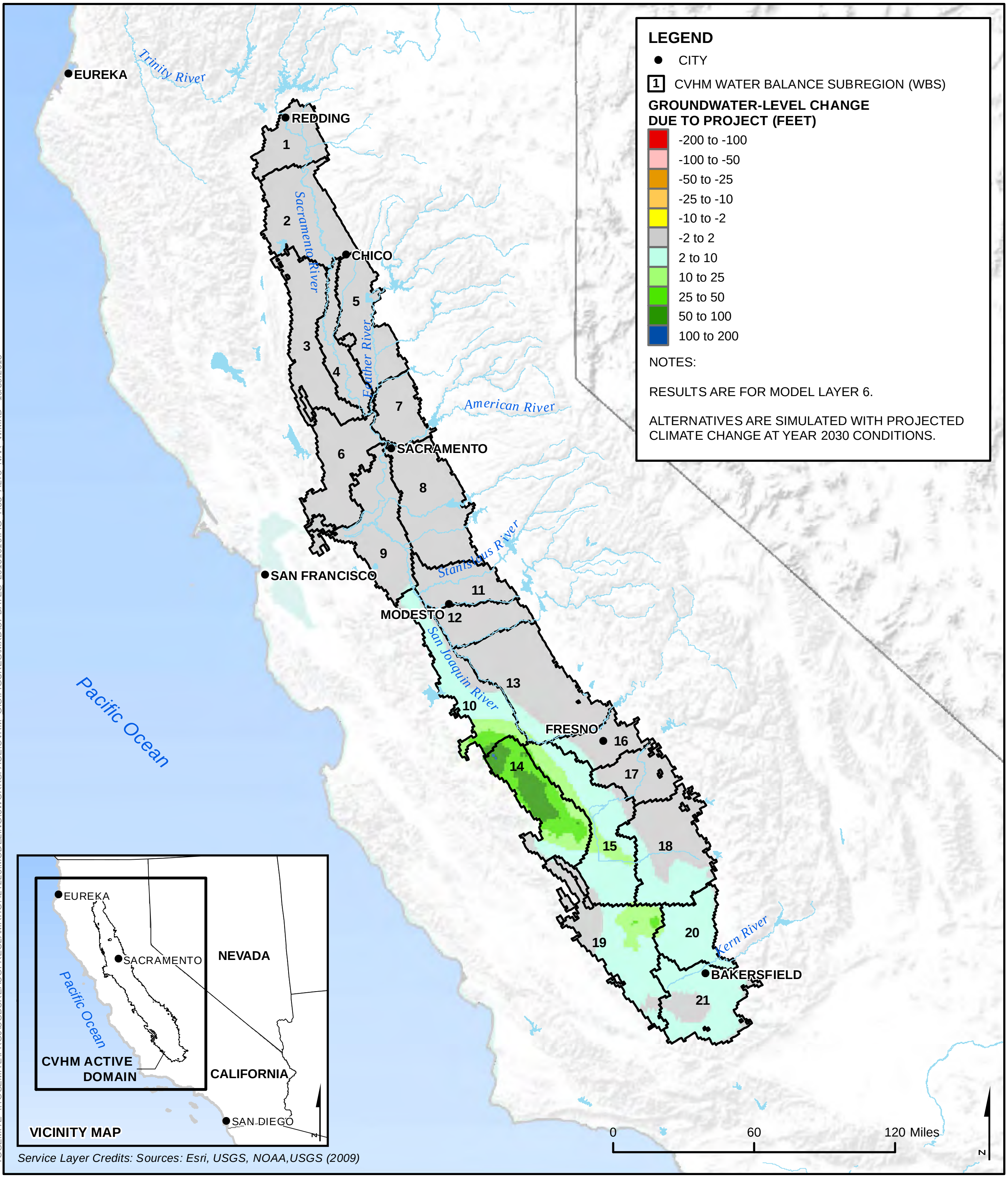



**Figure 7.33 Forecast Groundwater-Level Changes for Alternative 3 Compared to No Action Alternative for Average July in a Future Wet Year**

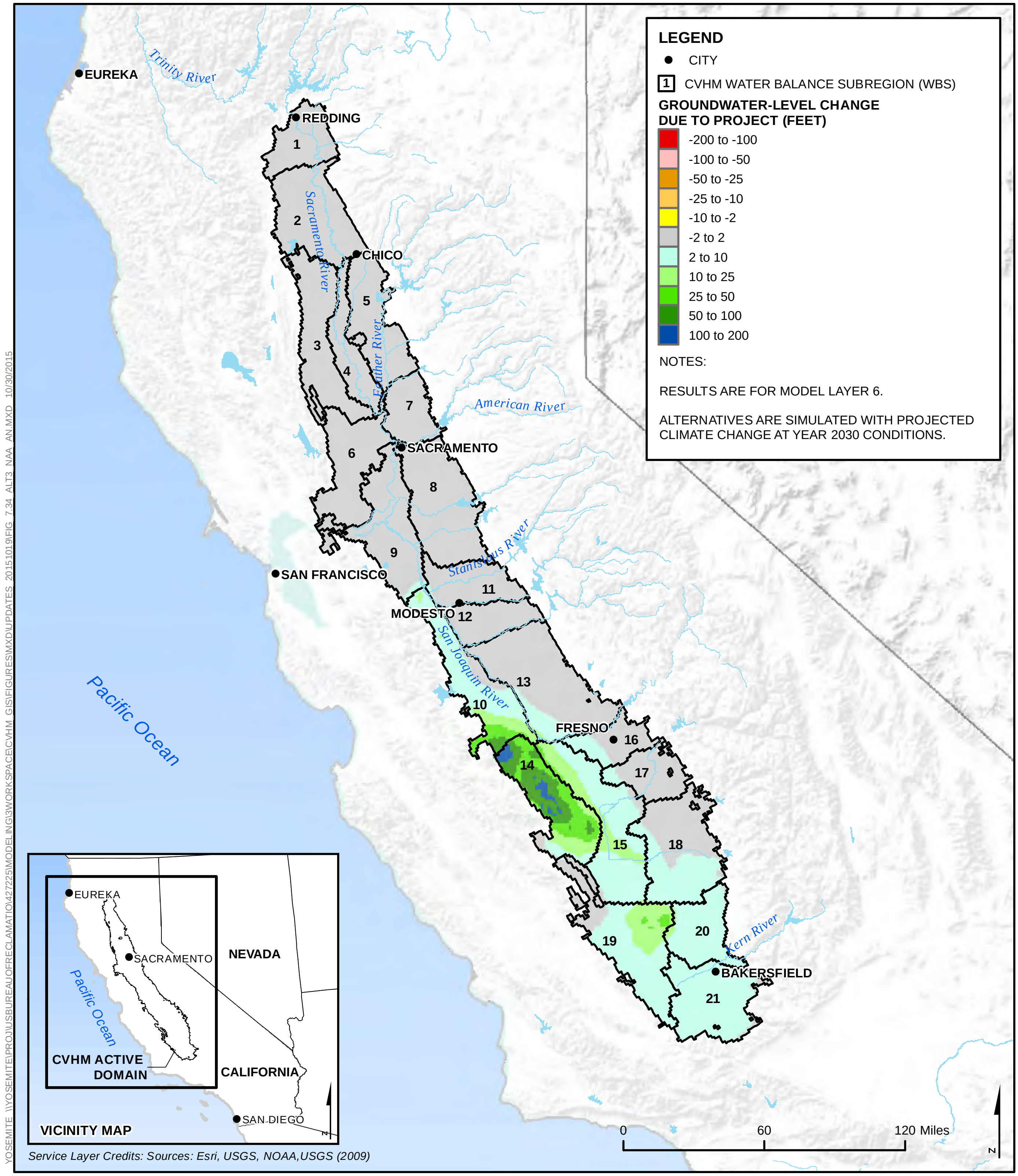



**Figure 7.34 Forecast Groundwater-Level Changes for Alternative 3 Compared to No Action Alternative for Average July in a Future Above-Normal Year**

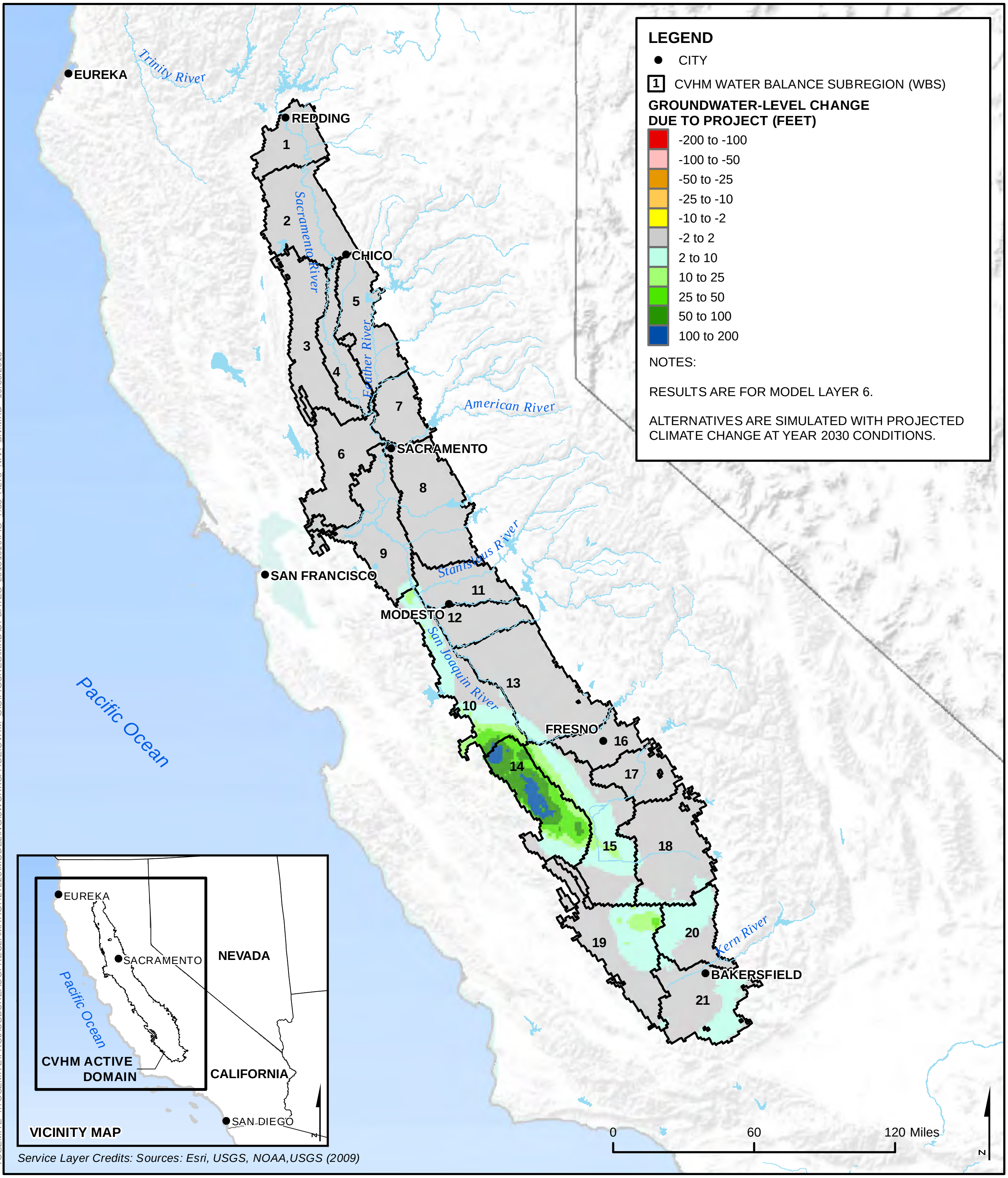



**Figure 7.35 Forecast Groundwater-Level Changes for Alternative 3 Compared to No Action Alternative for Average July in a Future Below-Normal Year**

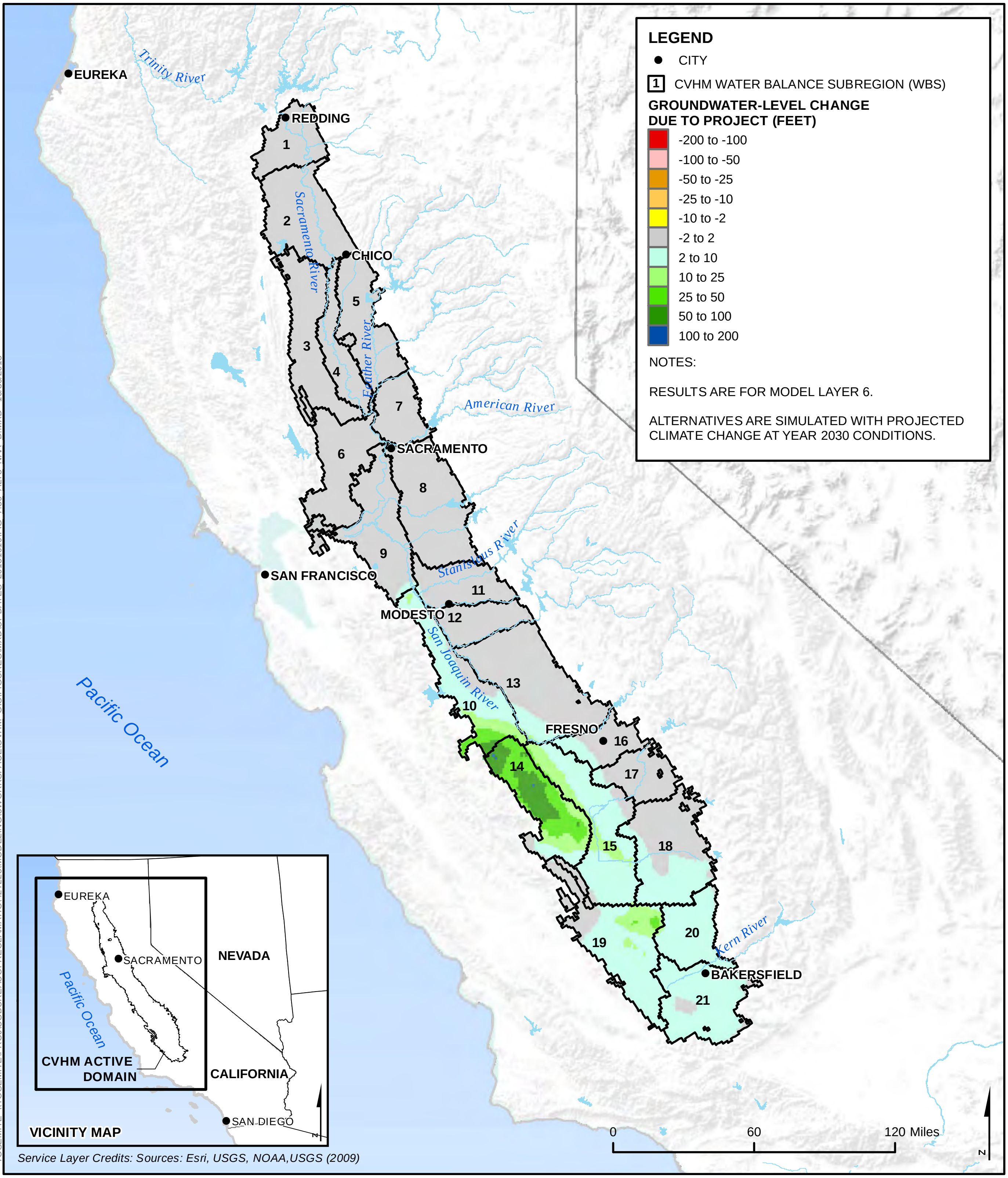



**Figure 7.36 Forecast Groundwater-Level Changes for Alternative 3 Compared to No Action Alternative for Average July in a Future Dry Year**

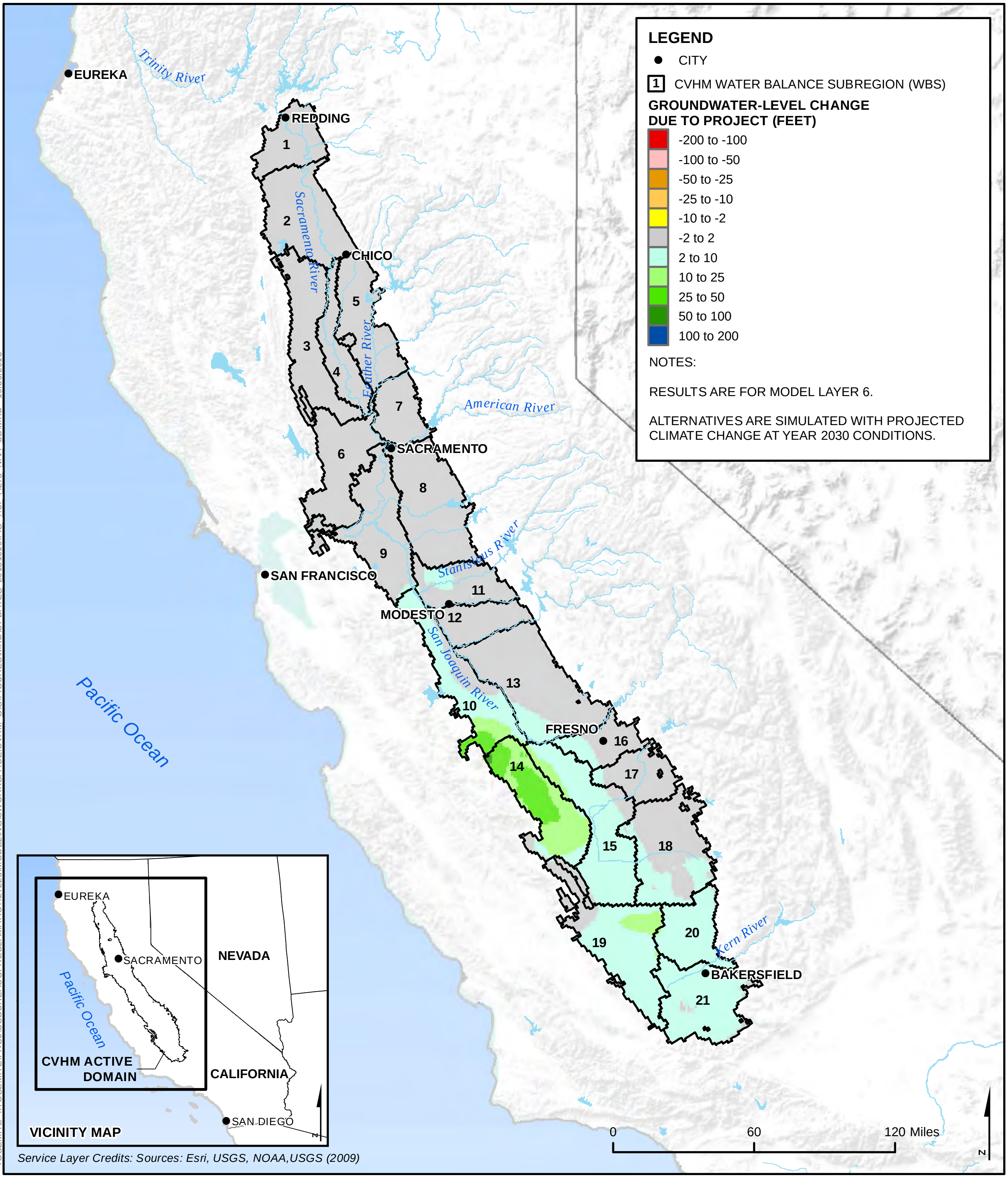



**Figure 7.37 Forecast Groundwater-Level Changes for Alternative 3 Compared to No Action Alternative for Average July in a Future Critically-Dry Year**

This page left blank intentionally.

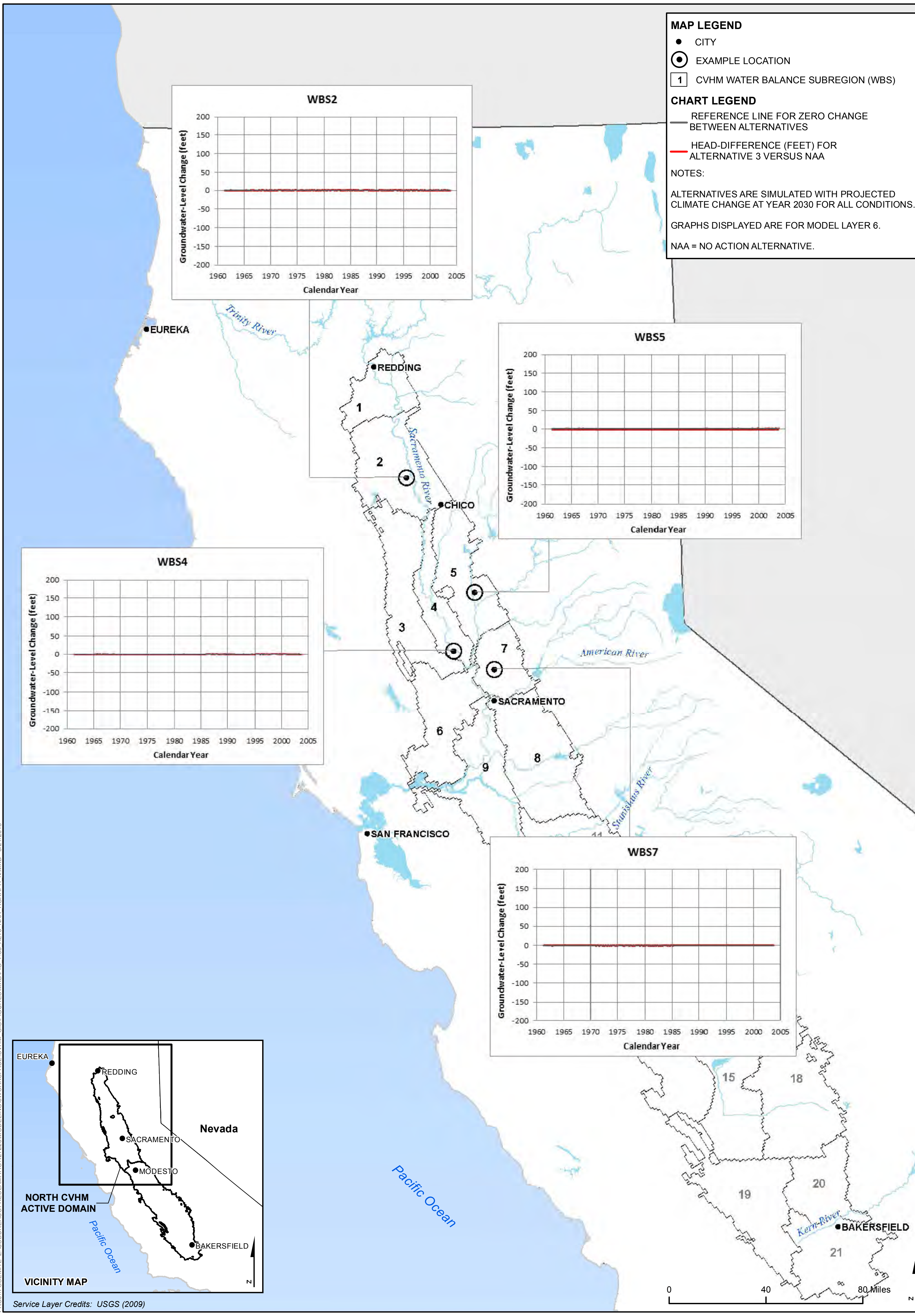



**Figure 7.38 Forecast Groundwater-Level Change Hydrographs for Alternative 3 Compared to No Action Alternative at Example Locations in the Sacramento Valley**

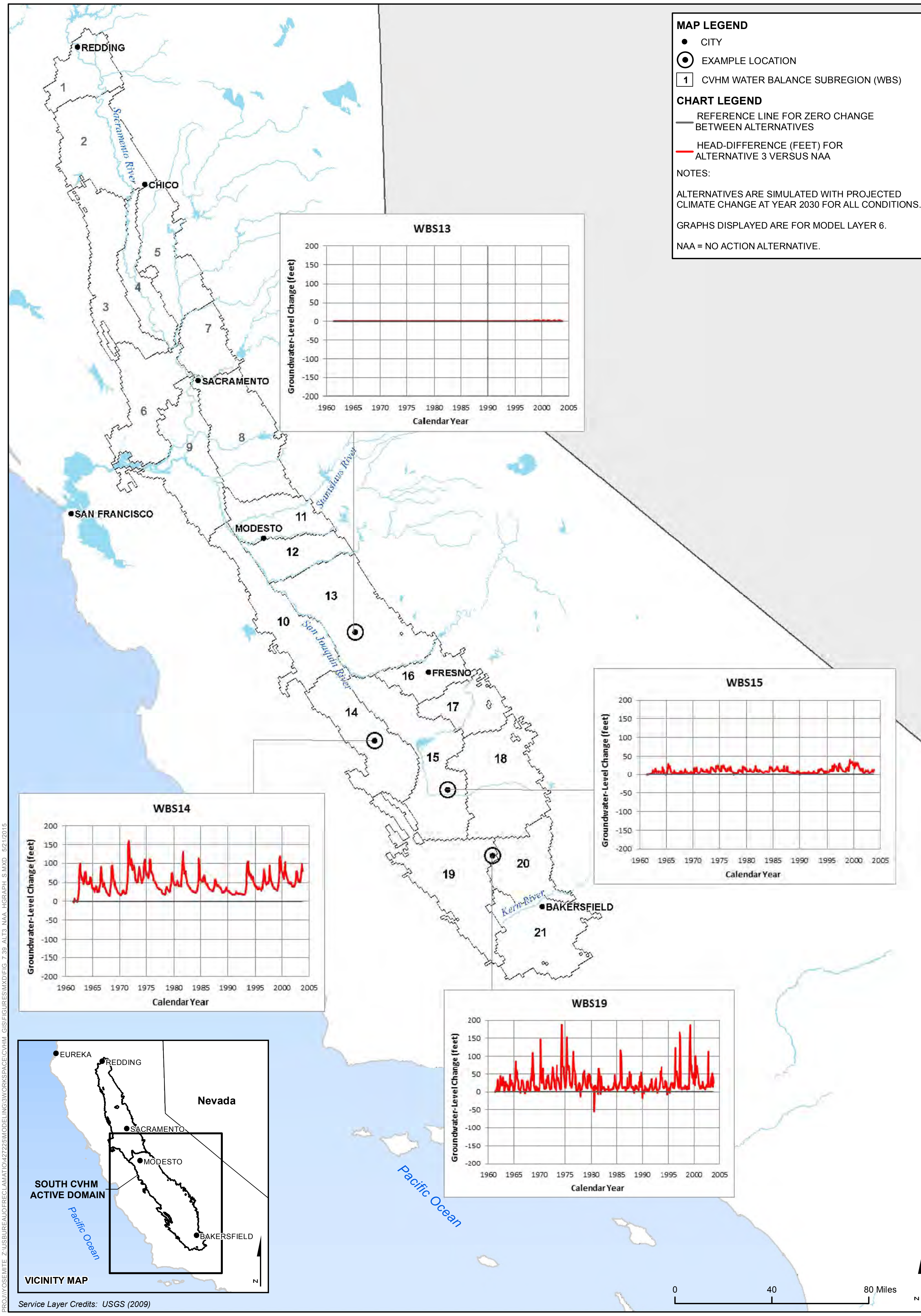



**Figure 7.39 Forecast Groundwater-Level Change Hydrographs for Alternative 3 Compared to No Action Alternative at Example Locations in the San Joaquin Valley**

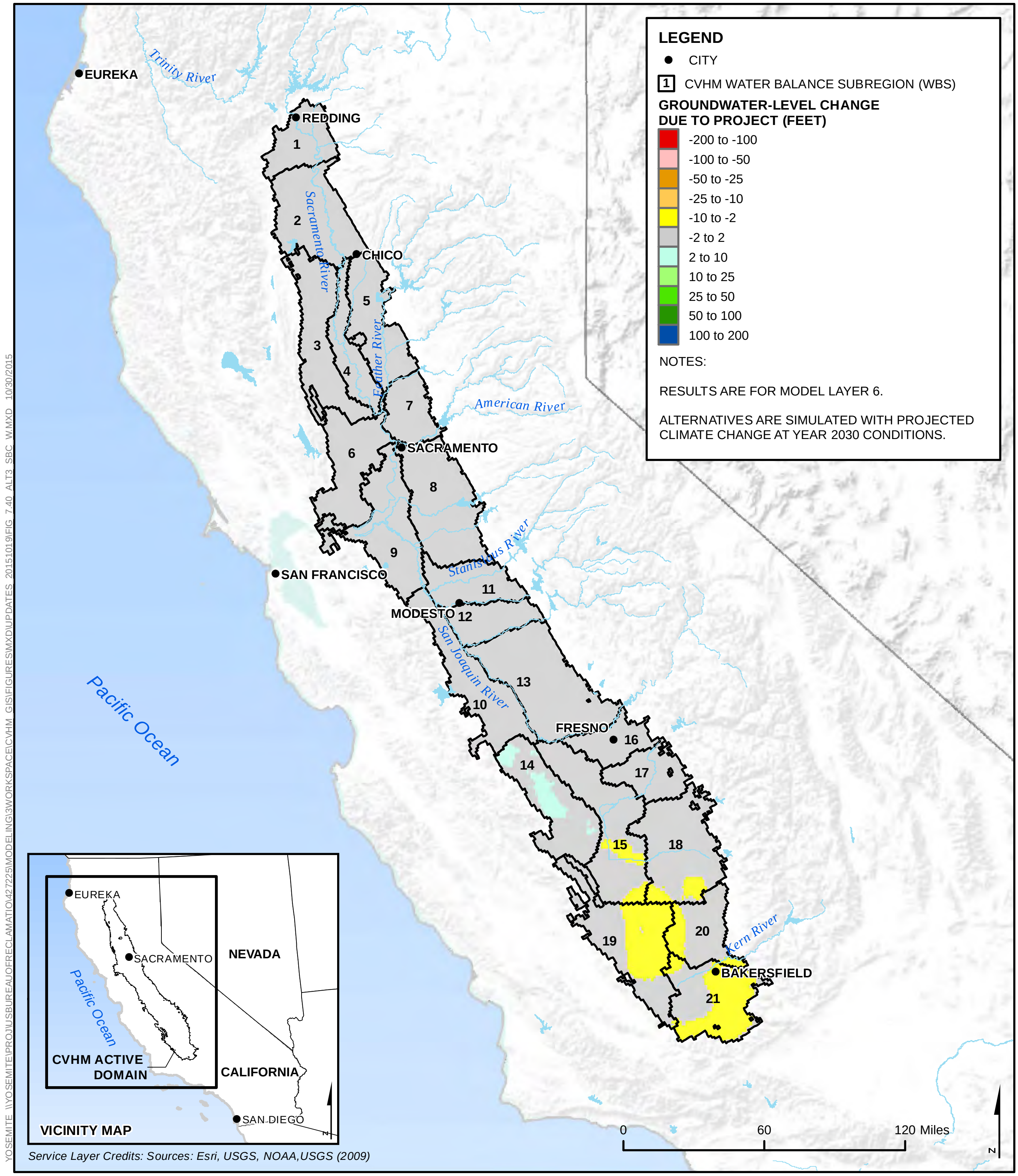



**Figure 7.40 Forecast Groundwater-Level Changes for Alternative 3 Compared to Second Basis of Comparison for Average July in a Future Wet Year**

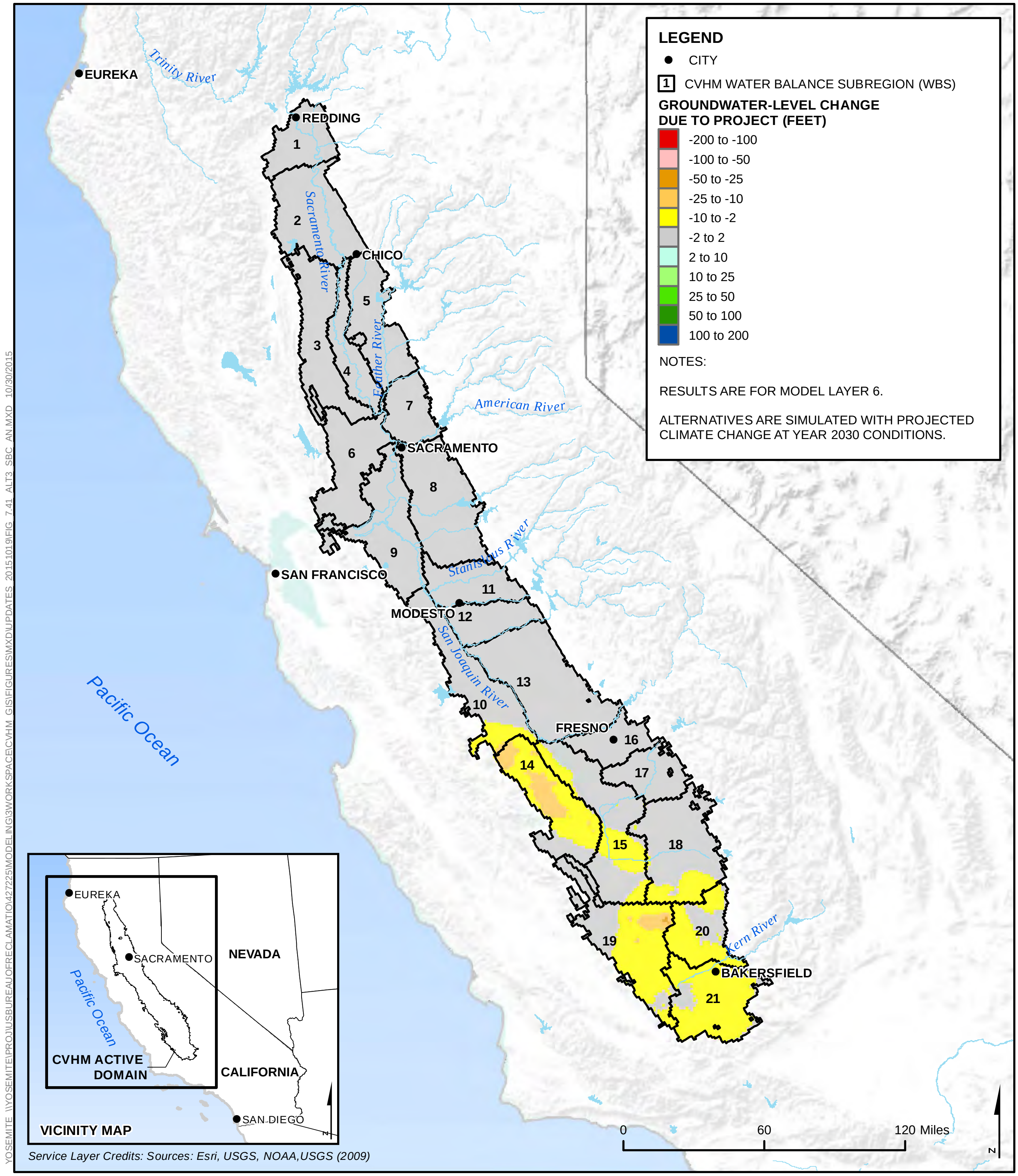



**Figure 7.41 Forecast Groundwater-Level Changes for Alternative 3 Compared to Second Basis of Comparison for Average July in a Future Above-Normal Year**

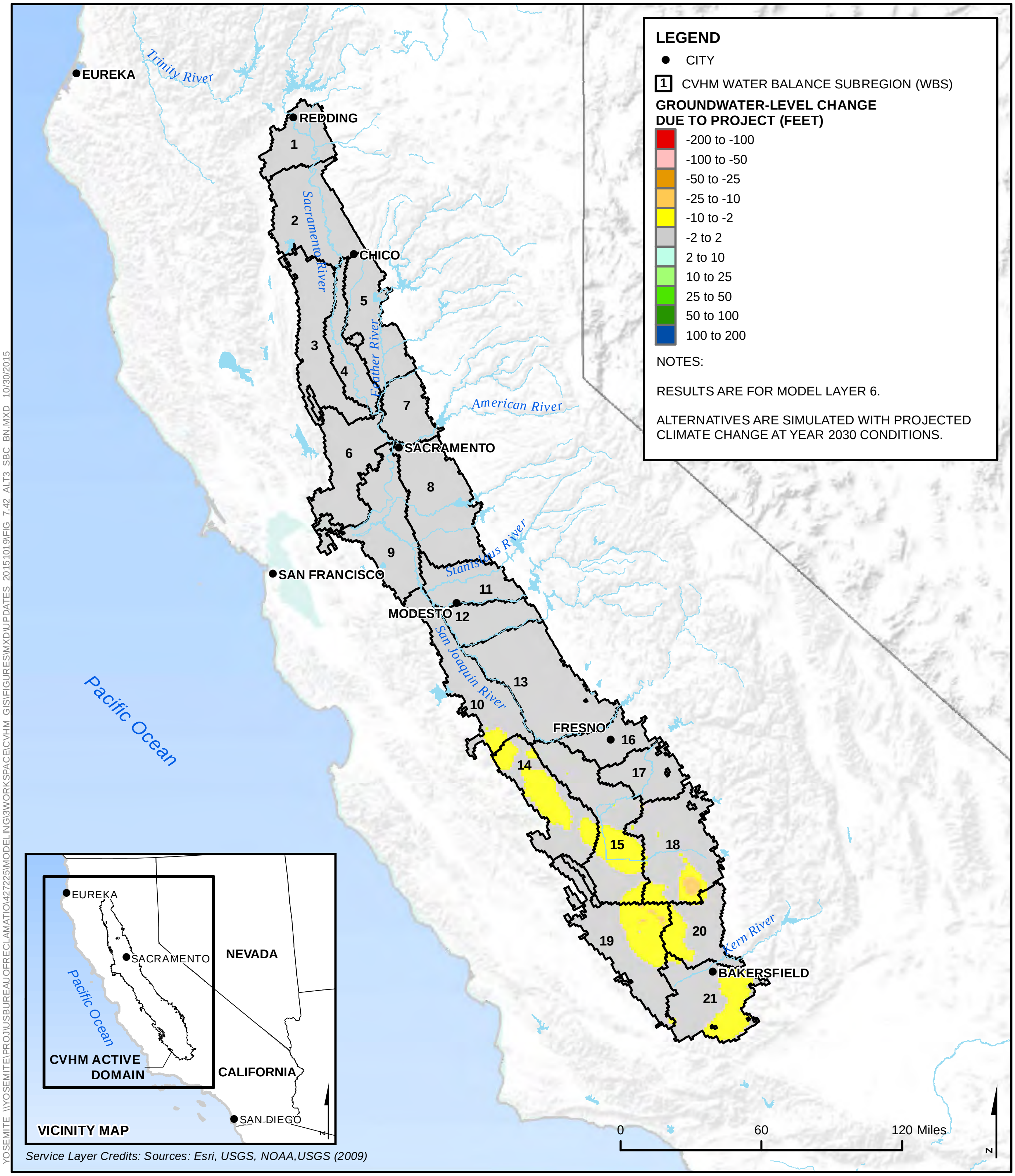



**Figure 7.42 Forecast Groundwater-Level Changes for Alternative 3 Compared to Second Basis of Comparison for Average July in a Future Below-Normal Year**

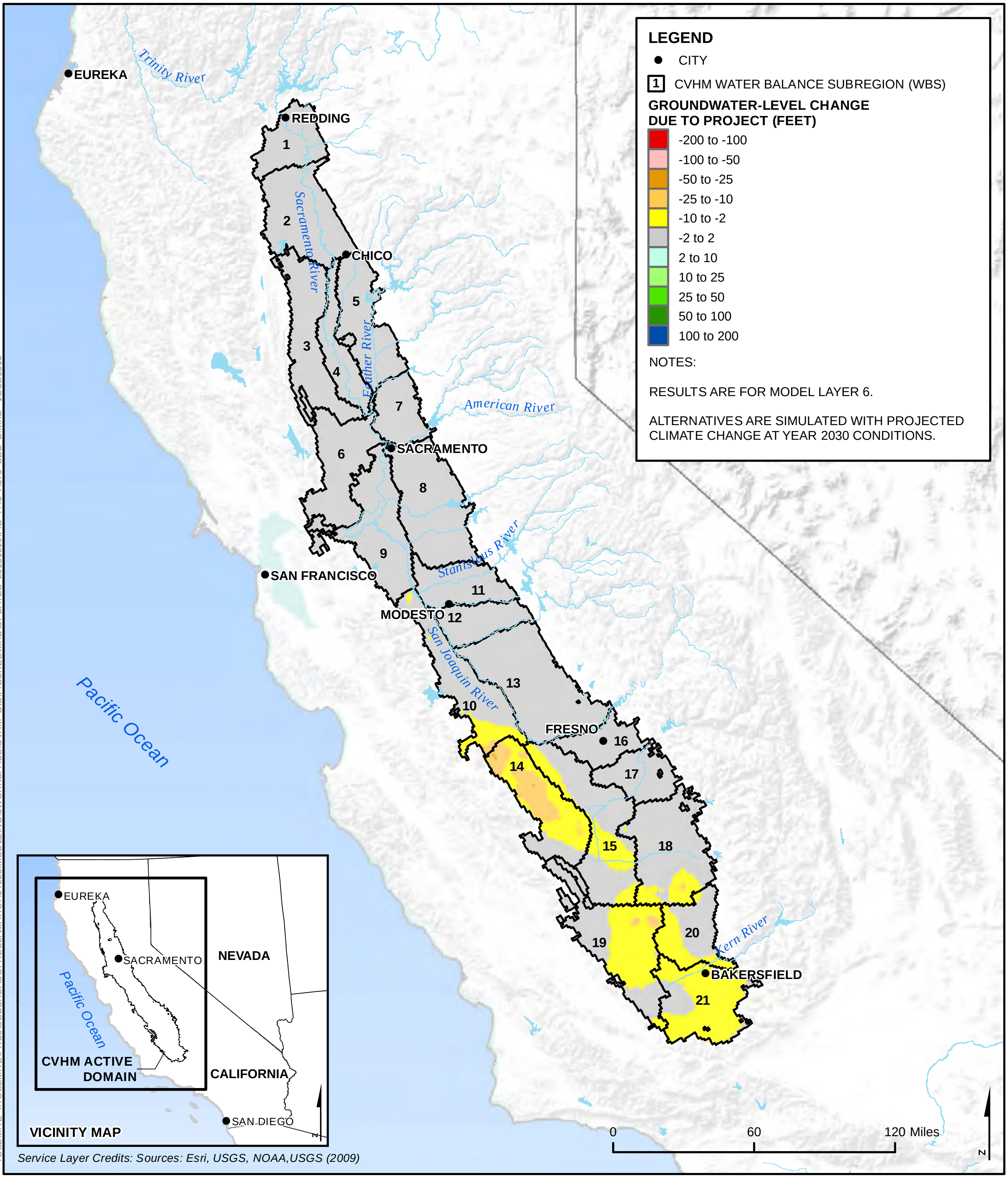



**Figure 7.43 Forecast Groundwater-Level Changes for Alternative 3 Compared to Second Basis of Comparison for Average July in a Future Dry Year**

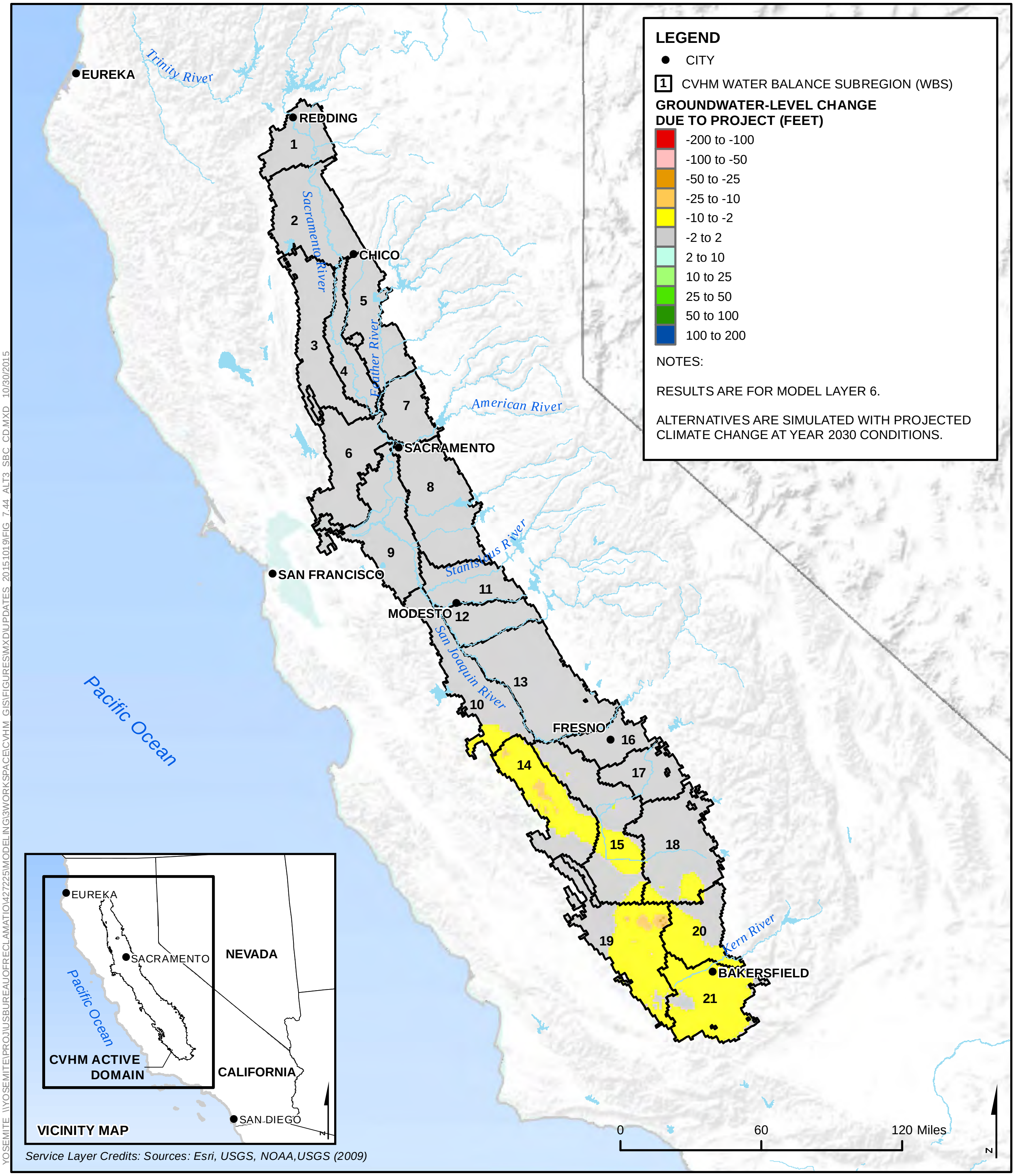



**Figure 7.44 Forecast Groundwater-Level Changes for Alternative 3 Compared to Second Basis of Comparison for Average July in a Future Critically-Dry Year**

This page left blank intentionally.

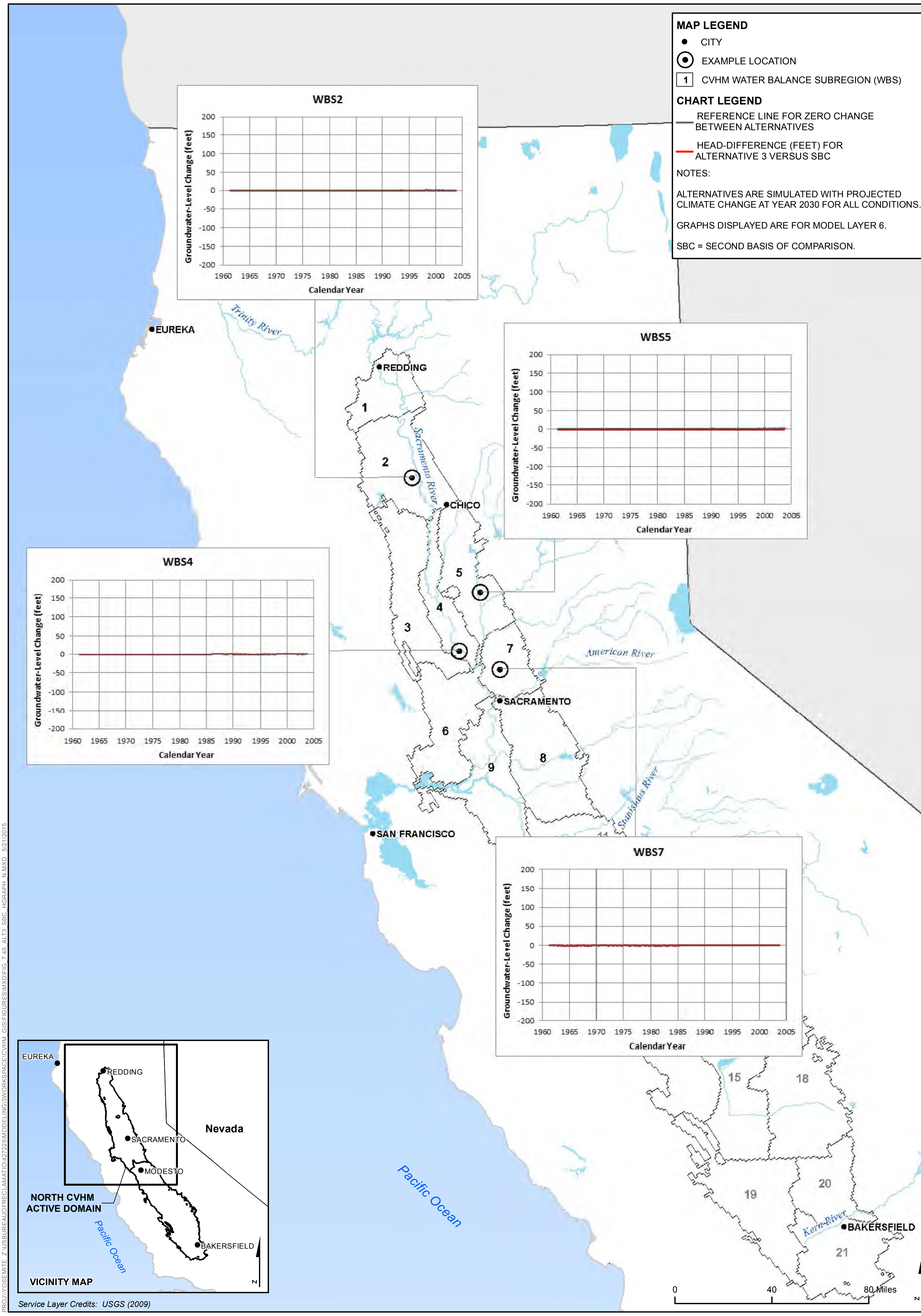



**Figure 7.45 Forecast Groundwater-Level Change Hydrographs for Alternative 3 Compared to Second Basis of Comparison at Example Locations in the Sacramento Valley**

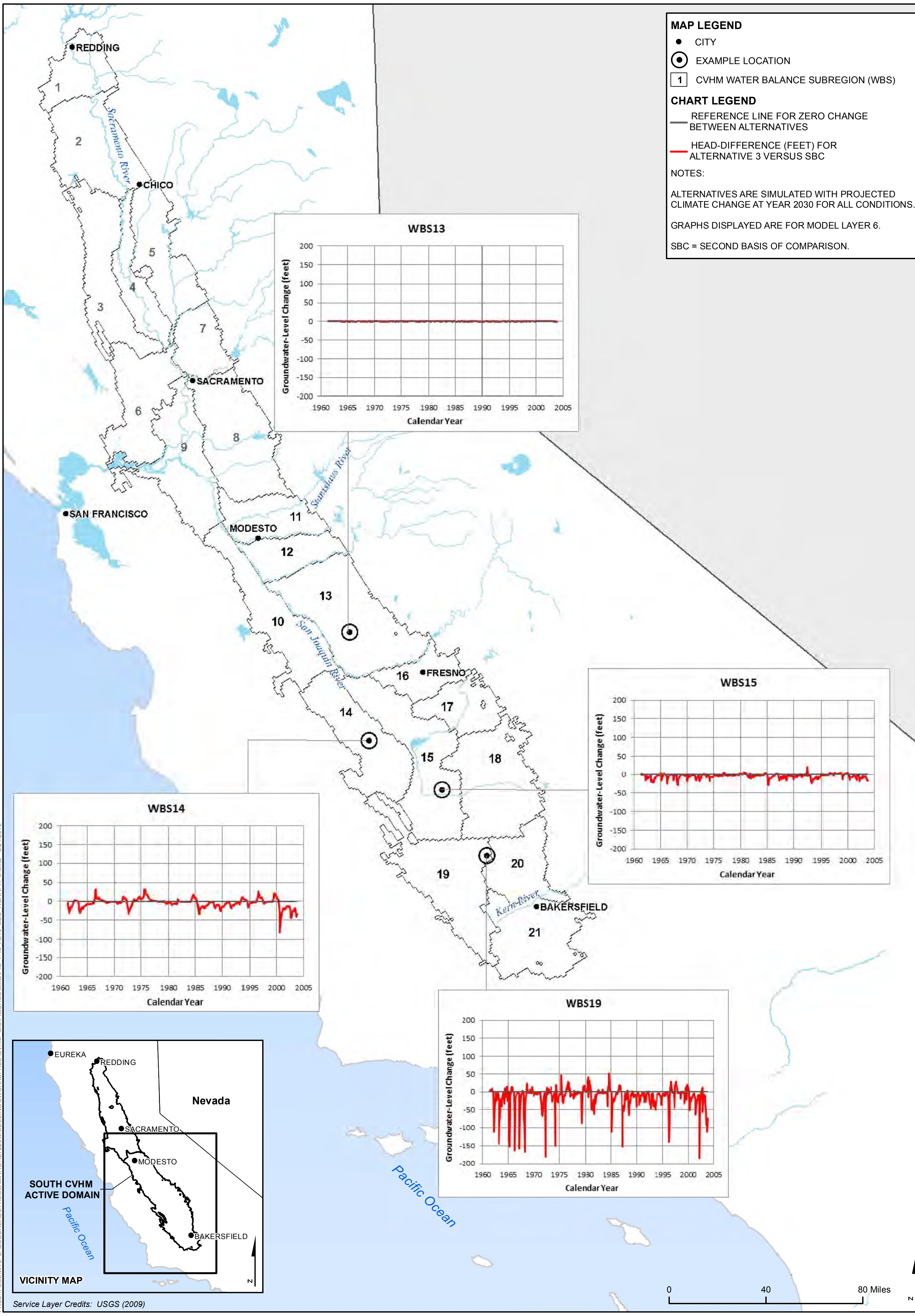



**Figure 7.46 Forecast Groundwater-Level Change Hydrographs for Alternative 3 Compared to Second Basis of Comparison at Example Locations in the San Joaquin Valley**

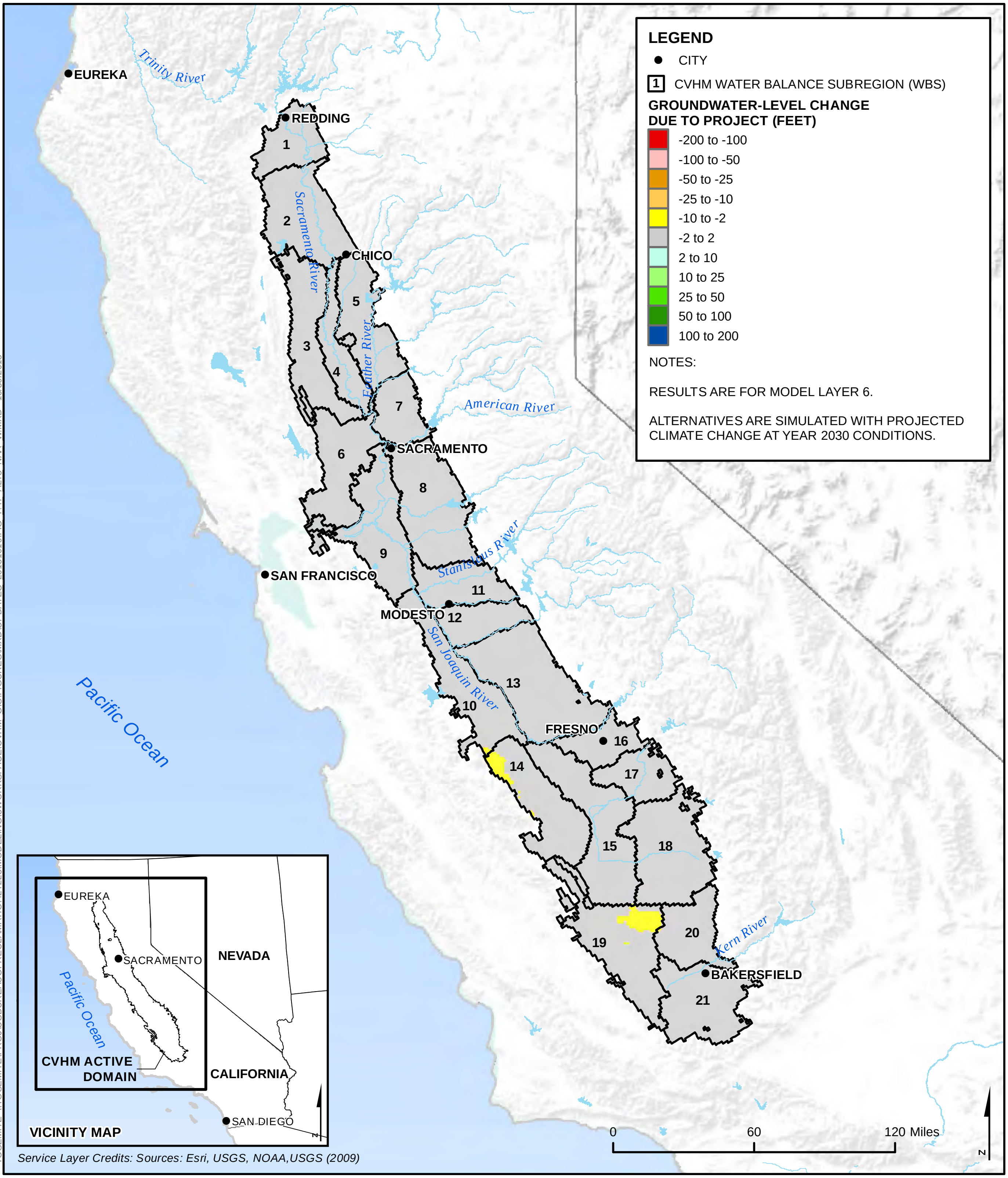



**Figure 7.47 Forecast Groundwater-Level Changes for Alternative 5 Compared to No Action Alternative For Average July in a Future Wet Year**

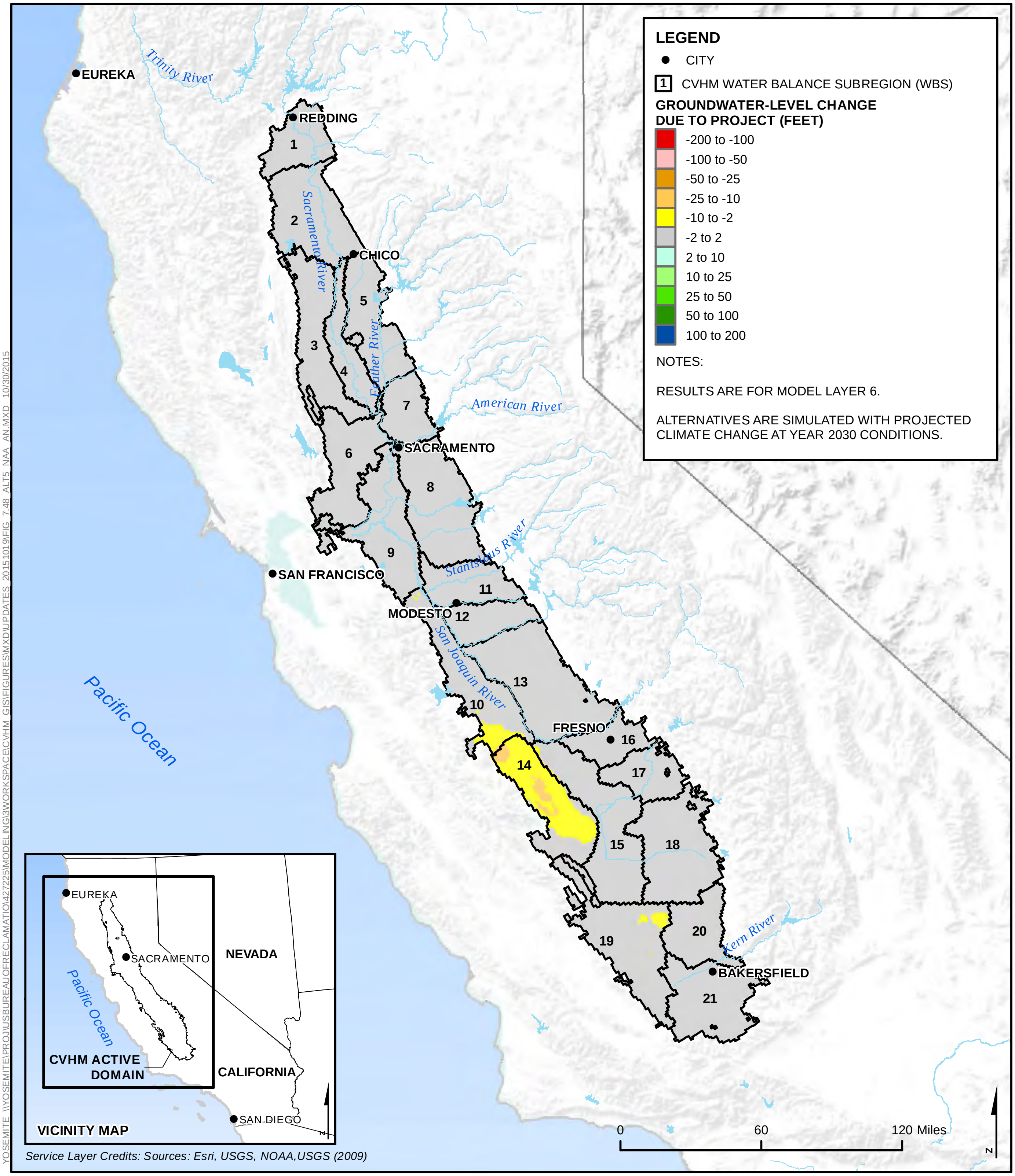



**Figure 7.48 Forecast Groundwater-Level Changes for Alternative 5 Compared to No Action Alternative For Average July in a Future Above-Normal Year**

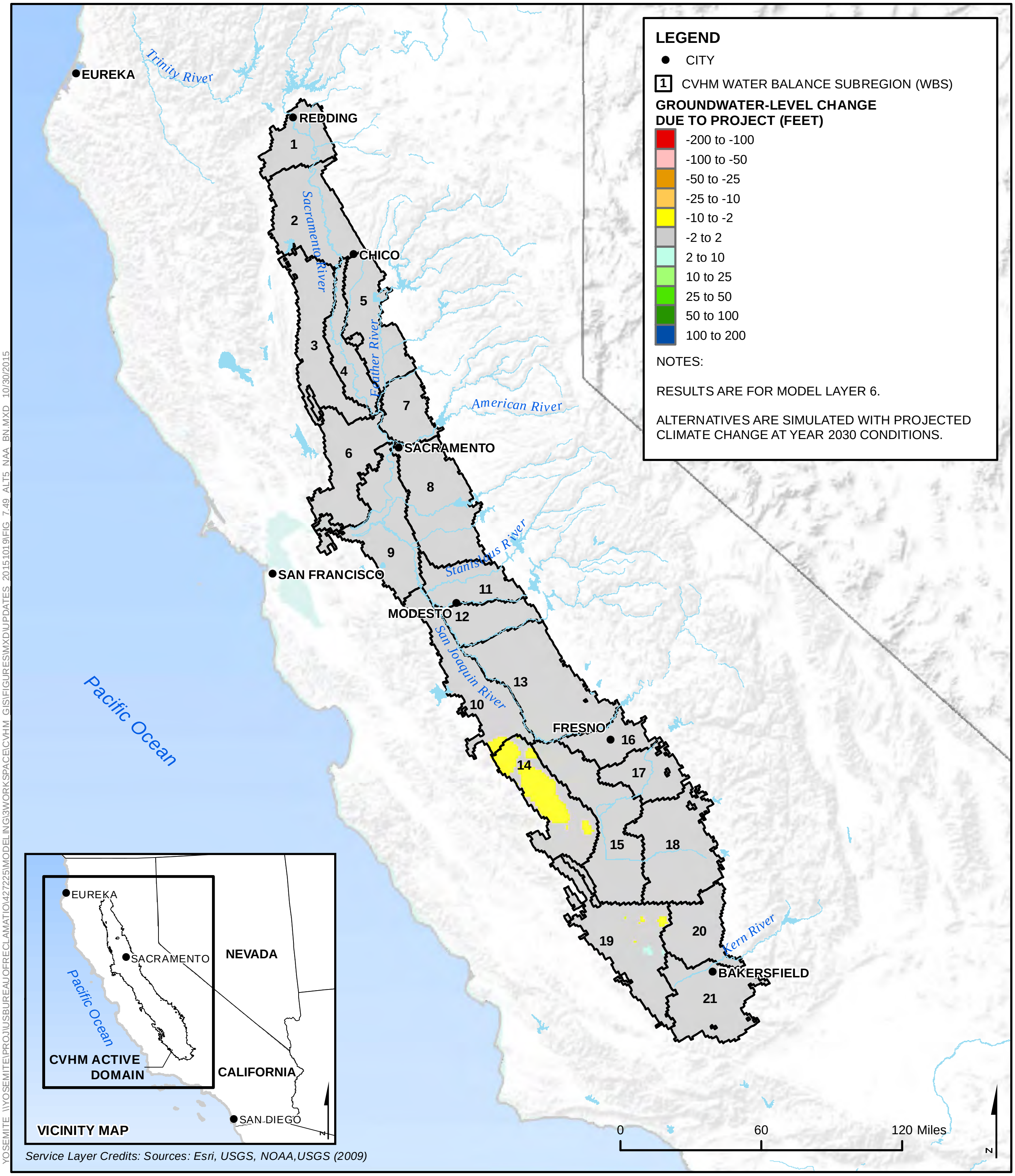



**Figure 7.49 Forecast Groundwater-Level Changes for Alternative 5 Compared to No Action Alternative For Average July in a Future Below-Normal Year**

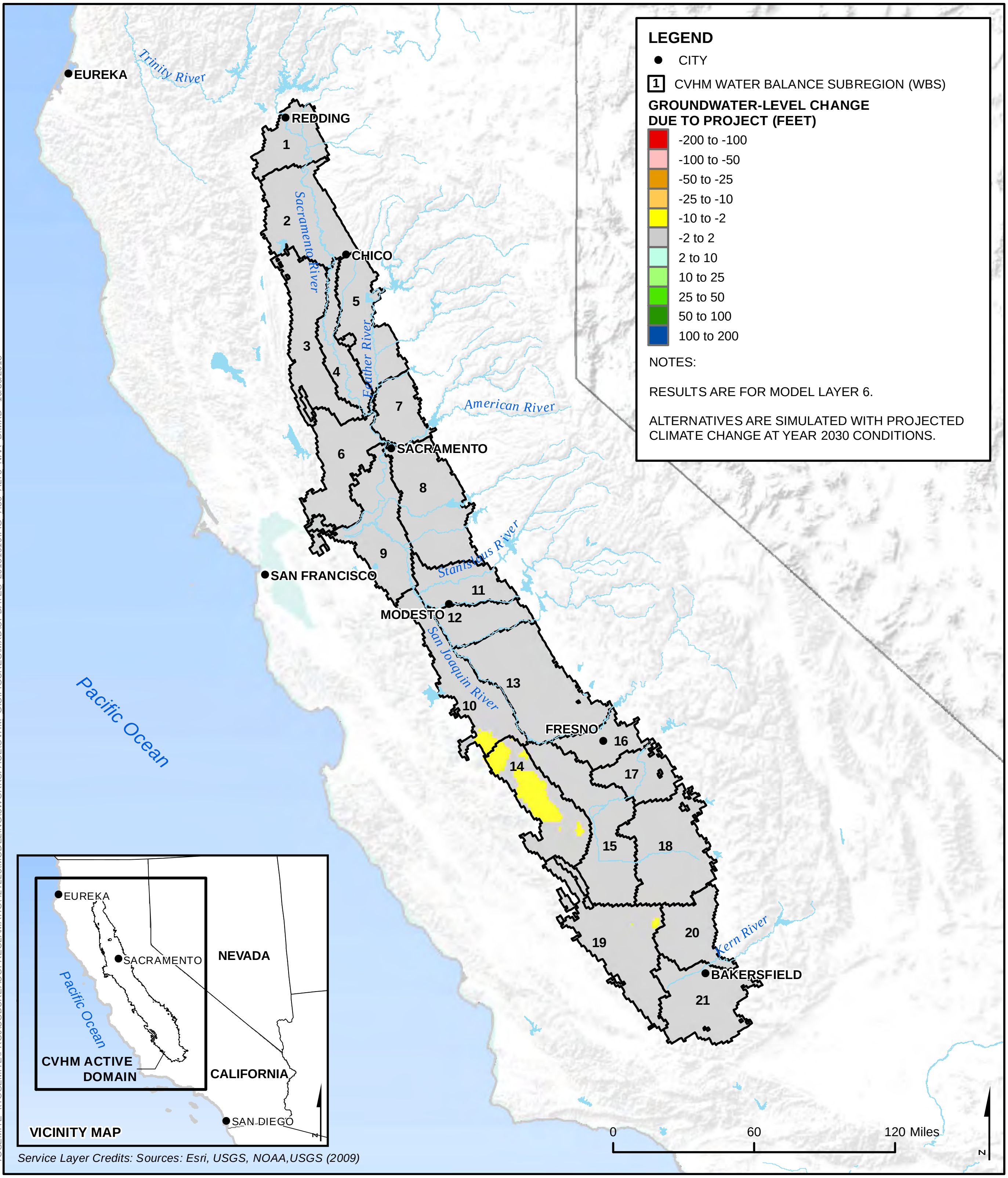



**Figure 7.50 Forecast Groundwater-Level Changes for Alternative 5 Compared to No Action Alternative for Average July in a Future Dry Year**

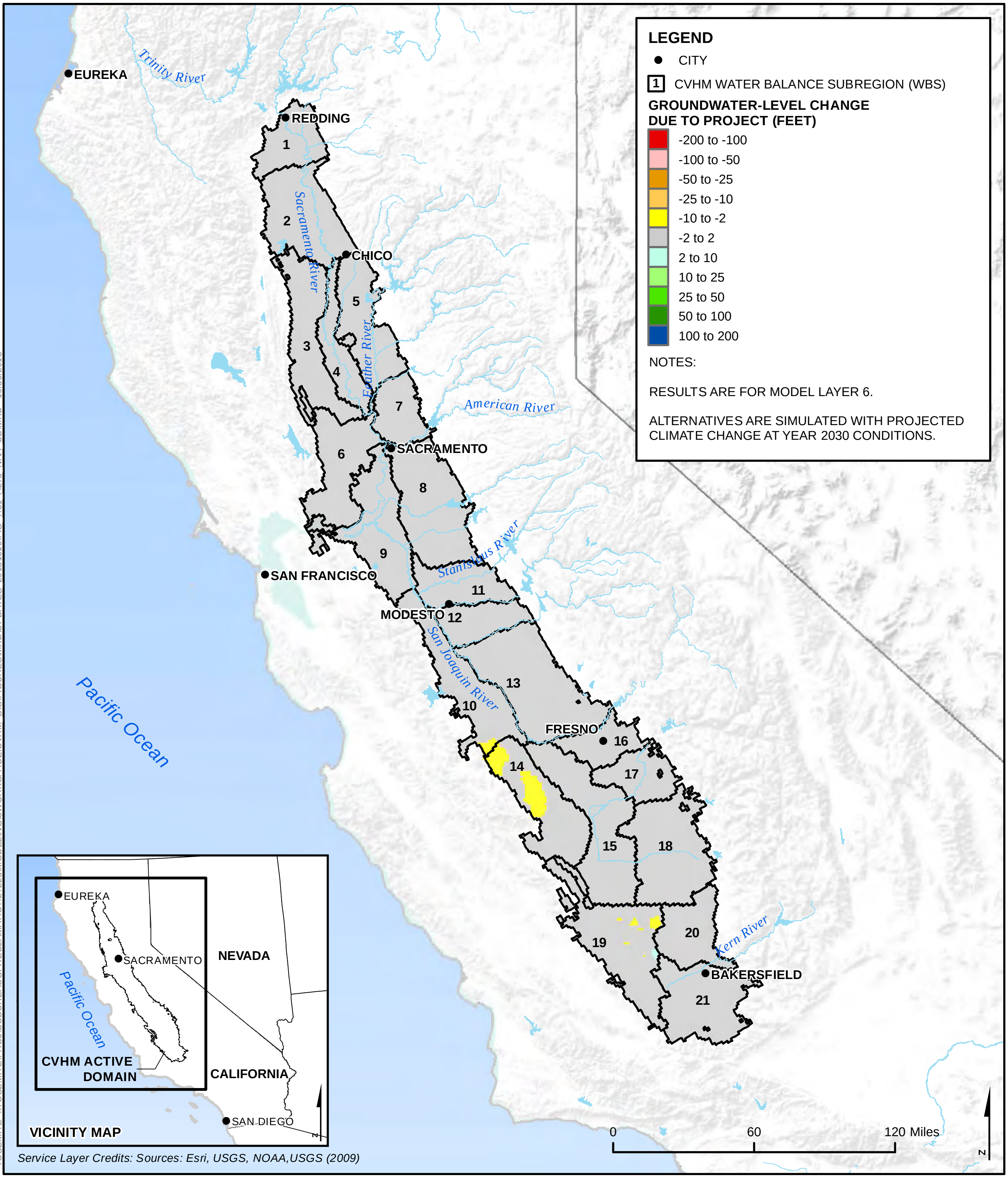



**Figure 7.51 Forecast Groundwater-Level Changes for Alternative 5 Compared to No Action Alternative for Average July in a Future Critically-Dry Year**

This page left blank intentionally.

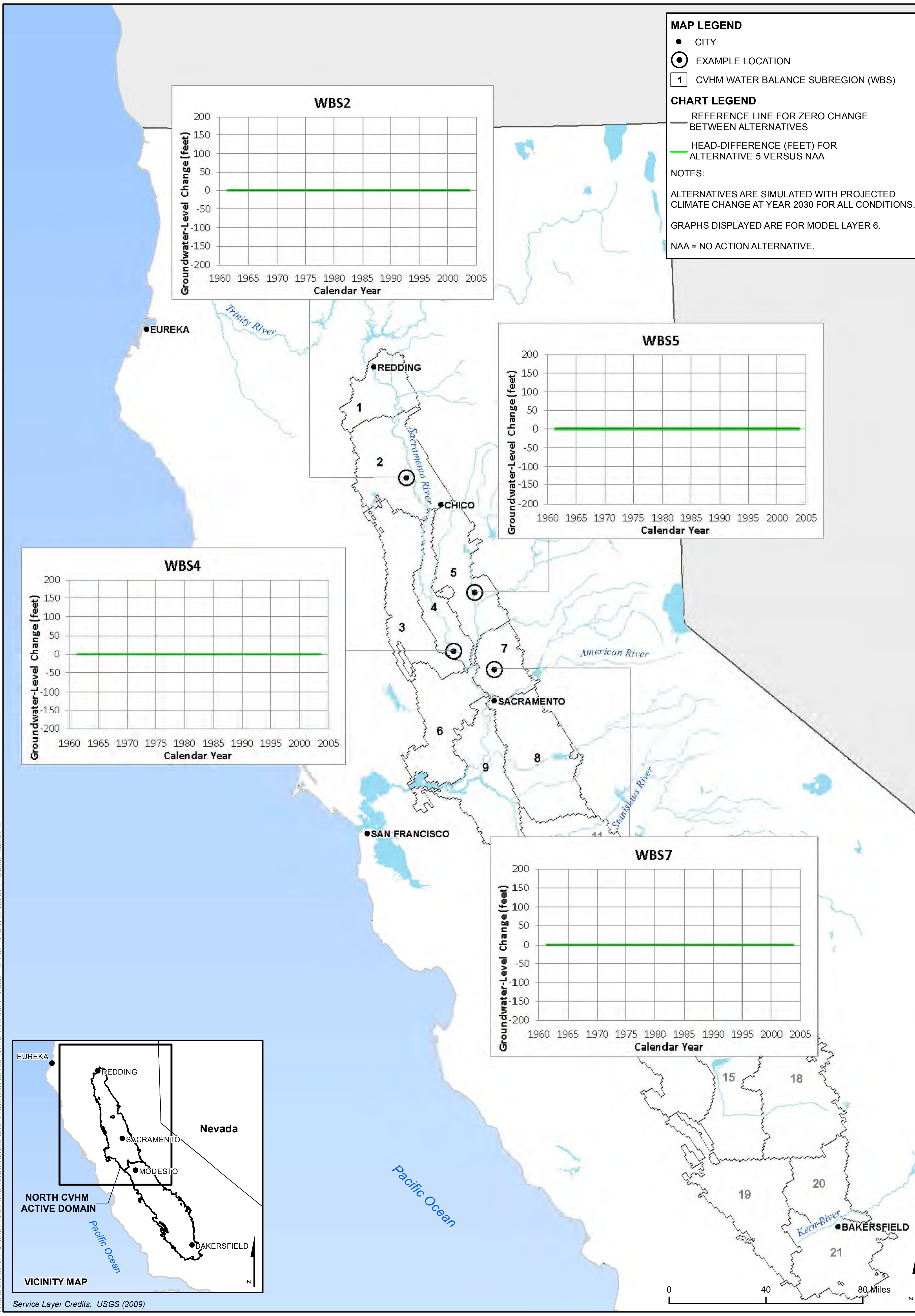



**Figure 7.52 Forecast Groundwater-Level Change Hydrographs for Alternative 5 Compared to No Action Alternative at Example Locations in the Sacramento Valley**

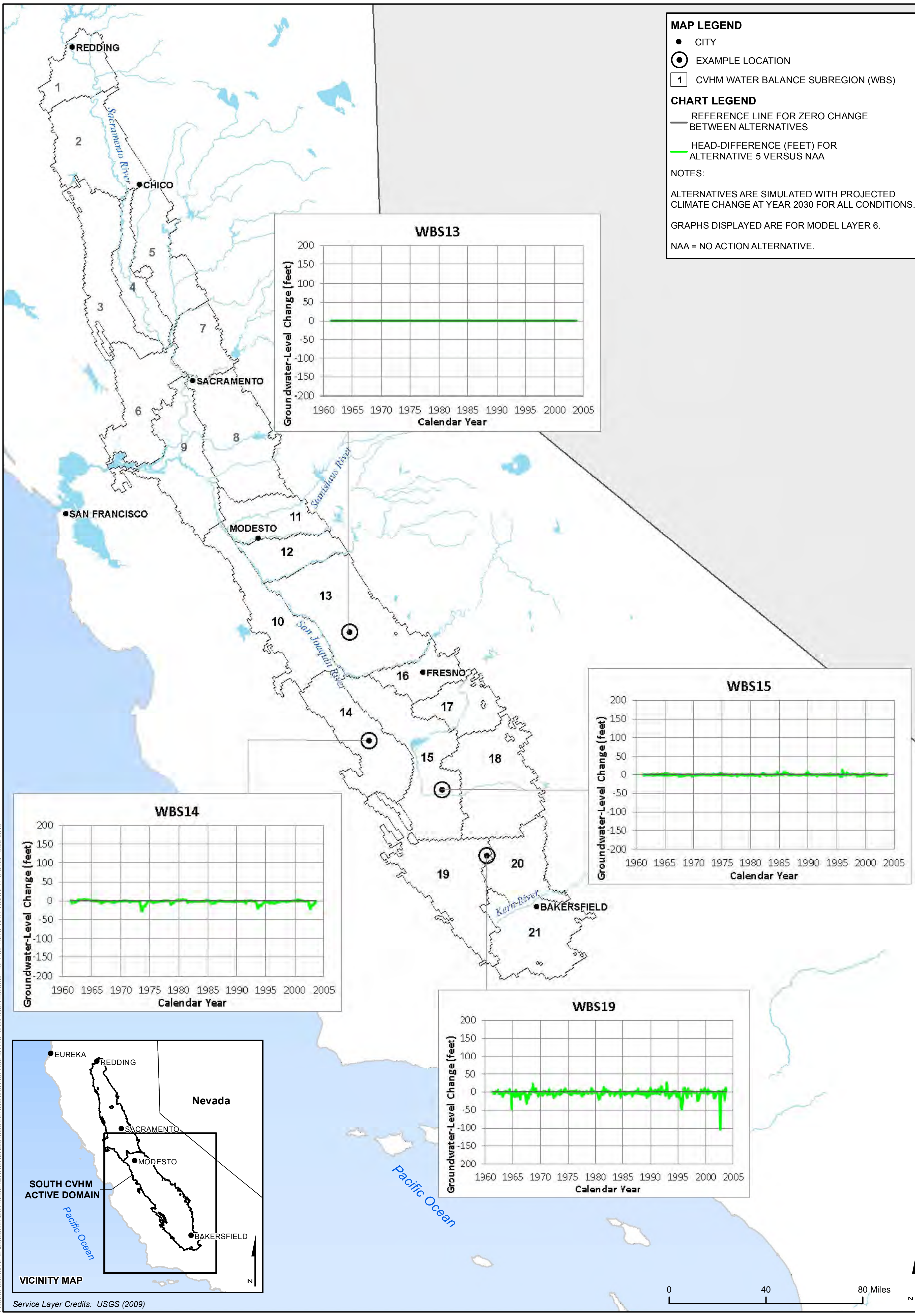



**Figure 7.53 Forecast Groundwater-Level Change Hydrographs for Alternative 5 Compared to No Action Alternative at Example Locations in the San Joaquin Valley**

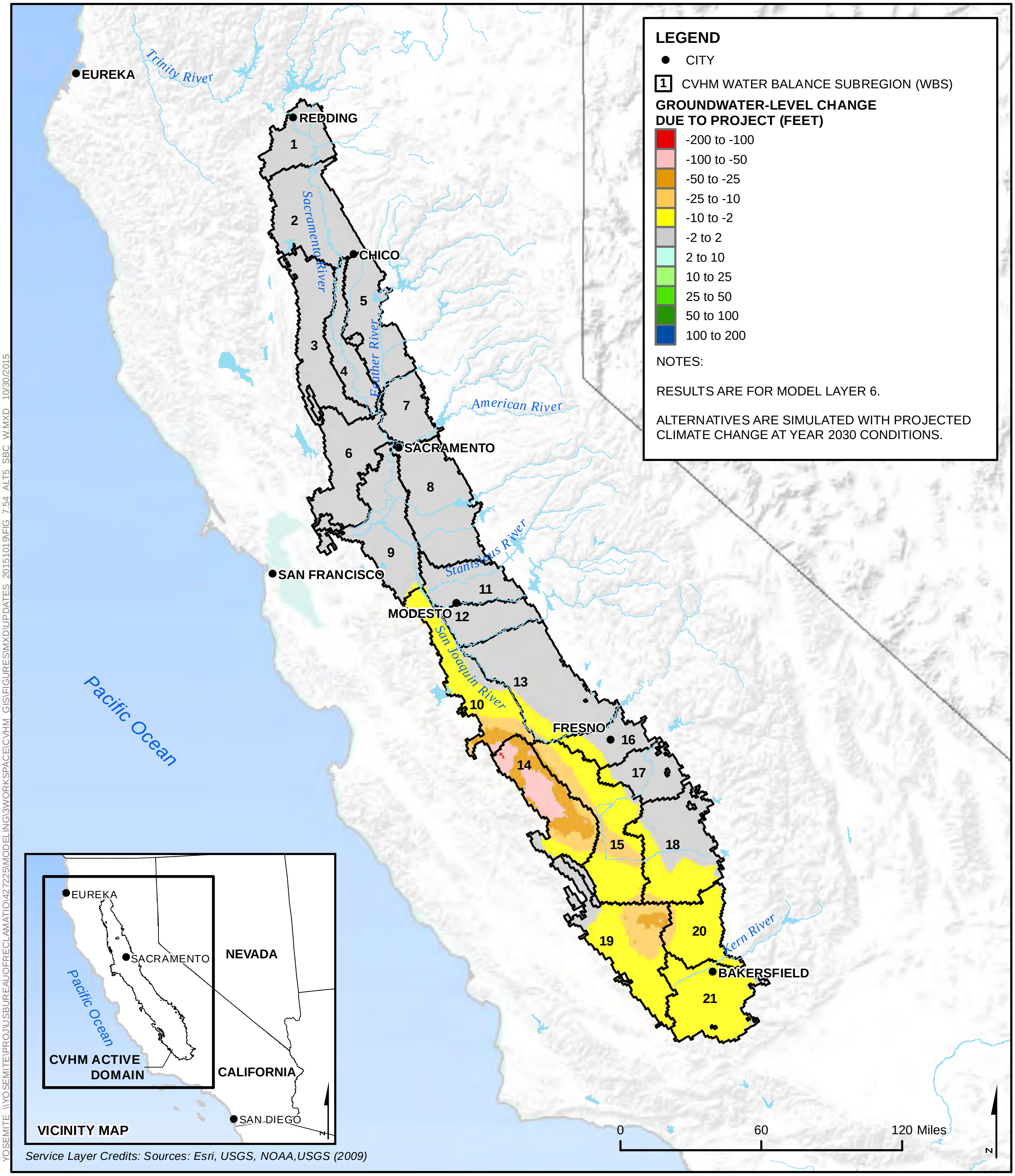



**Figure 7.54 Forecast Groundwater-Level Changes for Alternative 5 Compared to Second Basis of Comparison for Average July in a Future Wet Year**

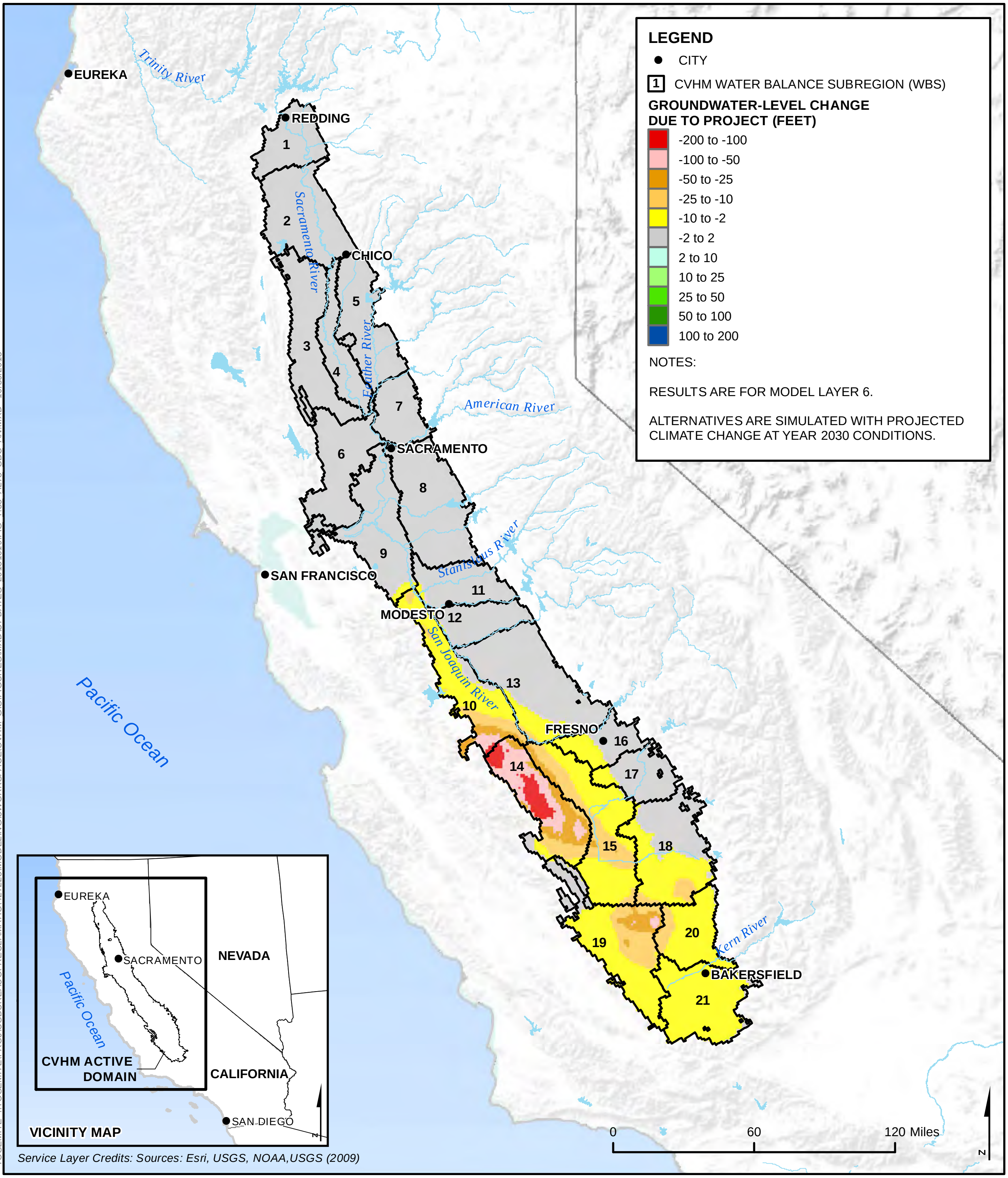



**Figure 7.55 Forecast Groundwater-Level Changes for Alternative 5 Compared to Second Basis of Comparison For Average July in a Future Below-Normal Year**

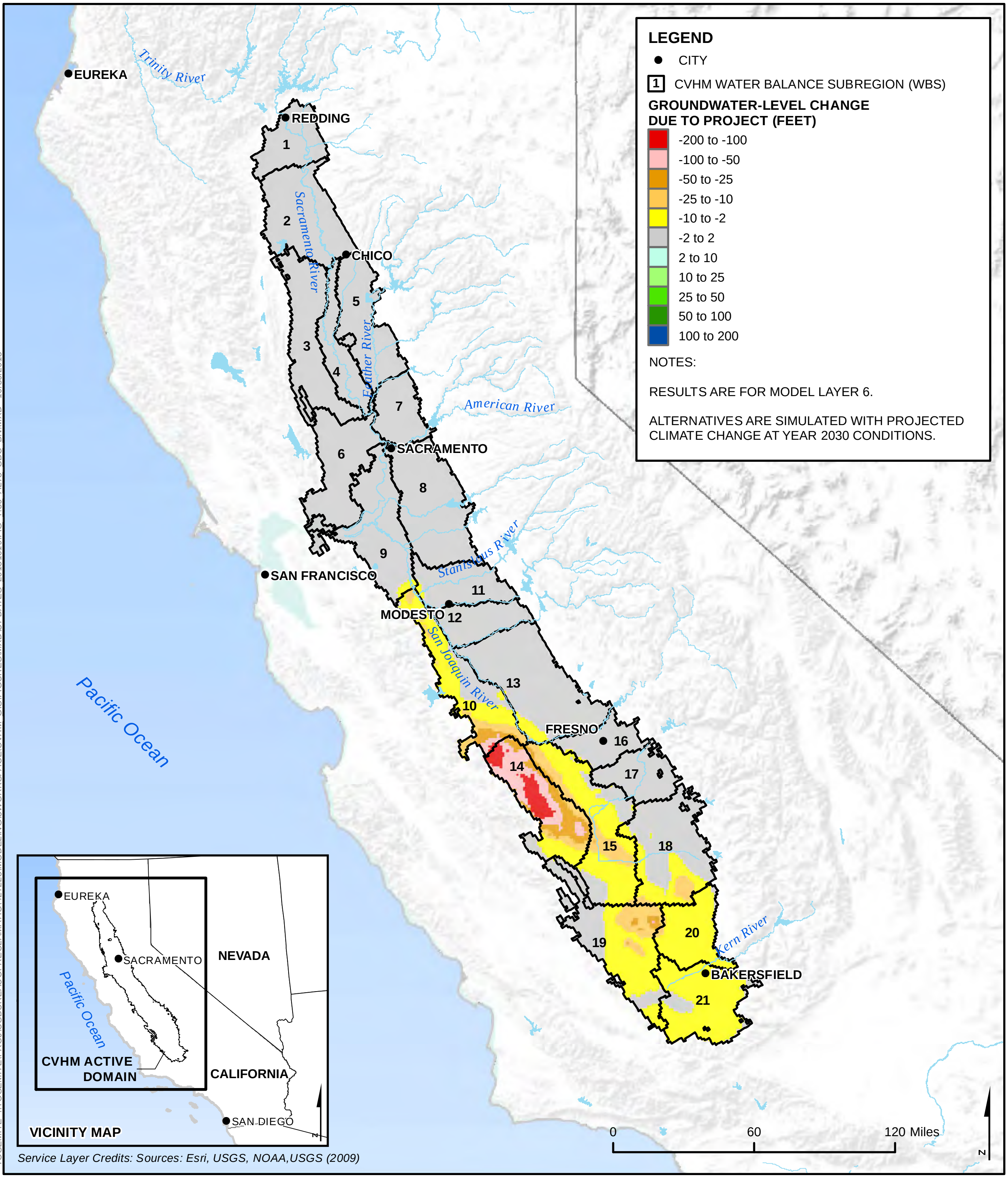



**Figure 7.56 Forecast Groundwater-Level Changes for Alternative 5 Compared to Second Basis of Comparison for Average July in a Future Below-Normal Year**

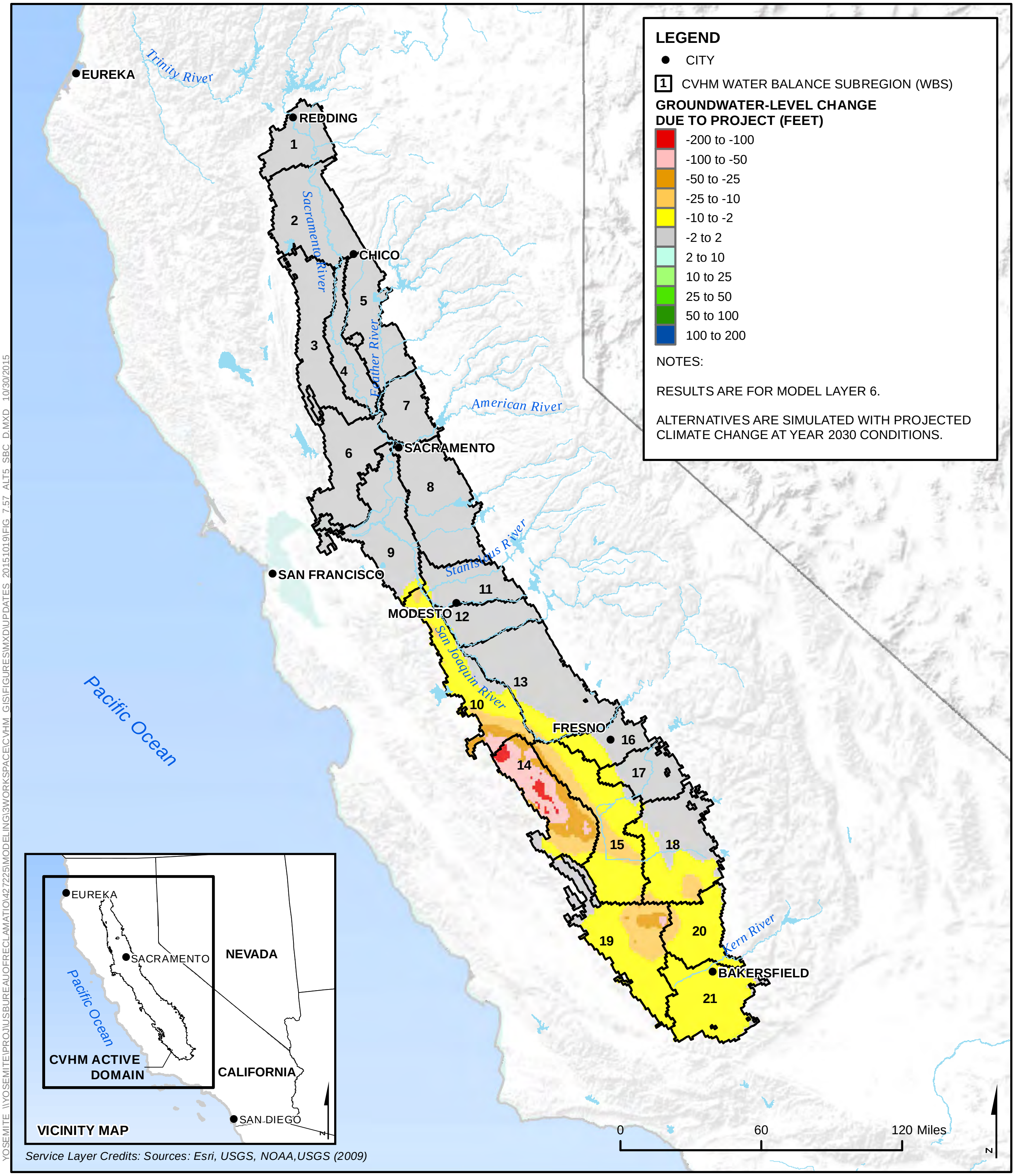



**Figure 7.57 Forecast Groundwater-Level Changes for Alternative 5 Compared to Second Basis of Comparison for Average July in a Future Dry Year**

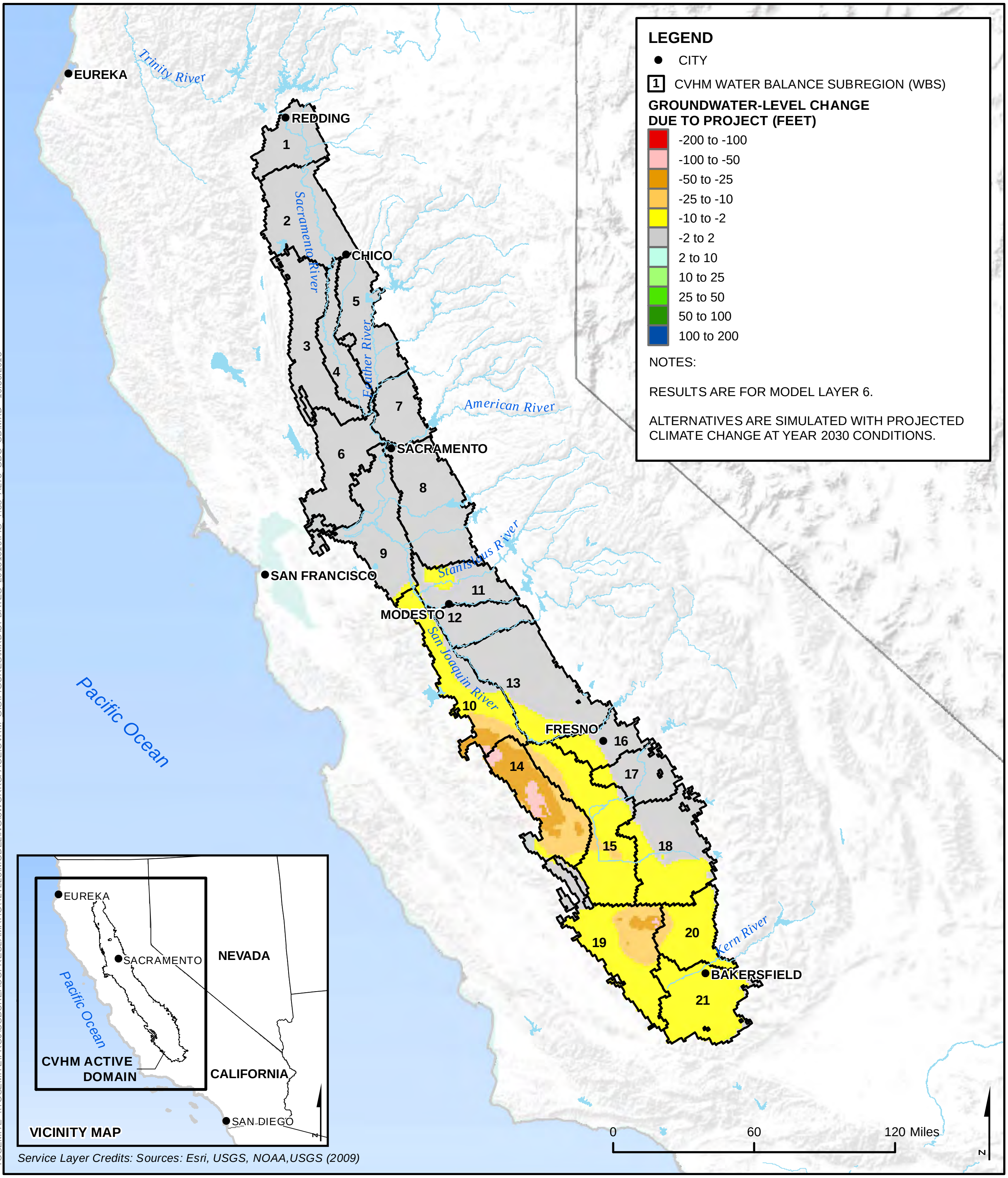



**Figure 7.58 Forecast Groundwater-Level Changes for Alternative 5 Compared to Second Basis of Comparison for Average July in a Future Critically-Dry Year**

This page left blank intentionally.

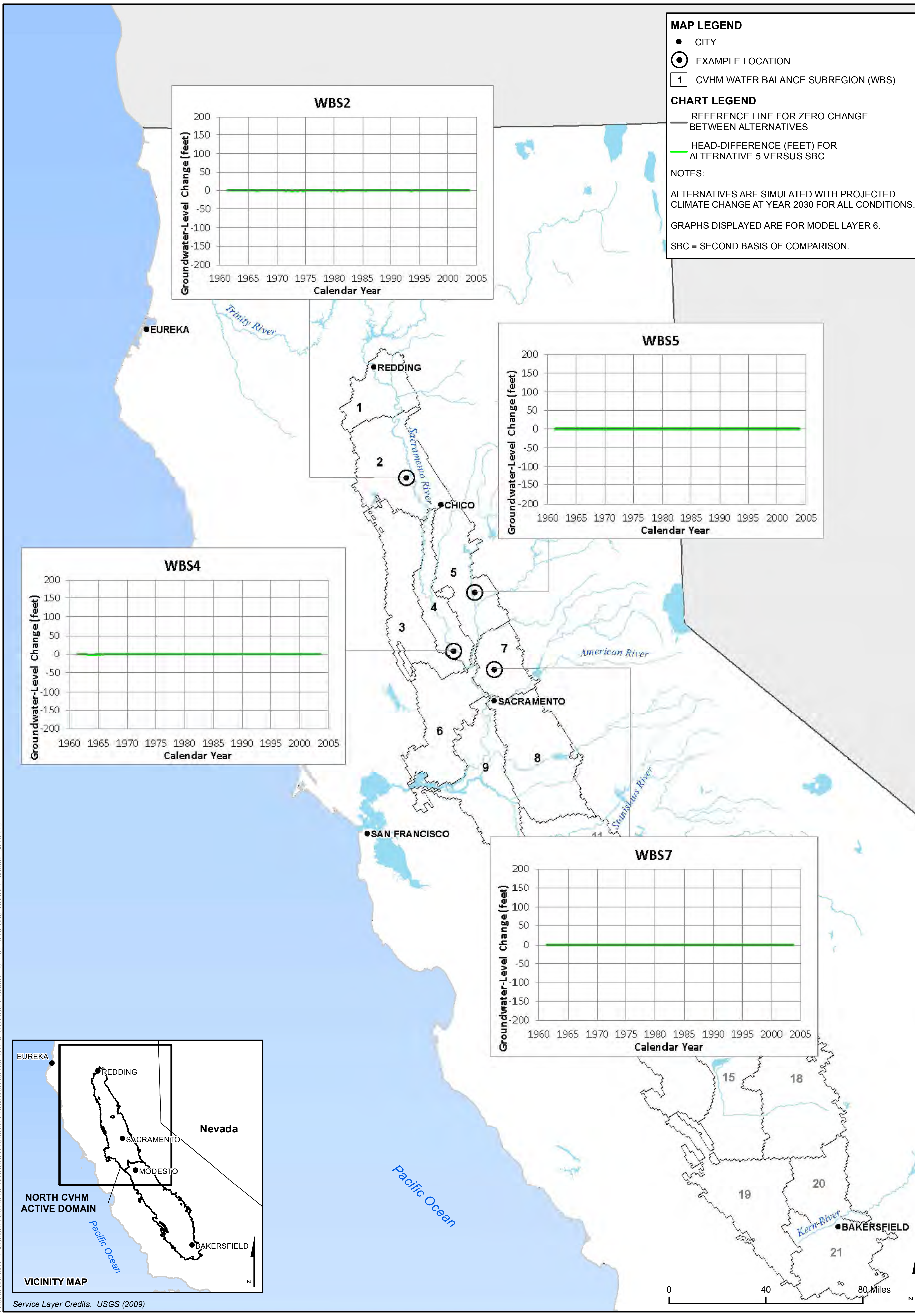



**Figure 7.59 Forecast Groundwater-Level Change Hydrographs for Alternative 5 Compared to Second Basis of Comparison at Example Locations in the Sacramento Valley**

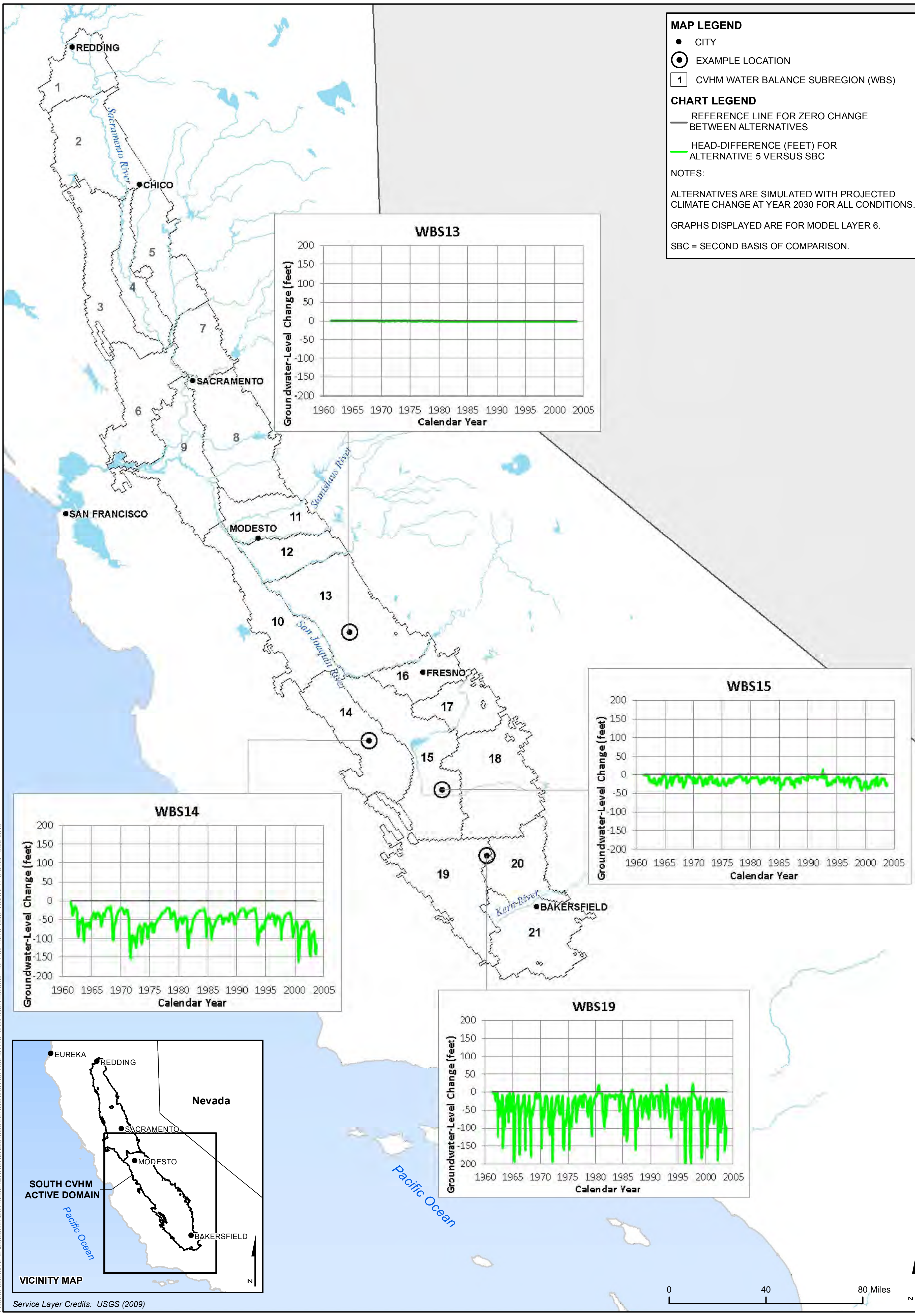



Figure 7.60 Forecast Groundwater-Level Change Hydrographs for Alternative 5 Compared to Second Basis of Comparison at Example Locations in the San Joaquin Valley

**Chapter 8**

# Energy

## 8.1 Introduction

This chapter describes the hydroelectric generation facilities and power demands for the Central Valley Project (CVP) and State Water Project (SWP) related to changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect CVP and SWP power generation and energy demands through potential changes in operation of the CVP and SWP facilities.

Changes in CVP and SWP operations are described in more detail in Chapter 5, Surface Water Resources and Water Supplies.

## 8.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect CVP and/or SWP hydroelectric generation and electricity use. The changes in power production and energy use would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analysis.

## 8.3 Affected Environment

This section describes CVP and SWP hydroelectric generation and electricity use of the generated electricity within the study area.

The study area includes CVP and SWP hydroelectric generation facilities at the CVP and SWP reservoirs; transmission of the generated electricity; and the CVP and SWP facilities and other users throughout California that rely upon electricity generated by the CVP and SWP hydroelectric facilities. These CVP and SWP energy generation facilities are located in the Trinity River and Central Valley regions. CVP and SWP energy use primarily occurs in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions, as defined below.

### 8.3.1 Central Valley Project and State Water Project Electric Generation Facilities

Hydroelectric facilities are located at most of the CVP and SWP dams, as shown on Figure 8.1. As water is released from the CVP and SWP reservoirs, the generation facilities produce power that is used by the CVP and SWP pumping plants, respectively. The SWP also generates hydroelectricity along the

California Aqueduct at energy recovery plants (California Department of Water Resources [DWR] 2013a, 2013b). Between 1983 and 2013, the DWR owned a portion of the Nevada Power Company's coal-fired Reid Gardner Unit 4 Powerplant. However, this agreement was not renewed upon expiration in 2013.

Power generated by the CVP is transmitted by Western Area Power Administration (Western) to CVP facilities. Power that is excess to CVP needs is marketed by Western to electric utilities, government and public installations, and commercial "preference" customers who have 20-year contracts (Bureau of Reclamation [Reclamation] 2012a). Power generated by the SWP is transmitted by Pacific Gas & Electric Company, Southern California Edison, and California Independent System Operator through other facilities (DWR 2013a, 2013b). The SWP also markets energy in excess of the SWP demands to a utility and members of the Western Systems Power Pool.

Hydropower is an important renewable energy and supplies between 14 and 28 percent of electricity used in California depending upon the water year type (The California Energy Commission [CEC] 2014a; Hydropower Working Group [HWG] 2014). In 1992, at the end of the 1987-to-1992 drought, hydropower provided less than 11 percent of the electricity used in California. However, during a wetter year (1995), hydropower provided approximately 28 percent of electricity used in California. Between 1982 and 2012, approximately 33,927 gigawatt-hours were generated in California by hydropower, including approximately 4,810 and 2,613 gigawatt-hours generated by the CVP and SWP, respectively.

#### *8.3.1.1 CVP Hydroelectric Generation Facilities*

The CVP power facilities include 11 hydroelectric powerplants and have a total maximum generating capacity of 2,076 megawatts, as presented in Table 8.1. Hydrology can vary significantly from year to year, which then affects the hydropower production. Typically, in an average water year, approximately 4,500 gigawatt-hours of energy is produced (Reclamation 2012a). Major factors that influence powerplant operations include required downstream water releases, electric system needs, and project use demand. The power generated from CVP powerplants is dedicated to first meeting the requirements of the CVP facilities. The remaining energy is marketed by Western to preferred customers in northern California.

**Table 8.1 Central Valley Project Hydroelectric Powerplants**

| Facility | Installed Capacity (Megawatts) |
|---|---|
| Trinity Powerplant | 140 |
| Lewiston Powerplant | 0.35 |
| Judge Francis Powerplant | 154 |
| Shasta Powerplant | 710 |
| Spring Creek Powerplant | 180 |
| Keswick Powerplant | 117 |
| Folsom Powerplant | 207 |
| Nimbus Powerplant | 17 |
| New Melones Powerplant | 383 |
| O'Neill Pump-Generating Plant | 14.4 |
| San Luis Powerplant (CVP portion of the William R. Gianelli/San Luis Pump-Generating Plant) | 202 |

Sources: Reclamation 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, 2013h, 2013i, 2013j, 2013k, 2013l

#### 8.3.1.1.1 Trinity Division Powerplants

The Trinity Powerplant is located along the Trinity River (Reclamation 2013b). Primary releases of Trinity Dam are made through the powerplant. Trinity County has first preference to the power from this plant.

The Lewiston Powerplant is located at the Lewiston Dam along the Trinity River (Reclamation 2013c). It is operated in conjunction with the spillway gates to maintain the minimum flow in the Trinity River downstream. The turbines are usually set at maximum output with the spillway gates adjusted to regulate river flow. The turbine capacity is less than the Trinity River minimum flow criteria, as described in Chapter 5, Surface Water Resources and Water Supplies. The Lewiston Powerplant provides power to the adjacent fish hatchery.

The Judge Francis Carr Powerplant is a peaking powerplant located on the Clear Creek Tunnel (Reclamation 2013d). It generates power from water exported from the Trinity River Basin. Similar to Trinity Powerplant, Trinity County has first preference to the power benefit from this facility.

#### 8.3.1.1.2 Sacramento River Powerplants

The Shasta Powerplant is a peaking powerplant located downstream of Shasta Dam along the Sacramento River (Reclamation 2013a, 2013e). Until early 1990s, concerns with downstream temperatures resulted in the bypasses of outflows around the powerplant and lost hydropower generation. Installation of the Shasta Temperature Control Device enabled operators to decide the depth of the reservoir from which the water feeding into the penstocks originates. The system has shown significant success in controlling the water temperature of powerplant releases through Shasta Dam. The Shasta Powerplant also provides water supply for the Livingston Stone National Fish Hatchery.

The Spring Creek Powerplant is a peaking plant located along Spring Creek, at the foot of Spring Creek Debris Dam (Reclamation 2013f). Water discharged via the Judge Francis Carr Powerplant flows into the Whiskeytown Reservoir and then provides the source of water for the Spring Creek Powerplant generation. Trinity County has first preference to the power benefits from Spring Creek Powerplant. Water from Spring Creek Powerplant is discharged into Keswick Reservoir. Releases from Spring Creek Powerplant also are operated to maintain water quality in the Spring Creek arm of Keswick Reservoir.

The Keswick Powerplant is located at Keswick Dam along the Sacramento River downstream of Shasta Dam and regulates the flows into the Sacramento River from both Shasta Lake and Spring Creek releases and can be considered as a run-of-the-river powerplant (Reclamation 2013g).

#### 8.3.1.1.3 American River Powerplants

The Folsom Powerplant is a peaking powerplant located at Folsom Dam along the American River (Reclamation 2013h). The Folsom Powerplant is operated in an integrated manner with flood control operations at Folsom Lake. One of the integrated operations is related to coordinating early flood control releases with power generation. It also provides power for the pumping plant that supplies the local domestic water supply. Folsom Powerplant supports voltage support for the Sacramento Region during summer heavy load times.

The Nimbus Powerplant is located at Nimbus Dam along the American River, downstream of Folsom Dam (Reclamation 2013i). The Nimbus Powerplant regulates releases from Folsom Dam into the American River and can be considered as a run-of-the river powerplant.

#### 8.3.1.1.4 Stanislaus River Powerplants

The New Melones Powerplant is a peaking powerplant located along the Stanislaus River (Reclamation 2013j). Primary reservoir releases are made through the powerplant. This plant provides significant voltage support to the Pacific Gas and Electric Company system during summer heavy load periods.

#### 8.3.1.1.5 San Luis Reservoir Powerplants

The O'Neill Pump-Generating Plant is located on a channel that conveys water between the Delta-Mendota Canal and the O'Neill Forebay (Reclamation 2013k). This pump-generating plant only generates power when water is released from the O'Neill Reservoir to the Delta-Mendota Canal. When water is conveyed from the Delta-Mendota Canal to O'Neill Forebay, the units serve as pumps, not hydroelectric generators. The generated power is used to support CVP pumping and irrigation actions of the CVP.

The William R. Gianelli (San Luis) Pump-Generating Plant is located along the along the western boundary of the O'Neill Forebay at the San Luis Dam

(Reclamation 2013l). This pump-generating plant is owned by the Federal government but is operated as a joint Federal-State facility that is shared by the CVP and SWP. Energy is generated when water is needed to be conveyed from San Luis Reservoir back into O'Neill Forebay for continued conveyance to the Delta-Mendota Canal. The plant is operated in pumping mode when water is moved from O'Neill Forebay to San Luis Reservoir for storage until heavier water demands develop. The generated power is used to offset CVP and SWP pumping loads. The powerplant can generate up to 424 megawatts, with the CVP share of the total capacity being 202 megawatts. This facility is operated and maintained by the State of California under an operation and maintenance agreement with Reclamation.

#### *8.3.1.2 SWP Electric Generation Facilities*

The SWP power facilities are operated primarily to provide power for the SWP facilities (DWR 2013b). The SWP power facilities and capacities are summarized in Table 8.2. The SWP has power contracts with electric utilities and the California Independent System Operator that act as exchange agreements with utility companies for transmission and power sales/purchases. In all years, the SWP must purchase additional power to meet pumping requirements.

**Table 8.2 State Water Project Hydroelectric Powerplants**

| Facility | Installed Capacity (Megawatts) |
|---|---|
| Oroville Facilities | – |
| Hyatt Pumping-Generating Plant | 645 |
| Thermalito Diversion Dam Powerplant | 3 |
| Thermalito Pumping-Generating Plant | 114 |
| William R. Gianelli (San Luis) Pumping-Generating Plant (SWP share) | 222 |
| Alamo Powerplant | 17 |
| Mojave Siphon Powerplant | 30 |
| Devil Canyon Powerplant | 276 |
| Warne Powerplant | 74 |

Source: DWR 2012

##### 8.3.1.2.1 Feather River Powerplants

The Hyatt Pumping-Generating Plant is located on the channel between Lake Oroville and the Thermalito Diversion Pool (DWR 2007). Water in the Thermalito Diversion Pool can be pumped back to Lake Oroville to be released through the Hyatt Pumping-Generating Plant and generate more electricity; released through the Thermalito Diversion Dam Powerplant for delivery to the low flow channel upstream of Thermalito Forebay; or conveyed to Thermalito Forebay for subsequent release through the Thermalito Pumping-Generating Plant. The combined Hyatt Pumping-Generating Plant and Thermalito Pumping-Generating Plant generate approximately 2,200 gigawatt-hours of energy in a median water year, while the 3 megawatts generated by Thermalito Diversion Dam Powerplant adds another 24 gigawatt-hours per year (DWR 2013).

#### 8.3.1.2.2 San Luis Reservoir Powerplant

As described above, the William R. Gianelli (San Luis) Pump-Generating Plant is owned by the Federal government and is operated as a joint Federal-state facility that is shared by the CVP and SWP. The SWP water flows from the California Aqueduct into O'Neill Forebay downstream of the CVP's O'Neill Pump-Generating Plant. The pump-generating plant is located along the western boundary of the O'Neill Forebay at the San Luis Dam (DWR 2013a, 2013b, Reclamation 2013l). Electricity is generated when water is transferred from San Luis Reservoir back to O'Neill Forebay for continued conveyance in the California Aqueduct. The plant acts as a pumping plant when water is transferred from O'Neill Forebay to San Luis Reservoir. The generated power is used to offset CVP and SWP pumping loads. The powerplant can generate up to 424 megawatts, with the SWP share of the total capacity being 222 megawatts. This facility is operated and maintained by the State of California under an operation and maintenance agreement with Reclamation.

#### 8.3.1.2.3 East Branch and West Branch Powerplants

Downstream of the Antelope Valley, the California Aqueduct divides into the East Branch and West Branch. The Alamo Powerplant, Mojave Powerplant, and Devil Canyon Powerplant are located along the East Branch which conveys water into San Bernardino County (DWR 2013a, 2013b). The Warne Powerplant is located along the West Branch which conveys water into Los Angeles County. The generation rates vary at these powerplants depending upon the amount of water conveyed.

#### 8.3.1.2.4 Other Energy Resources for the State Water Project

Other energy supplies have been obtained by DWR from other utilities and energy marketers under agreements that allow DWR to buy, sell, or exchange energy on a short-term hourly basis or a long-term multi-year basis (DWR 2013a, 2013b).

For example, DWR jointly developed the 1,254-megawatt Castaic Powerplant on the West Branch with the Los Angeles Department of Water and Power (DWR 2012, 2013). The power is available to DWR at the Sylmar Substation.

DWR has a long-term purchase agreement with the Kings River Conservation District for the approximately 400 million kilowatt-hours of energy from the 165-megawatt hydroelectric Pine Flat Powerplant (DWR 2012, 2013). DWR also purchases energy from five hydroelectric plants with 30 megawatts of installed capacity that are owned and operated by Metropolitan Water District of Southern California (DWR 2012, 2013).

DWR also purchases energy under short-term purchase agreements from utilities and energy marketers of the Western Systems Power Pool (DWR 2012, 2013). In addition, the 1988 Coordination Agreement between DWR and Metropolitan

Water District of Southern Californian enables DWR to purchase and exchange energy (DWR 2012, 2013).

### 8.3.2 Other Hydroelectric Generation Facilities

Hydroelectric facilities in addition to CVP and SWP hydroelectric facilities in the study area are owned by investor-owned utility companies, such as Pacific Gas & Electric Company and Southern California Edison; municipal agencies, such as Sacramento Municipal Utility District; and by local and regional water agencies. Some of the larger facilities outside the CVP and SWP systems and within or adjacent to the study area include (DWR 2013d; 2013e; YCWA 2012):

- Pacific Gas and Electric Company
  - Helms Pumped Storage (1,200 megawatts) in Fresno County.
  - Pit System (320 megawatts) and McCloud-Pit System (370 megawatts, total) in Shasta County.
  - Upper North Fork Feather River System (360 megawatts) in Plumas County.
- Sacramento Municipal Utility District Upper American River Project System (688 megawatts) in El Dorado County.
- City and County of San Francisco Hetch Hetchy Power System (390 megawatts) in Tuolumne County.
- Southern California Edison
  - Big Creek System and Eastwood Pump Storage (approximately 1,000 megawatts) in Fresno and Madera counties.
  - Mammoth Pool Project (187 megawatts) in Fresno and Madera counties.
- Turlock Irrigation District and Modesto Irrigation District New Don Pedro Project (203 megawatts) in Tuolumne County.
- Yuba County Water Agency Yuba River Development Project (390 megawatts) in Yuba County.

### 8.3.3 CVP and SWP System Energy Demands

Power generation at CVP and SWP hydropower facilities fluctuates in response to reservoir releases and conveyance flows. Reservoir releases are significantly affected by hydrologic conditions, minimum stream flow requirements, flow fluctuation restrictions, water quality requirements, and non-CVP and non-SWP water rights which must be met prior to releases for CVP water service contractors and SWP entitlement holders.

#### *8.3.3.1 CVP Power Generation and Energy Use*

The CVP power generation facilities were developed to meet CVP energy use loads.

The majority of the energy used by the CVP is needed for pumping plants located in the Delta, at San Luis Reservoir, and along the Delta-Mendota Canal and San Luis Canal portion of the California Aqueduct. Table 8.3 presents historical average annual CVP hydropower generation and use. Monthly power generation pattern follows seasonal reservoir releases, with peaks during the irrigation season, as shown on Figure 8.2. The hydropower generation between January and June decreases after 2007 because the potential to convey CVP water across the Delta during this period was reduced after 2007 to reduce reverse flows in Old and Middle River, in accordance with legal decisions and subsequently through implementation of the biological opinions.

**Table 8.3 Hydropower Generation and Energy Use by the CVP**

| Calendar Year | Water Year Type[a] | Net CVP Hydropower Generation (Gigawatt-hours) | Energy Used CVP Facilities (Gigawatt-hours) |
|---|---|---|---|
| 2000 | AN | 5,667 | – |
| 2001 | D | 4,107 | 957 |
| 2002 | D | 4,322 | 1,090 |
| 2003 | AN | 5,483 | 1,170 |
| 2004 | BN | 5,186 | 1,172 |
| 2005 | AN | 4,599 | 1,150 |
| 2006 | W | 7,284 | 1,037 |
| 2007 | D | 4,276 | 1,064 |
| 2008 | C | 3,659 | 923 |
| 2009 | D | 3,560 | 803 |
| 2010 | BN | 3,624 | 1,001 |
| 2011 | W | 5,469 | 1,276 |
| 2012 | BN | 4,849 | 990 |

Sources: Reclamation 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008a-l, 2009a-l, 2010a-l, 2011a-l, 2012b-m.

Note:
a. Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 5, Surface Water Resources and Water Supplies.

Recently, the California Public Utilities Commission (CPUC) evaluated the "energy intensity" of several types of water supplies (CPUC 2010). The energy intensity is defined as the average amount of energy required to convey and/or treat water on a unit basis, such as per 1 acre-foot. Substantial quantities of energy are required by the CVP pumping plants to convey large amounts of water over long distances with significant changes in elevation. The study indicated that the energy intensity of CVP water delivered to users downstream of San Luis Reservoir ranged from 0.292 megawatt-hours/acre-foot for users along the Delta-Mendota Canal; to 0.428 megawatt-hours/acre-foot for users along the San Luis

Canal/California Aqueduct; to 0.870 megawatt-hours/acre-foot in San Benito and Santa Clara counties.

#### *8.3.3.2 SWP Power Generation and Energy Use*

The SWP power generation facilities also were developed to meet SWP energy use loads. The majority of the energy used by the SWP is needed for pumping plants located in the Delta, at the San Luis Reservoir, and along the California Aqueduct. Table 8.4 presents historical average annual SWP hydropower generation and use. Monthly power generation pattern follows seasonal reservoir releases, with peaks during the irrigation season, as shown on Figure 8.3. Table 8.4 presents SWP power use and generation values for the period 2001 through 2012 that indicate the SWP generates approximately 63 percent of the energy needed for deliveries (DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013). The energy generation and purchases and energy use decreases after 2007 because the potential to convey SWP water across the Delta was reduced in accordance with legal decisions and subsequently through implementation of the biological opinions.

**Table 8.4 Hydropower Generation and Energy Use by the State Water Project**

| Calendar Year | Water Year Type[a] | SWP Hydropower Generation (Gigawatt-hour) | Energy Acquired through Long-term Agreements and Purchases (Gigawatt-hour) | Energy Used by SWP Facilities (Gigawatt-hour) |
|---|---|---|---|---|
| 2000 | AN | 6,372 | 5,741 | 9,190 |
| 2001 | D | 4,295 | 4,660 | 6,656 |
| 2002 | D | 4,953 | 4,610 | 8,394 |
| 2003 | AN | 5,511 | 4,668 | 9,175 |
| 2004 | BN | 6,056 | 4,429 | 9,868 |
| 2005 | AN | 5,151 | 5,367 | 8,308 |
| 2006 | W | 7,056 | 5,811 | 9,158 |
| 2007 | D | 5,577 | 6,642 | 9,773 |
| 2008 | C | 3,541 | 4,603 | 5,745 |
| 2009 | D | 4,295 | 4,660 | 6,656 |
| 2010 | BN | 4,953 | 4,610 | 8,394 |
| 2011 | W | 5.511 | 4,668 | 9.175 |
| 2012 | BN | 6,056 | 4,429 | 9.868 |

Sources: DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013

Note:

a. Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 5, Surface Water Resources and Water Supplies.

The energy intensity values calculated by the California Public Utilities Commission for the SWP ranged from 1.128 megawatt-hours/acre-foot for water users along the South Bay Aqueduct; to 1.157 megawatt-hours/acre-foot for water users in Kern County; to 4,644 megawatt-hours/acre-foot for water users at the terminal end of the East Branch Extension of the California Aqueduct (CPUC 2010).

### 8.3.4 Energy Demands for Groundwater Pumping

Groundwater provided approximately 37 percent of the state's agricultural, municipal, and industrial water supply of the average water needs between 1998 and 2010, or approximately 16 million acre-feet/year of groundwater (DWR 2013). The use of groundwater varies regionally throughout the State. For example in some areas, groundwater provides less than 10 percent to more than 90 percent, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

The amount of energy used statewide to pump groundwater is not well quantified (CPUC 2010). The California Public Utilities Commission estimated groundwater energy use by hydrologic region and by type of use to evaluate the water and energy relationships. Groundwater pumping estimates were calculated in each DWR Planning Areas for agricultural and municipal water demands. Groundwater energy use was estimated based upon assumptions of well depths and pump efficiencies. Some wells use natural gas for individual engines instead of electricity; however, the amount of natural gas pumping versus electric pumping is generally unknown. In 2010, average groundwater use in the state was approximately 14.7 million acre-feet, or 36 percent of total agricultural, municipal, and industrial water supplies (DWR 2013). The California Public Utilities Commission estimated that in 2010, statewide groundwater pumping accounted for more electricity use between May and August than the total electricity use by the CVP and SWP during that time period (CPUC 2010). Over the entire year, it was estimated that groundwater pumping used approximately 10 percent more electricity than the SWP and approximately 5 percent less than the CVP and SWP combined.

## 8.4 Impact Analysis

This section describes the potential mechanisms for change in energy generation and analytical methods; results of the impact analyses; potential mitigation measures; and cumulative effects.

### 8.4.1 Potential Mechanisms for Change and Analytical Tools

The environmental consequences assessment considers changes in energy resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

#### 8.4.1.1 Changes in Energy Resources Related to CVP and SWP Water Users

Energy generation is limited on a monthly bases by the average power capacity of each generation facility based upon reservoir elevations and water release patterns. The majority of the CVP and SWP energy use is for the conveyance facilities located in the Delta and south of the Delta. Energy use would change with changes in CVP and SWP deliveries.

Reservoir elevations and flow patterns through pumping facilities output from the CalSim II model (see Chapter 5, Surface Water Resources and Water Supplies) are used with LTGen and SWP Power tools, as described in Appendix 8A, Power Model Documentation. These tools estimate average annual peaking power capacity, energy use, and energy generation at CVP and SWP facilities, respectively. The tools estimate average annual energy generation and use and net generation. When net generation values are negative, the CVP or SWP would purchase power from other generation facilities. When net generation values are positive, power would be available for use by non-CVP and SWP electricity users.

When CVP and SWP water deliveries change, water users would are anticipated do change their use of groundwater, recycled water, and/or desalinated water, as described in Chapter 5, Surface Water Resources and Water Supplies, Chapter 12, Agricultural Resources, and Chapter 19, Socioeconomics. Specific responses by water users to changes in CVP and SWP water deliveries are not known; and therefore, energy use for the alternate water supplies cannot be quantified in this analysis. It is not known whether the net change in energy use for the CVP and SWP would or would not be similar to the net change in energy use for alternate water supplies (e.g., groundwater pumping, water treatment, water conveyance).

#### 8.4.1.2 Effect Related to Cross Delta Water Transfers

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years. Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities, especially in drier years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Changes in net energy generation could occur statewide during cross Delta water transfers due to following reasons:

- Changed reservoir release patterns at CVP and SWP reservoirs
- Changed conveyance patterns at the CVP and SWP pumping plants

- Increased groundwater pumping in the seller's service area if groundwater substitution is used to make the transferred water available
- Reductions in groundwater pumping in the purchaser's service area if less groundwater would be used due to the water transfer

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 8.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section.

Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison. Other future conditions would be different under the No Action Alternative as compared to the Second Basis of Comparison due to the implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO under the No Action Alternative.

This section of Chapter 8 provides qualitative projections of the No Action Alternative as compared to existing conditions described under the Affected Environment; and qualitative projections of the Second Basis of Comparison as compared to "recent historical conditions." Recent historical conditions are not the same as existing conditions which include implementation of the 2008 USFWS BO and 2009 NMFS BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

#### *8.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries, as described in Chapter 5, Surface Water Resources and Water Supplies.

#### 8.4.2.1.1 Changes in Conditions due to Climate Change and Sea Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and potential hydropower generation in the summer. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

#### 8.4.2.1.2 General Plan Development in California

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and the Second Basis of Comparison assume that land uses will develop through 2030 in accordance with existing general plans.

Statewide the increased population would result in increased energy demands. Under the No Action Alternative and Second Basis of Comparison, it is assumed that energy demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, increased efficiency in energy generation and transmission, and renewable energy sources.

#### 8.4.2.1.3 Reasonable and Foreseeable Water Resources Management Projects

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of the 2008 USFWS BO and 2009 NMFS BO by 2030, as described in Chapter 3, Description of Alternatives. Many of these future actions involve additional water treatment and conveyance facilities that would change statewide energy demands.

### *8.4.2.2 Changes in Conditions under the No Action Alternative*

Due to the climate change and sea level rise and increased water demands in the Sacramento Valley, CVP and SWP energy generation would be less in the summer months when energy demand is high for water conveyance and air conditioning equipment throughout the state. It is also anticipated that water deliveries would be less in 2030 than under recent historical conditions; and, therefore, energy use for CVP and SWP water conveyance facilities would be less.

#### *8.4.2.3 Changes in Conditions under the Second Basis of Comparison*

Due to the climate change and sea level rise and increased water demands in the Sacramento Valley, CVP and SWP energy generation would be less in the summer months when energy demand is high for water conveyance and air conditioning equipment throughout the State. It is also anticipated that water deliveries would be less in 2030 than under recent historical conditions; and, therefore, energy use for CVP and SWP water conveyance facilities would be less.

As described in Chapter 5, Surface Water Resources and Water Supplies, the availability of CVP and SWP water supplies would be greater under the Second Basis of Comparison as compared to the No Action Alternative because CVP and SWP water operations would not include requirements of the 2008 USFWS BO and 2009 NMFS BO. Therefore, CVP and SWP energy use would be greater, and possibly groundwater pumping use would be less, under the Second Basis of Comparison as compared to the No Action Alternative.

### 8.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

#### *8.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 8.4.3.1.1 Potential Changes in Energy Resources Related to CVP and SWP Water Users

Changes in CVP and SWP operations under the No Action Alternative as compared to the Second Basis of Comparison would result in a reduction of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use would result in changes in CVP and SWP energy resources, as summarized in Table 8.5. The CVP net generation over the long-term conditions (averaged over the 81-year model simulation period, as described in Chapter 5) and in dry and critical dry years would be similar (within 5 percent) under the No Action Alternative and the Second Basis of Comparison. The SWP net generation would be reduced by 29 percent over the long-term condition and by 37 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.5 Energy Generation, Energy Use, and Net Generation under the No Action Alternative as Compared to the Second Basis of Comparison**

| Project | Water Year | Energy (Gigawatt-hours) | No Action Alternative (NAA) | Second Basis of Comparison (SBC) | Changes between NAA and SBC |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,558 | 4,604 | -46 |
| | | Energy Use | 1,113 | 1,289 | -177 |
| | | Net Generation | 3,445 | 3,315 | 131 |
| | Dry and Critical Water Years | Energy Generation | 2,696 | 2,773 | -77 |
| | | Energy Use | 699 | 773 | -75 |
| | | Net Generation | 1,997 | 2,000 | -2 |
| SWP Facilities | Long-term Average | Energy Generation | 4,202 | 4,721 | -520 |
| | | Energy Use | 7,798 | 9,802 | -2,004 |
| | | Net Generation | -3,597 | -5,081 | 1,484 |
| | Dry and Critical Water Years | Energy Generation | 1,914 | 2,494 | -579 |
| | | Energy Use | 3,929 | 5,686 | -1,757 |
| | | Net Generation | -2,015 | -3,192 | 1,177 |

Under the No Action Alternative as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be less and it is anticipated that CVP and SWP water users would use more alternate water supplies. These alternate water supplies would require energy. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the reduced energy use by the CVP and SWP operations in 2030 under the No Action Alternative as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under the No Action Alternative than under the Second Basis of Comparison.

##### 8.4.3.1.2 Effects Related to Cross Delta Water Transfers

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to energy resources were identified as changes in power generation patterns at the reservoirs due to changes in reservoir release patterns and surface water elevation patterns. These potential changes were not considered to be substantial because the total amount of electricity generated would be similar and the power loss would be minimal due to changes in release patterns. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Groundwater pumping in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater pumping would be similar with or without water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison; however, energy resources conditions would be similar.

#### *8.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because energy resource conditions under Alternative 1 are identical to energy resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 8.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Potential Changes in Energy Resources Related to CVP and SWP Water Users*

Changes in CVP and SWP operations under Alternative 1 as compared to the No Action Alternative would result in an increase of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use would result in changes in CVP and SWP energy resources, as summarized in Table 8.6. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 1 as compared to the No Action Alternative. The SWP net generation would be increased by 41 percent over the long-term condition and by 58 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.6 Energy Generation, Energy Use, and Net Generation under Alternative 1 as Compared to the No Action Alternative**

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 1 | No Action Alternative (NAA) | Changes between Alternative 1 and NAA |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,604 | 4,558 | 46 |
| | | Energy Use | 1,289 | 1,113 | 177 |
| | | Net Generation | 3,315 | 3,445 | -131 |
| | Dry and Critical Water Years | Energy Generation | 2,773 | 2,696 | 77 |
| | | Energy Use | 773 | 699 | 75 |
| | | Net Generation | 2,000 | 1,997 | 2 |
| SWP Facilities | Long-term Average | Energy Generation | 4,721 | 4,202 | 520 |
| | | Energy Use | 9,802 | 7,798 | 2,004 |
| | | Net Generation | -5,081 | -3,597 | -1,484 |
| | Dry and Critical Water Years | Energy Generation | 2,494 | 1,914 | 579 |
| | | Energy Use | 5,686 | 3,929 | 1,757 |
| | | Net Generation | -3,192 | -2,015 | -1,177 |

Under Alternative 1 as compared to the No Action Alternative, CVP and SWP water deliveries would be increased and it is anticipated that CVP and SWP water users would use less alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the decreased regional and local water supply energy requirements would be similar to the increased energy use by the CVP and SWP operations in 2030 under Alternative 1 as compared to the No Action Alternative. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be lower under Alternative 1 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar energy conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative; however, energy resources conditions would be similar.

##### 8.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *8.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, the energy resources conditions under Alternative 2 is only compared to the Second Basis of Comparison.

##### 8.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to energy resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 8.4.3.1, No Action Alternative.

### *8.4.3.4 Alternative 3*

CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative or

Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a Warren Act Contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

##### 8.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Potential Changes in Energy Resources to CVP and SWP Water Users*

Changes in CVP and SWP operations under Alternative 3 as compared to the No Action Alternative would result in changes in CVP and SWP energy resources, as summarized in Table 8.7. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the No Action Alternative. The SWP net generation would be increased by 27 percent over the long-term condition and by 16 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.7 Energy Generation, Energy Use, and Net Generation under Alternative 3 as Compared to the No Action Alternative**

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 3 | No Action Alternative (NAA) | Changes between Alternative 3 and NAA |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,582 | 4,558 | 24 |
| | | Energy Use | 1,238 | 1,113 | 125 |
| | | Net Generation | 3,344 | 3,445 | -102 |
| | Dry and Critical Water Years | Energy Generation | 2,798 | 2,696 | 102 |
| | | Energy Use | 715 | 699 | 16 |
| | | Net Generation | 2,084 | 1,997 | 86 |
| SWP Facilities | Long-term Average | Energy Generation | 4,537 | 4,202 | 335 |
| | | Energy Use | 9,115 | 7,798 | 1,317 |
| | | Net Generation | -4,578 | -3,597 | -981 |

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 3 | No Action Alternative (NAA) | Changes between Alternative 3 and NAA |
|---|---|---|---|---|---|
| | Dry and Critical Water Years | Energy Generation | 2,128 | 1,914 | 214 |
| | | Energy Use | 4,455 | 3,929 | 526 |
| | | Net Generation | -2,327 | -2,015 | -312 |

Under Alternative 3 as compared to the No Action Alternative, CVP and SWP water deliveries would be increased and it is anticipated that CVP and SWP water users would use less alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the decreased regional and local water supply energy requirements would be similar to the increased energy use by the CVP and SWP operations in 2030 under Alternative 3 as compared to the No Action Alternative. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be lower under Alternative 3 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar energy conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative; however, energy resources conditions would be similar.

#### 8.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Potential Changes in Energy Resources to CVP and SWP Water Users*

Changes in CVP and SWP operations under Alternative 3 as compared to the Second Basis of Comparison would result in changes in CVP and SWP energy resources, as summarized in Table 8.8. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the Second Basis of Comparison. The SWP net generation would be reduced by 10 percent over the long-term condition and by 58 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.8 Energy Generation, Energy Use, and Net Generation under Alternative 3 as Compared to the Second Basis of Comparison**

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 3 | Second Basis of Comparison (SBC) | Changes between Alternative 3 and SBC |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,582 | 4,604 | -22 |
| | | Energy Use | 1,238 | 1,289 | -51 |
| | | Net Generation | 3,344 | 3,315 | 29 |
| | Dry and Critical Water Years | Energy Generation | 2,798 | 2,773 | 25 |
| | | Energy Use | 715 | 773 | -59 |
| | | Net Generation | 2,084 | 2,000 | 84 |
| SWP Facilities | Long-term Average | Energy Generation | 4,537 | 4,721 | -184 |
| | | Energy Use | 9,115 | 9,802 | -687 |
| | | Net Generation | -4,578 | -5,081 | 503 |
| | Dry and Critical Water Years | Energy Generation | 2,128 | 2,494 | -366 |
| | | Energy Use | 4,455 | 5,686 | -1,230 |
| | | Net Generation | -2,327 | -3,192 | 865 |

Under Alternative 3 as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be decreased and it is anticipated that CVP and SWP water users would use more alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the decreased energy use by the CVP and SWP operations in 2030 under Alternative 3 as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under Alternative 3 as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar energy conditions would occur during implementation of cross Delta water transfers under Alternative 3 as compared to the Second Basis of Comparison.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 as compared to the Second Basis of Comparison; and energy resources conditions would be similar.

### *8.4.3.5 Alternative 4*

Energy resources under Alternative 4 would be identical to the conditions under the Second Basis of Comparison. Alternative 4 is only compared to the No Action Alternative.

#### 8.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in energy resources under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 8.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

### *8.4.3.6 Alternative 5*

The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a Warren Act Contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 8.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Potential Changes in Energy Resources to CVP and SWP Water Users*

Changes in CVP and SWP operations under Alternative 5 as compared to the No Action Alternative would result in changes in CVP and SWP energy resources, as summarized in Table 8.9. The CVP and SWP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 5 as compared to the No Action Alternative. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.9 Energy Generation, Energy Use, and Net Generation under Alternative 5 as Compared to the No Action Alternative**

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 3 | Second Basis of Comparison (SBC) | Changes between Alternative 3 and SBC |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,552 | 4,558 | -6 |
| | | Energy Use | 1,110 | 1,113 | -3 |
| | | Net Generation | 3,442 | 3,445 | -4 |
| | Dry and Critical Water Years | Energy Generation | 2,684 | 2,696 | -12 |
| | | Energy Use | 699 | 699 | 0 |
| | | Net Generation | 1,986 | 1,997 | -11 |
| SWP Facilities | Long-term Average | Energy Generation | 4,191 | 4,202 | -11 |
| | | Energy Use | 7,732 | 7,798 | -66 |
| | | Net Generation | -3,541 | -3,597 | 56 |
| | Dry and Critical Water Years | Energy Generation | 1,904 | 1,914 | -10 |
| | | Energy Use | 3,841 | 3,929 | -88 |
| | | Net Generation | -1,937 | -2,015 | 78 |

Under Alternative 5 as compared to the No Action Alternative, CVP and SWP water deliveries would be similar, and it is anticipated that CVP and SWP water users would use similar alternate water supplies. Therefore, for the purposes of this analysis, it is assumed that total energy use by CVP and SWP water users could be similar under Alternative 5 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar energy conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 as compared to the No Action Alternative; and energy resources conditions would be similar.

#### 8.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Potential Changes in Energy Resources to CVP and SWP Water Users*

Changes in CVP and SWP operations under Alternative 5 as compared to the Second Basis of Comparison would result in changes in CVP and SWP energy resources, as summarized in Table 8.10. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the Second Basis of Comparison. The SWP net generation would be reduced by 30 percent over the long-term condition and by 39 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

**Table 8.10 Energy Generation, Energy Use, and Net Generation under Alternative 5 as Compared to the Second Basis of Comparison**

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 5 | Second Basis of Comparison (SBC) | Changes between Alternative 5 and SBC |
|---|---|---|---|---|---|
| CVP Facilities | Long-term Average | Energy Generation | 4,552 | 4,604 | -52 |
| | | Energy Use | 1,110 | 1,289 | -179 |
| | | Net Generation | 3,442 | 3,315 | 127 |
| | Dry and Critical Water Years | Energy Generation | 2,684 | 2,773 | -89 |
| | | Energy Use | 699 | 773 | -75 |
| | | Net Generation | 1,986 | 2,000 | -14 |
| SWP Facilities | Long-term Average | Energy Generation | 4,191 | 4,721 | -530 |
| | | Energy Use | 7,732 | 9,802 | -2,070 |
| | | Net Generation | -3,541 | -5,081 | 1,540 |

| Project | Water Year | Energy (Gigawatt-hours) | Alternative 5 | Second Basis of Comparison (SBC) | Changes between Alternative 5 and SBC |
|---|---|---|---|---|---|
| | Dry and Critical Water Years | Energy Generation | 1,904 | 2,494 | -590 |
| | | Energy Use | 3,841 | 5,686 | -1,845 |

Under Alternative 5 as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be decreased and it is anticipated that CVP and SWP water users would use more alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the decreased energy use by the CVP and SWP operations in 2030 under Alternative 5 as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under Alternative 5 as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to energy resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar energy conditions would occur during implementation of cross Delta water transfers under Alternative 5 as compared to the Second Basis of Comparison.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison; however, energy resources conditions would be similar.

#### 8.4.3.7 Summary of Impact Analysis

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 8.11 and 8.12.

**Table 8.11 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | CVP annual net generation would be similar.<br>SWP annual net generation would be increased by 41 percent over the long-term condition; and by 58 percent in dry and critical dry years.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to decrease. | None needed. |
| Alternative 2 | No effects on energy resources. | None needed. |
| Alternative 3 | CVP annual net generation would be similar.<br>SWP annual net generation would be increased by 27 percent over the long-term condition and by 16 percent in dry and critical dry years.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to decrease. | None needed. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed. |
| Alternative 5 | CVP and SWP annual net generation would be similar.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to be similar. | None needed. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be "similar."

**Table 8.12 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | CVP annual net generation would be similar.<br>SWP annual net generation would be reduced by 29 percent over the long-term condition and by 37 percent in dry and critical dry years.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase. | Not considered for this comparison. |
| Alternative 1 | No effects on energy resources. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | CVP annual net generation would be similar.<br>SWP annual net generation would be reduced by 10 percent over the long-term condition and by 58 percent in dry and critical dry years.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase. | Not considered for this comparison. |
| Alternative 4 | No effects on energy resources. | Not considered for this comparison. |
| Alternative 5 | CVP annual net generation would be similar.<br>SWP annual net generation would be reduced by 30 percent over the long-term condition and by 39 percent in dry and critical dry years.<br>Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

#### *8.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes under Alternatives 1 through 5 as compared to the No Action Alternative would result in similar or increased net energy generation, and reduced potential energy use by CVP and SWP water users for alternate water supplies. Therefore, there would be no adverse impacts to energy resources as compared to the No Action Alternative; and no mitigation measures are needed.

#### *8.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Energy Resources are summarized in Table 8.13.

**Table 8.13 Summary of Cumulative Effects on Energy Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs | These effects would be the same in all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce carryover storage in reservoirs and changes in stream flow patterns in a manner that could reduce hydroelectric generation in the summer and fall months.<br>Reduced CVP and SWP water deliveries south of the Delta would also reduce CVP and SWP electricity use.<br>Future water supply projects are anticipated to both improve water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- San Joaquin River Restoration Program<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased use of groundwater pumps would increase energy use; however, this energy use would be similar or less than the energy used for CVP and SWP water conveyance.<br>Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability. |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program | These effects would be the same in all alternatives.<br>Most of the future reasonably foreseeable actions are anticipated to improve water supplies in California to reduce impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth. If CVP and SWP water supply reliability increases, energy use for conveyance of CVP and SWP water supplies also would increase.<br>Some of the future reasonably foreseeable actions are anticipated to potentially reduce CVP and SWP water supply reliability (e.g., Water Quality Control Plan Update and FERC Relicensing Projects).<br>Future water supply projects are anticipated to both improve water supply reliability due to reduced |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - San Luis Reservoir Low Point Improvement Project<br>- Westlands Water District v. United States Settlement<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects. However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased use of groundwater pumps would increase energy use; however, this energy use would be similar or less than the energy used for CVP and SWP water conveyance. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP | Implementation of No Action Alternative future reasonably foreseeable actions would result in changes stream flows and related changes in hydroelectric generation patterns, and reduced CVP and SWP water supplies as compared to conditions prior to the BOs.<br><br>If CVP and SWP water supply reliability decreases, energy use for conveyance of CVP and SWP water supplies also would decrease and energy use for alternative water supplies could increase. |
| Alternatives 1 and 4 with Associated Cumulative Effects Actions Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 future reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | | water supplies as compared to the No Action Alternative with the added actions.<br>Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br><br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 future reasonably foreseeable actions with future reasonably foreseeable actions for energy resources would be the same as for the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br><br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 future reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br><br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 would result in changes in stream flows and related hydroelectric generation patterns, and reduced CVP and SWP water supplies as compared to the No Action |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | | Alternative with the added actions.<br>Reduced CVP and SWP water supply reliability would decrease energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would increase as compared to the No Action Alternative with the added actions. |

## 8.5 References


CEC (The California Energy Commission). 2014a. Hydroelectric Power in California. Site accessed June 8, 2014. http://www.energy.ca.gov/hydroelectric/.

____. 2014b. *How the Drought Affects California's Energy, Economy, and Emission Goals*. Site accessed June 8, 2014. http://www.energy.ca.gov/drought /

CPUC (California Public Utilities Commission). 2010. *Embedded Energy in Water Studies, Study 1: Statewide and Regional Water-Energy Relationship*. August 31.

DWR (California Department of Water Resources). 2002. *Management of the California State Water Project. Bulletin 132-01*. December.

____. 2004a. *Management of the California State Water Project. Bulletin 132-02*. January.

____. 2004b. *Management of the California State Water Project. Bulletin 132-03*. December.

____. 2005. *Management of the California State Water Project. Bulletin 132-04*. September.

____. 2006. *Management of the California State Water Project. Bulletin 132-05*. December.

____. 2007. *Management of the California State Water Project. Bulletin 132-06*. December.

____. 2008. *Management of the California State Water Project. Bulletin 132-07*. December.

____. 2012a. *Management of the California State Water Project. Bulletin 132-08*. June.

____. 2012b. *Management of the California State Water Project. Bulletin 132-09*. December.

____. 2013a. *Management of the California State Water Project. Bulletin 132-10*. June.

____. 2013b. *Management of the California State Water Project. Bulletin 132-11*. December.

____. 2013c. *California Water Plan Update 2013 – Public Review Draft*.

____. 2013d. *California Hydroelectric Statistics & Data*. Site accessed June 17, 2014. http://energyalmanac.ca.gov/renewables/hydro/.

____. 2013e. Excel spreadsheet from *California Hydroelectric Statistics & Data*. Site accessed June 17, 2014. http://energyalmanac.ca.gov/renewables/hydro/.

____. 2013f. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp.

HWG (Hydropower Working Group, California Energy Commission, California Public Utilities Commission, Department of Water Resources, State Water Resources Control Board, and California Independent System Operator). 2014. *Hydropower Working Group*. February 27.

Reclamation (Bureau of Reclamation). 2001. *Central Valley Operations Office Report of Operations*. December.

____. 2002. *Central Valley Operations Office Report of Operations*. December.

____. 2003. *Central Valley Operations Office Report of Operations*. December.

____. 2004. *Central Valley Operations Office Report of Operations*. December.

____. 2005. *Central Valley Operations Office Report of Operations*. December.

____. 2006. *Central Valley Operations Office Report of Operations*. December.

____. 2007. *Central Valley Operations Office Report of Operations*. December.

____. 2008a. *Central Valley Project-California Monthly Power System Generation Summary*. January.

____. 2008b. *Central Valley Project-California Monthly Power System Generation Summary*. February.

____. 2008c. *Central Valley Project-California Monthly Power System Generation Summary*. March.

____. 2008d. *Central Valley Project-California Monthly Power System Generation Summary*. April.

____. 2008e. *Central Valley Project-California Monthly Power System Generation Summary*. May.

____. 2008f. *Central Valley Project-California Monthly Power System Generation Summary*. June.

____. 2008g. *Central Valley Project-California Monthly Power System Generation Summary*. July.

____. 2008h. *Central Valley Project-California Monthly Power System Generation Summary*. August.

____. 2008i. *Central Valley Project-California Monthly Power System Generation Summary*. September.

____. 2008j. *Central Valley Project-California Monthly Power System Generation Summary*. October.

____. 2008k. *Central Valley Project-California Monthly Power System Generation Summary*. November.

____. 2008l. *Central Valley Project-California Monthly Power System Generation Summary*. December.

____. 2009a. *Central Valley Project-California Monthly Power System Generation Summary*. January.

____. 2009b. *Central Valley Project-California Monthly Power System Generation Summary*. February.

____. 2009c. *Central Valley Project-California Monthly Power System Generation Summary*. March.

____. 2009d. *Central Valley Project-California Monthly Power System Generation Summary*. April.

____. 2009e. *Central Valley Project-California Monthly Power System Generation Summary*. May.

____. 2009f. *Central Valley Project-California Monthly Power System Generation Summary*. June.

____. 2009g. *Central Valley Project-California Monthly Power System Generation Summary*. July.

____. 2009h. *Central Valley Project-California Monthly Power System Generation Summary*. August.

____. 2009i. *Central Valley Project-California Monthly Power System Generation Summary*. September.

____. 2009j. *Central Valley Project-California Monthly Power System Generation Summary*. October.

____. 2009k. *Central Valley Project-California Monthly Power System Generation Summary*. November.

____. 2009l. *Central Valley Project-California Monthly Power System Generation Summary*. December.

____. 2010a. *Central Valley Project-California Monthly Power System Generation Summary*. January.

____. 2010b. *Central Valley Project-California Monthly Power System Generation Summary*. February.

____. 2010c. *Central Valley Project-California Monthly Power System Generation Summary*. March.

____. 2010d. *Central Valley Project-California Monthly Power System Generation Summary*. April.

____. 2010e. *Central Valley Project-California Monthly Power System Generation Summary*. May.

____. 2010f. *Central Valley Project-California Monthly Power System Generation Summary*. June.

____. 2010g. *Central Valley Project-California Monthly Power System Generation Summary*. July.

____. 2010h. *Central Valley Project-California Monthly Power System Generation Summary*. August.

____. 2010i. *Central Valley Project-California Monthly Power System Generation Summary*. September.

____. 2010j. *Central Valley Project-California Monthly Power System Generation Summary*. October.

____. 2010k. *Central Valley Project-California Monthly Power System Generation Summary*. November.

____. 2010l. *Central Valley Project-California Monthly Power System Generation Summary*. December.

____. 2011a. *Central Valley Project-California Monthly Power System Generation Summary*. January.

____. 2011b. *Central Valley Project-California Monthly Power System Generation Summary*. February.

____. 2011c. *Central Valley Project-California Monthly Power System Generation Summary*. March.

____. 2011d. *Central Valley Project-California Monthly Power System Generation Summary*. April.

____. 2011e. *Central Valley Project-California Monthly Power System Generation Summary*. May.

____. 2011f. *Central Valley Project-California Monthly Power System Generation Summary*. June.

____. 2011g. *Central Valley Project-California Monthly Power System Generation Summary*. July.

____. 2011h. *Central Valley Project-California Monthly Power System Generation Summary*. August.

____. 2011i. *Central Valley Project-California Monthly Power System Generation Summary*. September.

____. 2011j. *Central Valley Project-California Monthly Power System Generation Summary*. October.

____. 2011k. *Central Valley Project-California Monthly Power System Generation Summary*. November.

____. 2011l. *Central Valley Project-California Monthly Power System Generation Summary*. December.

____. 2012a. *Central Valley Project Hydropower Production*. September.

____. 2012b. *Central Valley Project-California Monthly Power System Generation Summary*. January.

____. 2012c. *Central Valley Project-California Monthly Power System Generation Summary*. February.

____. 2012d. *Central Valley Project-California Monthly Power System Generation Summary*. March.

____. 2012e. *Central Valley Project-California Monthly Power System Generation Summary*. April.

____. 2012f. *Central Valley Project-California Monthly Power System Generation Summary*. May.

____. 2012g. *Central Valley Project-California Monthly Power System Generation Summary*. June.

____. 2012h. *Central Valley Project-California Monthly Power System Generation Summary*. July.

____. 2012i. *Central Valley Project-California Monthly Power System Generation Summary*. August.

____. 2012j. *Central Valley Project-California Monthly Power System Generation Summary*. September.

____. 2012k. *Central Valley Project-California Monthly Power System Generation Summary*. October.

____. 2012l. *Central Valley Project-California Monthly Power System Generation Summary*. November.

____. 2012m. *Central Valley Project-California Monthly Power System Generation Summary*. December.

____. 2013a. *Mid-Pacific Region, Central Valley Project Hydropower Production*. July.

____. 2013b. Trinity River Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Trinity+Powerplant.

____. 2013c. Lewiston Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Lewiston+Powerplant.

____. 2013d. Judge Francis Carr Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Judge Francis Carr Powerplant.

____. 2013e. Shasta Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Shasta Powerplant.

____. 2013f. Spring Creek Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Spring Creek Powerplant.

____. 2013g. Keswick Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Keswick Powerplant.

____. 2013h. Folsom Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Folsom Powerplant.

____. 2013i. Nimbus Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=Nimbus Powerplant.

____. 2013j. New Melones Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=New+Melones+Powerplant.

____. 2013k. O'Neill Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=O%60Neill+Powerplant

____. 2013l. San Luis (William R. Gianelli) Powerplant. Site accessed September 24, 2013. http://www.usbr.gov/projects/powerplants. jsp?fac_Name=San Luis (William R. Gianelli) Powerplant.

____. 2013m. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

____. 2013n. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

____. 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

____. 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

____. 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

____. 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*. November.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

____. 2013. C*omprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

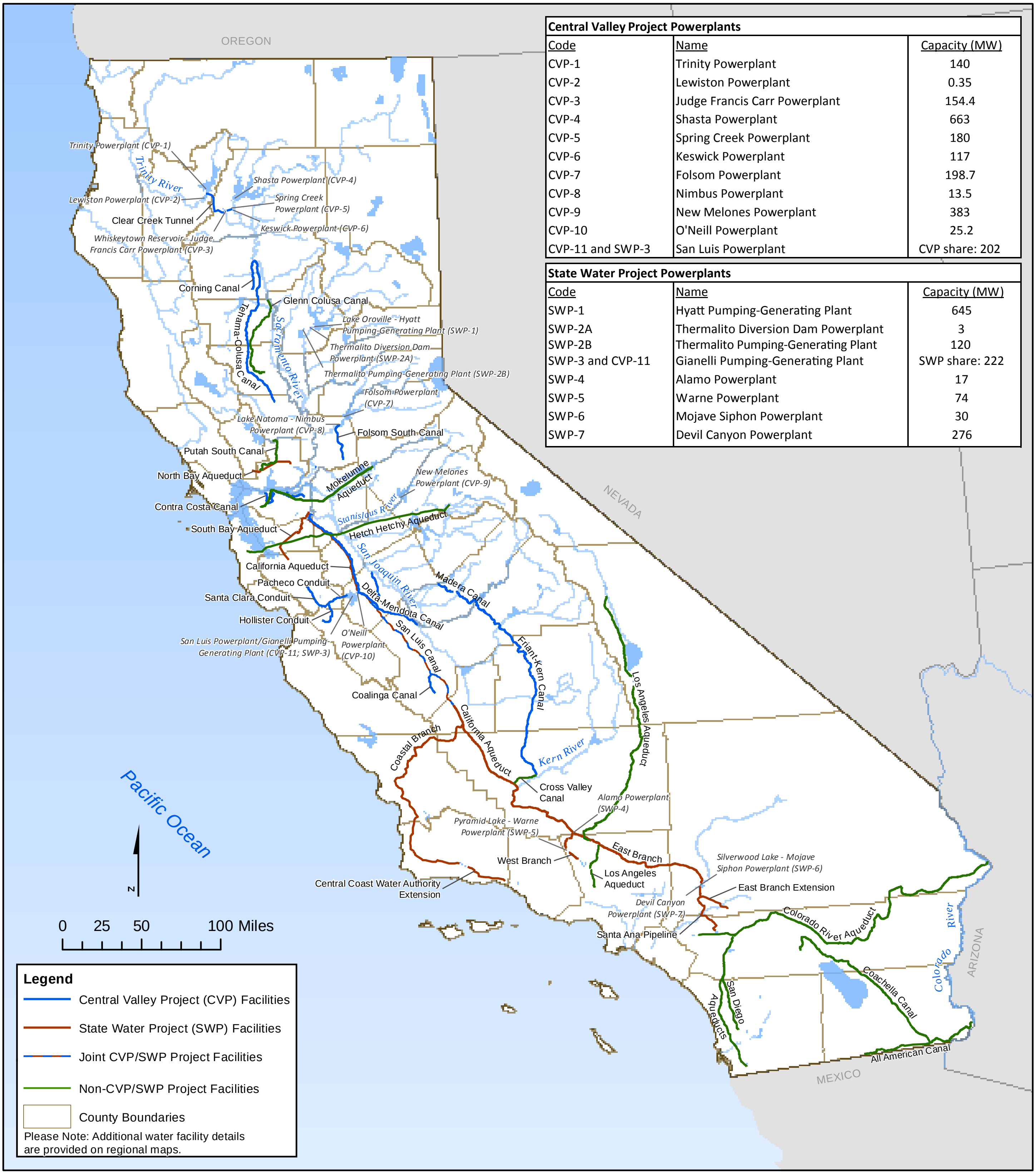
YCWA (Yuba County Water Agency). 2012. *Yuba River Development Project Relicensing*.

**Chapter 8**

# Energy Figures

The following figures are included in Chapter 8, Energy.

- 8.1 Central Valley Project and State Water Project Hydroelectric Generation Facilities
- 8.2 Central Valley Project Energy Generation and Energy Use
- 8.3 State Water Project Energy Generation and Energy Use




**Central Valley Project Powerplants**

| Code | Name | Capacity (MW) |
|---|---|---|
| CVP-1 | Trinity Powerplant | 140 |
| CVP-2 | Lewiston Powerplant | 0.35 |
| CVP-3 | Judge Francis Carr Powerplant | 154.4 |
| CVP-4 | Shasta Powerplant | 663 |
| CVP-5 | Spring Creek Powerplant | 180 |
| CVP-6 | Keswick Powerplant | 117 |
| CVP-7 | Folsom Powerplant | 198.7 |
| CVP-8 | Nimbus Powerplant | 13.5 |
| CVP-9 | New Melones Powerplant | 383 |
| CVP-10 | O'Neill Powerplant | 25.2 |
| CVP-11 and SWP-3 | San Luis Powerplant | CVP share: 202 |

**State Water Project Powerplants**

| Code | Name | Capacity (MW) |
|---|---|---|
| SWP-1 | Hyatt Pumping-Generating Plant | 645 |
| SWP-2A | Thermalito Diversion Dam Powerplant | 3 |
| SWP-2B | Thermalito Pumping-Generating Plant | 120 |
| SWP-3 and CVP-11 | Gianelli Pumping-Generating Plant | SWP share: 222 |
| SWP-4 | Alamo Powerplant | 17 |
| SWP-5 | Warne Powerplant | 74 |
| SWP-6 | Mojave Siphon Powerplant | 30 |
| SWP-7 | Devil Canyon Powerplant | 276 |

**Figure 8.1 Central Valley Project and State Water Project Hydroelectric Generation Facilities**

Sources: Reclamation 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, 2013h, 2013i, 2013j, 2013k, 2013l; DWR 2012

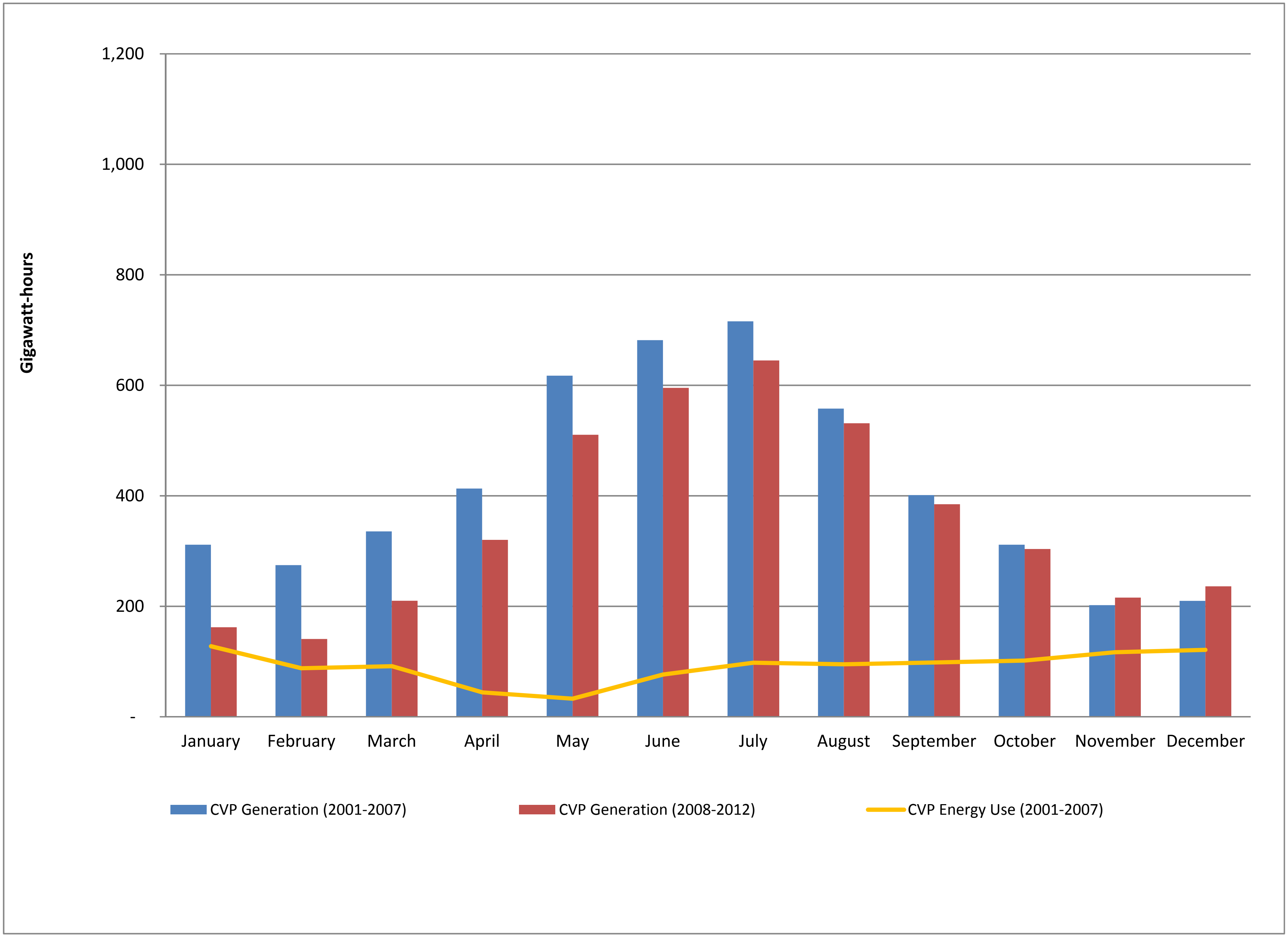



**Figure 8.2 Central Valley Project Energy Generation and Energy Use**

Sources: Reclamation 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008 a-l, 2009a-l, 2010a-l, 2011a-l, 2012a-l

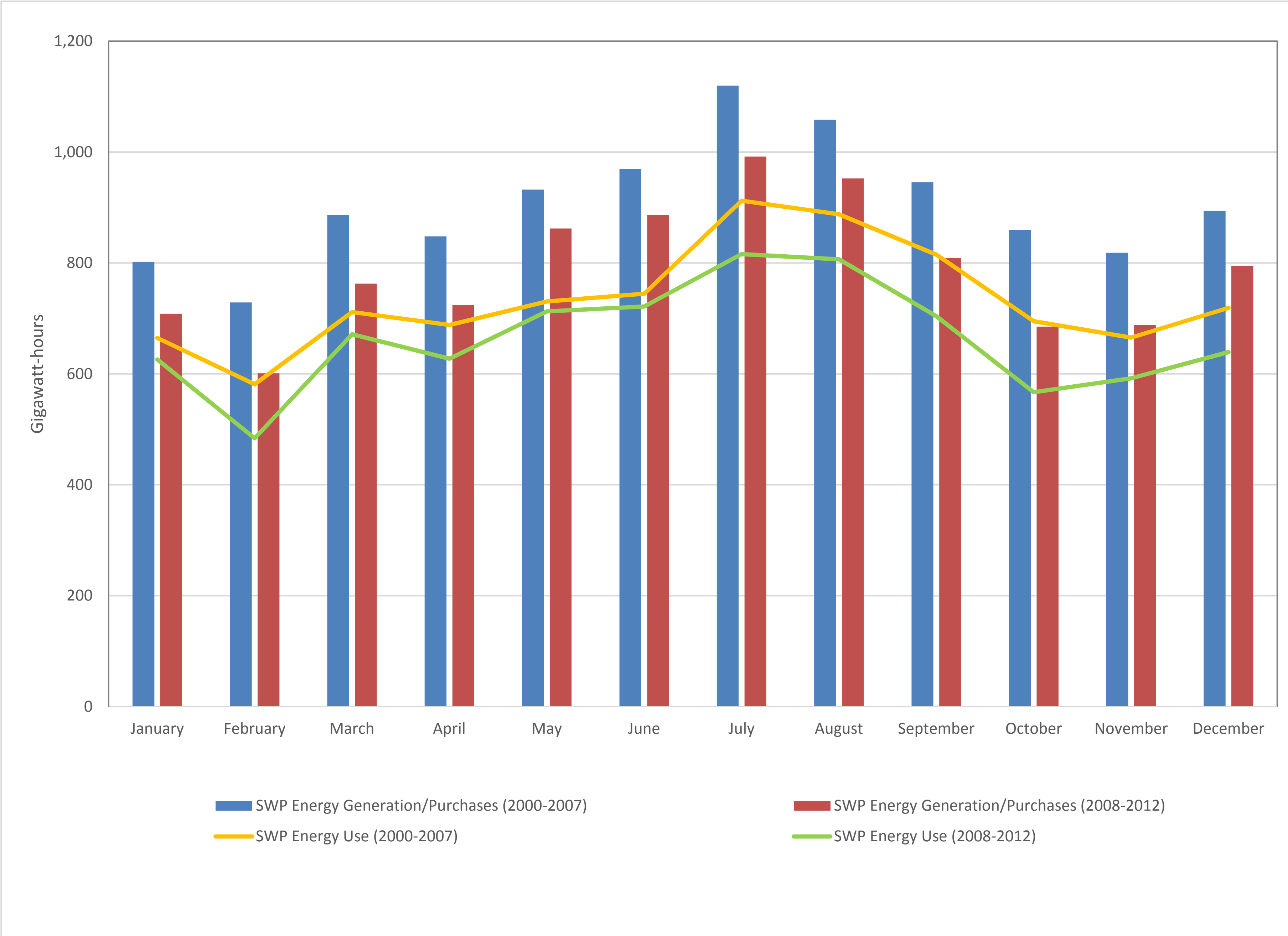



**Figure 8.3 State Water Project Energy Generation and Energy Use**
Sources: DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013

Chapter 9

# Fish and Aquatic Resources

## 9.1 Introduction

This chapter describes the fish and aquatic resources that occur in the portions of the project area that could be affected as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect aquatic resources through changes in ecological attributes as a result of potential changes in long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 9.2 Regulatory Environment and Compliance Requirements

Potential actions implemented under the alternatives evaluated in this EIS could affect fish and aquatic resources. Actions located on public agency lands, or implemented, funded, or approved by Federal and state agencies, would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 9.3 Affected Environment

This section describes fish and aquatic resources that could be affected by the implementation of the alternatives considered in this EIS. Changes in aquatic resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

The following description of the affected environment focuses on CVP and SWP reservoirs, rivers downstream of CVP and SWP reservoirs, the Sacramento-San Joaquin Rivers Delta Estuary (Delta), and conditions downstream of the Delta that are affected by operation of the CVP and SWP.

This section is organized by geographic area, generally in an upstream to downstream direction. This format does not necessarily coincide with the use by fish and aquatic species, which can move among geographic areas either seasonally or during different phases of their life history.

The descriptions of species and biological and hydrodynamic processes in this chapter frequently use the terms “Delta” and “San Francisco Estuary.” The Delta refers to the Sacramento-San Joaquin Delta, as legally defined in the Delta Protection Act. The San Francisco Estuary refers to the portion of the Sacramento-San Joaquin Rivers watershed downstream of Chipps Island that is influenced by tidal action and where fresh water and salt water mix, which includes the following waterbodies: Suisun, San Pablo, and San Francisco bays.

### 9.3.1 Fish and Aquatic Species Evaluated

Many fish and aquatic species use the project area during all or some portion of their lives; however, certain fish and aquatic species were selected to be the focus of the analysis of alternatives considered in this EIS based on their sensitivity and their potential to be affected by changes in the operation of the CVP and SWP implemented under the alternatives considered in this EIS, as summarized in Table 9.1. While many of the species identified in Table 9.1 also occur in tributaries to the major rivers, the focus of this EIS is on the waterbodies influenced by operations of the CVP and SWP. Operation of the CVP and SWP would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook Salmon (produced in the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales.

These focal species are fish and marine mammal species listed as threatened or endangered or at risk of being listed as endangered or threatened, legally protected, or are otherwise considered sensitive by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), or California Department of Fish and Wildlife (CDFW) (previously known as Department of Fish and Game [DFG]) and fish that have tribal, commercial or recreational importance. In addition, salmon, steelhead, sturgeon, Striped Bass, and American Shad are managed in accordance with Section 3406of the Central Valley Project Improvement Act. Details on the status, life history, habitat requirements, and population trends for each of the aquatic focal species are provided in Appendix 9B.

**Table 9.1 Focal Fish Species by Region of Occurrence**

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| **Trinity River Region** | | | | |
| Coho Salmon *Southern Oregon/Northern California Coast ESU* | Threatened | Threatened | Yes | Trinity River, Klamath River |
| Eulachon *Southern DPS* | Threatened | None | Yes | Klamath River |
| Green Sturgeon *Southern DPS* | Threatened | Species of Special Concern | Yes | Trinity River, Klamath River |
| Spring-run Chinook Salmon *Upper Klamath-Trinity River ESU* | None | Species of Special Concern | Yes | Trinity River, Klamath River |
| Steelhead (winter- and summer-run) *Klamath Mountains Province DPS* | None | Species of Special Concern[c] | Yes | Trinity River, Klamath River |
| American Shad | None | None | Yes | Trinity River |
| Pacific Lamprey | None | None | Yes | Trinity River, Klamath River |

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| White Sturgeon | None | None | Yes | Trinity River, Klamath River |
| Black Bass (Largemouth, Smallmouth, Spotted) | None | None | Yes | Trinity River |
| **Central Valley Region** | | | | |
| Winter-run Chinook Salmon *Sacramento River ESU* | Endangered | Endangered | Yes | Sacramento River[d], Delta, and Suisun Marsh |
| Spring-run Chinook Salmon *Central Valley ESU* | Threatened | Threatened | Yes | Clear Creek, Sacramento River, Feather River, American River, Delta, and Suisun Marsh |
| Steelhead *Central Valley DPS* | Threatened | None | Yes | Clear Creek, Feather River, Sacramento River; American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh |
| Green Sturgeon *Southern DPS* | Threatened | Species of Special Concern | Yes | Feather River, Sacramento River, Delta and Suisun Marsh |
| Delta Smelt | Threatened | Endangered | No | Delta and Suisun Marsh |
| Longfin Smelt *Bay Delta DPS* | Candidate | Threatened | No | Delta and Suisun Marsh |
| Fall-/late Fall-run Chinook Salmon *Central Valley ESU* | None | Species of Special Concern | Yes | Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh |
| Sacramento Splittail | None | Species of Special Concern | No | Feather River, American River, Sacramento River, Delta and Suisun Marsh, San Joaquin River |
| Hardhead | None | Species of Special Concern | No | Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River |
| Sacramento-San Joaquin Roach | None | Species of Special Concern | No | Clear Creek, Feather River, American River, Sacramento River, Delta, Stanislaus River, San Joaquin River |

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| River Lamprey | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Pacific Lamprey | None | None | Yes | Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River |
| White Sturgeon | None | None | Yes | Feather River, Sacramento River, American River, San Joaquin River, Delta and Suisun Marsh |
| American Shad | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Black Bass (Largemouth, Smallmouth, Spotted) | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Striped Bass | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| **San Francisco Bay and Pacific Ocean Waters** | | | | |
| Steelhead Central California Coast DPS | Threatened | None | Yes | San Francisco Bay region |
| Killer Whale *Southern Resident DPS* | Endangered | None | Yes | Pacific Coast |

Notes:

a. The term *population* refers to the listed Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) for that species.

b. Includes species listed by the State of California as threatened, endangered, or considered a Species of Special Concern.

c. The California Species of Special Concern designation refers only to the summer-run of the Klamath Mountains Province DPS steelhead population

d. Also includes lower reaches of tributaries (e.g., American River) used for nonnatal rearing areas by juvenile salmon.

The life history attributes (e.g., timing of juvenile outmigration) for most of the species listed above, along with the ecological attributes important to the species and potentially influenced by the alternatives, are discussed in this chapter according to the geographic areas (regions/subregions) where the species occurs; Pacific Lamprey, Green Sturgeon, White Sturgeon, American Shad, and Striped Bass are discussed in detail only in those regions where they spend the majority of their life cycle such that geographic information is available. There are also several species (i.e., River Lamprey, Sacramento-San Joaquin Roach, and Hardhead) for which little geographic information is available; therefore, they are not discussed in detail in this chapter, but are described in the species accounts presented in Appendix 9B. Additionally, these species are only generally addressed in the analysis of impacts presented in the Environmental Consequences section of this chapter.

The level of detail presented in the Affected Environment section is tailored to correspond the level of resolution of the analysis, which relies on modeling tools that broadly characterize the changes in CVP and SWP operations on reservoir storage and flows. This level of detail is intended to support an understanding of the resources potentially affected and the context within which the project is evaluated. The inclusion of unnecessary detail is avoided.

### 9.3.2 Critical Habitat

Critical habitat refers to areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the Endangered Species Act (ESA). When a species is proposed for listing under the ESA, USFWS or NMFS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5 of the ESA as follows.

> *(5)(A) The term "critical habitat" for a threatened or endangered species means–*
>
> > *(i) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and*
> >
> > *(ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.*

Any Federal action (permit, license, or funding) in critical habitat requires that the Federal agency consult with USFWS or NMFS where the action has potential to adversely modify the habitat for the listed species.

ESA regulations state that the physical and biological features essential to the conservation of the species include space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of a species. These principal biological and physical features are known as Primary Constituent Elements (PCEs)[1]. Specific PCEs identified for salmonids, Green Sturgeon, Delta Smelt, and Eulachon are described below.

#### *9.3.2.1 Anadromous Salmonids*

In designating critical habitat for anadromous salmonids (70 Federal Register [FR] 52536), NMFS identified the following PCEs as essential to the conservation of the listed populations:

- Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development.
- Freshwater rearing sites with:
  - Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility
  - Water quality and forage supporting juvenile development
  - Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- Estuarine areas free of obstruction and excessive predation with:
  - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh water and salt water
  - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
  - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation

Critical habitat in nontidal waters includes the stream channels in the designated stream reaches, the lateral extent of which generally defined by the ordinary high-water line.

##### **9.3.2.1.1 Central Valley Spring-run Chinook Salmon ESU**

This ESU consists of spring-run Chinook Salmon in the Sacramento River Basin, including spring-run Chinook Salmon from the Feather River Hatchery. Designated critical habitat for Central Valley spring-run Chinook Salmon includes stream reaches of the American, Feather, Yuba, and Bear rivers;

[1] The U.S. Fish and Wildlife Service and National Marine Fisheries Service have proposed discontinuing the use of the term “Primary Constituent Elements” to simplify and clarify the critical habitat process and to provide consistency with the language contained in the Endangered Species Act, which uses the term “physical or biological features.”

tributaries of the Sacramento River, including Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the main stem of the Sacramento River from Keswick Dam through the Delta. Designated critical habitat in the Delta includes portions of the Delta Cross Channel (DCC); Yolo Bypass; and portions of the network of channels in the northern Delta. Critical habitat for spring-run Chinook Salmon was not designated for the Stanislaus or San Joaquin River.

The spring-run Chinook Salmon critical habitat potentially affected by operation of the CVP and SWP includes the network of channels in the northern Delta, Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Watt Avenue in the Sacramento Valley subregion. The section of the American River denoted as critical habitat serves only as juvenile nonnatal rearing habitat; spring-run Chinook Salmon do not spawn in the American River. Operation of the CVP and SWP would have no effect on designated critical habitat for spring-run Chinook Salmon in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River. Operation of the CVP and SWP could affect designated critical habitat in the Delta subregion. There is no designated critical habitat for spring-run Chinook Salmon in the San Joaquin Valley subregion.

#### 9.3.2.1.2 Sacramento River Winter-run Chinook Salmon ESU

The Sacramento River winter-run Chinook Salmon ESU consists of only one population confined to the upper Sacramento River. This ESU includes all fish spawning naturally in the Sacramento River and its tributaries, as well as fish that are propagated at the Livingston Stone National Fish Hatchery (NFH), operated by USFWS (NMFS 2005a). Critical habitat was delineated as the Sacramento River from Keswick Dam to Chipps Island at the westward margin of the Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco-Oakland Bay Bridge) to the Golden Gate Bridge (NMFS 1993).

#### 9.3.2.1.3 Central Valley Steelhead DPS

The California Central Valley Steelhead DPS includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries, excluding steelhead from San Francisco and San Pablo bays and their tributaries. Two artificial propagation programs, the Coleman NFH and Feather River Hatchery steelhead hatchery programs, are considered to be part of the DPS. Critical habitat for Central Valley Steelhead includes stream reaches of the American, Feather, Yuba, and Bear rivers and their tributaries, and tributaries of the Sacramento River including Deer, Mill, Battle, Antelope, and Clear creeks in the Sacramento River Basin; the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers in the San Joaquin River Basin; and portions of the Sacramento and San Joaquin rivers. Designated critical habitat in the Delta includes portions of the DCC, Yolo Bypass, Ulatis Creek, and portions of the network of channels in the Sacramento River portion of the Delta; and portions of the San Joaquin, Cosumnes, and Mokelumne rivers and portions of the network of channels in the San Joaquin portion of the Delta.

The Central Valley Steelhead critical habitat potentially affected by operation of the CVP and SWP includes the Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Nimbus Dam in the Sacramento Valley subregion. Operation of the CVP and SWP would have no effect on designated critical habitat for steelhead in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River.

##### 9.3.2.1.4 Central California Coast Steelhead DPS

The Central California Coast Steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River to Aptos Creek, Santa Cruz County (inclusive). It also includes the drainages of San Francisco and San Pablo bays. Critical habitat for Central California Coast Steelhead includes stream reaches in the Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin Hydrologic Units. Operation of the CVP and SWP would not affect designated critical habitat for this DPS of Central California Coast Steelhead, and NMFS (2009a) concluded that operation would not likely adversely affect individual fish; therefore, this species is not addressed in this EIS.

##### 9.3.2.1.5 Southern Oregon/Northern California Coastal Coho Salmon ESU

The Southern Oregon/Northern California Coast Coho Salmon ESU consists of populations from Cape Blanco, Oregon, to Punta Gorda, California, including Coho Salmon in the Trinity River. In the Trinity River Region, all Trinity River reaches downstream of Lewiston Dam, the south fork of the Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (NMFS 1999).

#### *9.3.2.2 North American Green Sturgeon Southern DPS*

The North American Green Sturgeon Southern DPS consists of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River. In designating critical habitat for the North American Green Sturgeon Southern DPS, NMFS (74 FR 52345) identified PCEs as essential to the conservation of this species in freshwater riverine systems, estuarine areas, and nearshore marine waters. The PCEs for each area largely overlap and include the following items:

- **Food Resources.** Abundant prey items for larval, juvenile, subadult, and adult life stages.
- **Substrate Type or Size (i.e., structural features of substrates).** Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to “collect” eggs and provide protection from predators, and free of excessive silt

and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high-flow conditions), and subadults and adults (e.g., substrates for holding and spawning).

- **Water Flow.** A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.
- **Water Quality.** Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
- **Migratory Corridor.** A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).
- **Water Depth.** Deep (greater than 5 meters [m]) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.
- **Sediment Quality.** Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Critical habitat in freshwater riverine habitats includes the stream channels in the designated stream reaches with the lateral extent defined by the ordinary high-water line. The ordinary high-water line on nontidal rivers is defined as “the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas” [33 Code of Federal Regulations 329.11(a)(1)].

Within the study area, critical habitat includes the Sacramento River from the I-Street Bridge upstream to Keswick Dam, including areas in the Yolo Bypass and the Sutter Bypass and the lower American River from the confluence with the Sacramento River upstream to the State Route 160 bridge over the American River; the lower Feather River from the confluence with the Sacramento River upstream to the Fish Barrier Dam; and the lower Yuba River from the confluence with the Feather River upstream to Daguerre Dam. Critical habitat also includes all waterways of the Delta up to the elevation of mean higher high water except for certain excluded areas and all tidally influenced areas of San Francisco Bay, San Pablo Bay, and Suisun Bay up to the elevation of mean higher high water (NMFS 2009b).

#### *9.3.2.3 Delta Smelt*

In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified the following PCEs essential to the conservation of the species: (1) suitable substrate for spawning; (2) water of suitable quality and depth to support survival and reproduction (e.g., temperature, turbidity, lack of contaminants); (3) sufficient Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to appropriate rearing habitats; and (4) salinity, which influences the extent and location of the low salinity zone where Delta Smelt rear. The location of the low salinity zone (or X2) is described in terms of the average distance of the two practical salinity units isohaline from the Golden Gate Bridge. Critical habitat for Delta Smelt includes all water and submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained in the legal Delta (as defined in Section 12220 of the California Water Code) (USFWS 1994a).

#### *9.3.2.4 Eulachon Southern DPS*

In designating critical habitat for Eulachon, NMFS (76 FR 65323) identified the following physical or biological features essential to the conservation of the Eulachon Southern DPS fall reflecting key life history phases of Eulachon: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles; (2) freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted; and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Within the study area, critical habitat for Eulachon includes the Klamath River from the mouth upstream to the confluence with Omogar Creek. The critical habitat designation specifically excludes all lands of the Yurok Tribe and Reshigini Rancheria, based upon a determination that the benefits of exclusion outweigh the benefits of designation (NMFS 2011b). Exclusion of these areas will not result in the extinction of the Southern DPS because the overall percentage of critical habitat on Indian lands is so small (approximately 5 percent of the total are designated), and it is likely that Eulachon production on these lands represents a small percent of the total annual production for the DPS (NMFS 2011a, 2011b).

### 9.3.3 Trinity River Region

The Trinity River Region includes Trinity Lake, Lewiston Reservoir and the Trinity River from Lewiston Reservoir to the confluence with the Klamath River; and the portion of the lower Klamath River watershed in Humboldt and Del Norte counties from the confluence with the Trinity River to the Pacific Ocean. The

CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of several Trinity River tributaries (i.e., north fork, south fork, and New River) and flows on these tributaries are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Reservoir to its confluence with the Klamath River, traversing through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties. The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects, and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low.

#### *9.3.3.1 Trinity Lake and Lewiston Reservoir*

Trinity Lake is created by Trinity Dam and is considered relatively unproductive, with low-standing crops of phytoplankton and zooplankton (USFWS et al. 2004). The fish in Trinity Lake include cold-water and warm-water species. Trinity Lake supports a trophy Smallmouth Bass fishery and provides substantial sport fishing for Largemouth Bass, Rainbow and Brown Trout, and Kokanee Salmon (landlocked Sockeye Salmon). Other fish species in Trinity Lake include Speckled Dace, Klamath Smallscale Sucker, Coast Range Sculpin, and the nonnative Green Sunfish and Brown Bullhead.

Lewiston Reservoir is a re-regulating reservoir for Trinity Lake. The water surface elevation is relatively constant. The reservoir contains Rainbow, Brown, and Brook Trout and Kokanee Salmon. Other fish species present include Pacific Lamprey, Speckled Dace, Klamath Smallscale Sucker, Coast Range Sculpin, and Smallmouth Bass (USFWS et al. 2004).

#### *9.3.3.2 Trinity River from Lewiston Reservoir to Klamath River*

The Trinity River flows out of Trinity Lake and Lewiston Reservoir. Native anadromous salmonids in the mainstem Trinity River and its tributaries downstream of Lewiston Dam are spring- and fall-run Chinook Salmon, Coho Salmon, and steelhead (NCRWQCB et al. 2009). Native non-salmonid anadromous species that inhabit the Trinity River Basin include Green Sturgeon, White Sturgeon, Pacific Lamprey, and Eulachon.

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston dams changed the character of the river channel substantially and altered the quantity and quality of aquatic habitat. Riparian vegetation was allowed to encroach on areas that had previously been scoured by flood flows, resulting in the formation of a riparian berm that armored and anchored the river banks and prevented meandering of the river channel (USFWS et al. 1999). The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel.

The ongoing Trinity River Restoration Program includes specific minimum instream flows (as described in Chapter 5, Surface Water Resources and Water Supplies); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009, USFWS et al. 1999). The mechanical channel rehabilitation includes removal of fossilized riparian berms that had been anchored by extensive woody vegetation root systems and had confined the river. Following removal of the berms, the areas have been re-vegetated to support native vegetation, re-establish alternate point bars, and re-establish complex fish habitat similar to conditions prior to construction of the dams. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages; and relocation of sand outside of the floodway. In areas closer to Lewiston Dam with limited gravel supply, gravel/cobble point bars are being rebuilt to increase gravel storage and improve channel dynamics. Riparian vegetation planted on the restored floodplains and flows will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Improvement projects have been completed and others are under construction or in the planning phases. These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with north fork of the Trinity River (TRRP 2014).

#### 9.3.3.2.1 Fish in the Trinity River

The following focal fish species that occur in the Trinity River are considered in this EIS.

- Coho Salmon
- Chinook Salmon (spring- and fall-run)
- Steelhead (winter-and summer-run)
- Green Sturgeon
- White Sturgeon
- Pacific Lamprey
- American Shad

*Coho Salmon*

Coho Salmon in the Trinity River are thought to be exclusively 3-year lifecycle fish, living a full year in the river as juveniles before migrating to the ocean. Most returning adult Coho Salmon enter rivers between August and January. Spawning in the Trinity River and tributaries occurs primarily in November and December. Most of the spawning by Coho Salmon in the mainstem Trinity River occurs from Lewiston Dam downstream to the North Fork Trinity confluence (NMFS 2014a). Coho Salmon eggs incubate from 35 to more than 100 days, depending on water temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching. Because juvenile Coho Salmon remain in their spawning stream for a full year after emerging from the gravel, they are exposed to a broad range of freshwater conditions. Coho Salmon smolts typically migrate to the ocean between March and June, with most leaving in April and May (the term “smolt” refers to young salmon prior to entering the ocean that have undergone the physiological changes necessary for life in salt water).

Coho Salmon were not likely the dominant species of salmon in the Trinity River before dam construction. However, the species was widespread in the Trinity River Basin, ranging as far upstream as Stuarts Fork above present-day Trinity Dam. Passage for Coho Salmon and other anadromous salmonids is now blocked at Lewiston Dam, which prevents access to roughly 109 miles of upstream habitat for Coho Salmon (DOI 2000). The Trinity River Salmon and Steelhead Hatchery (Trinity River Hatchery) produces Coho Salmon with an annual production goal of 500,000 yearlings to mitigate the upstream habitat loss (CHSRG 2012).

Several interrelated factors affect Coho Salmon abundance and distribution in the Trinity River. These factors include degradation of spawning and rearing habitat, sparse spawning gravel recruitment, lack of deep pools, stressful late summer water temperatures, water diversions, channelization and confinement, irregular timing of flows, fragmentation of populations, genetic and ecological interactions with hatchery salmonids, migration barriers, water quality problems, and unscreened diversions (NMFS 2014a). Current CVP operations primarily affect water temperature, water flow, and habitat suitability in the Trinity River (Reclamation 2008a). Currently accessible habitat downstream of Lewiston Dam represents about 50 percent of historically available habitat (USFWS 1999).

Habitat in the Trinity River has changed since flow regulation that began with the completion of Trinity and Lewiston dams, with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al. 2000). The Trinity River Restoration Program is implemented to provide higher peak flows to restore attributes of a fully functioning alluvial river, such as alternating bar features and additional off-channel habitat, and to provide better rearing habitat for Coho Salmon (Reclamation 2008a, TRRP 2013). Several restoration actions have been completed to reconnect the river with the floodplain, including selective removal of terraces and riparian berms and physical alteration of the adjacent floodplain to increase inundation frequency. Releases from Trinity Lake occur on a variable flow schedule with higher spring releases to promote the restored geomorphic processes and habitat.

An estimated 21,906 adult Coho Salmon migrated into the Trinity River Basin upstream of Willow Creek (about 88 miles downstream of Lewiston Dam) in 2013, of which 6,631 entered Trinity River Hatchery (located near Lewiston Dam) and 15,275 were estimated to have spawned in the river (CDFW 2014). The run-size estimates have ranged from 852 fish in 1994 to 59,079 fish in 1987. The 2011 run was ranked 10th of the 37 years on record and is 27.6 percent of the 17,161 average (CDFW 2014). Both intra- and inter-specific redd superimposition on the spawning grounds can affect salmon reproductive success and the spawning areas downstream of Lewiston Dam are likely near carrying capacity (NMFS 2014a).

*Spring-run Chinook Salmon*

Adult spring-run Chinook Salmon migrate upstream in the Trinity River from April through September, with most fish arriving at the mouth of the North Fork Trinity by the end of July. These fish remain in deep pools until the onset of the spawning season, which typically begins the third week of September, peaks in October, and continues through November. The distribution of spawning extends upstream to Lewiston Dam, and is concentrated in the reaches immediately downstream of the dam to the mouth of the North Fork Trinity River. Williams et al. (2011) concluded that although abundance is low compared with historical abundance, the current spring-run Chinook Salmon population (which includes hatchery fish) appears to have been fairly stable for the past 30 years. In 2013, an estimated 8,961 spring-run Chinook Salmon entered the Trinity River upstream of Junction City, including the 2,578 fish that entered the Trinity River Hatchery and 6,129 natural area spawners CDFW 2014). This run-size estimate is approximately 51 percent of the 34-year average spring-run Chinook Salmon run-size of 17,402, which has ranged from 2,381 fish in 1991 to 62,692 fish in 1988 (CDFW 2014).

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in December and continues into mid-April. Juvenile spring-run Chinook Salmon typically outmigrate after a year of growth in the Trinity River. Outmigration from the lower Trinity River, as indicated by monitoring near Willow Creek, peaks in May and June.

*Fall-run Chinook Salmon*

The adult fall-run Chinook Salmon migration in the Trinity River begins in August and continues into December, with spawning beginning in mid-October. Spawning activity peaks in November, and continues through December. Spawning of fall-run Chinook Salmon occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998). The first spawning activity usually occurs just downstream from Lewiston Dam and extends farther downstream as the spawning season progresses.

Like spring-run Chinook Salmon, emergence of fall-run Chinook Salmon fry begins in December and continues into mid-April. Juvenile fall-run Chinook Salmon typically outmigrate after a few months of growth in the Trinity River. Outmigration from the upper river, as indicated by monitoring near Junction City, begins in March and peaks in early May, ending by late May or early June. Outmigration of fall-run Chinook Salmon fry in the lower Trinity River occurs over approximately the same time period described above for the spring run.

An estimated 36,989 fall-run Chinook Salmon migrated into the Trinity River upstream of Willow Creek in 2013, of which 3,852 entered Trinity River Hatchery and 32,257 spawned naturally (CDFW 2014). This estimate is approximately 84.5 percent of the 43,762 mean run-size for the years since 1977, which has ranged from 9,207 fish in 1991 to 147,888 fish in 1986 (CDFW 2014).

*Steelhead*

Steelhead in the Trinity River exhibit two primary life history strategies: a summer-run that is stream maturing and a winter-run that is ocean maturing. The winter-run is considered by some to be composed of a fall-run and a winter-run based upon the timing of the adult migration. Summer-run steelhead have been observed in the north and south forks of the Trinity River and in the tributaries of New River and Canyon Creek (BLM 1995).

Adult summer-run steelhead enter the Trinity River from April through September and over-summer in deep pools within the mainstem. Some enter the smaller tributary streams of the Trinity River during the first November rains (Hill 2010), with most fish spawning in both the mainstem and tributaries from February through April (USFWS et al. 2004). Summer-run steelhead spawner escapements for the Trinity River upstream of Lewiston Dam prior to its construction were estimated to average 8,000 adults annually. Post-dam survey (reported in 2004) ranged from 20 to 1,037 adult summer steelhead in the tributaries and Trinity River (USFWS et al. 2004).

Juvenile summer-run steelhead may rear in fresh water for up to three years before outmigrating. Rearing in the Trinity River is highly variable, but most summer-run steelhead either outmigrate as young-of-the-year (YOY) or at age 1+ (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). For juveniles that rear at least a year in fresh water, survival appears to be higher for those that outmigrate to the ocean at age 2+ (DFG 1998a). Juveniles outmigrating from the tributaries as 0+ or age 1+ may rear in the mainstem or in nonnatal tributaries (particularly during periods of poor water quality) for one or more years before smolting. Juvenile outmigration can occur from spring through fall, with three peak migration periods including March, May/June, and October/November (USFWS et al. 2004).

Fall-run and winter-run steelhead also are widely distributed throughout the Trinity River. Adult fall-run steelhead enter the Klamath River system in September and October (Hill 2010) and likely spawn in tributaries such as the Trinity River from January through April. Adult winter-run steelhead begin their upstream migration in the Klamath River from November through March (USFWS 1997). Winter-run steelhead primarily spawn in Klamath River tributaries (including the Trinity River) from January through April (USFWS 1997), with peak spawn timing in February and March (NRC 2004).

An estimated run-size of 16,594 adult fall-run steelhead migrated into the Trinity River upstream of Willow Creek in 2013, including the 2,375 fish (80 natural-origin and 2,295 hatchery-origin) that entered the Trinity River Hatchery and 13,560 natural area spawners (9,039 of natural origin and 4,521 of hatchery origin) (CDFW 2014). Since 1980, run-size estimates have ranged from 2,972 in 1998 to 53,885 in 2007. The estimated abundance of steelhead in 2013 was 8.4 percent above the average since 1980 (CDFW 2014).

*Green Sturgeon*

Limited Green Sturgeon data has been collected in the Trinity River, so most information on life history characteristics for Green Sturgeon in the Trinity River is based on data from the Klamath River. Green Sturgeon in the Klamath River sampled during their spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al. 2006). Green Sturgeon are generally believed to have a life span of at least 50 years and spawn every four years on average after around age 16 (Klimley et al. 2007). Green Sturgeon enter the Trinity and Klamath rivers to spawn from February through July, and most spawning occurs from the middle of April to the middle of June (NRC 2004). After spawning, around 25 percent of Green Sturgeon migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools through November. During the onset of fall rainstorms and increased river flow, adult sturgeon move downstream and leave the river system (Benson et al. 2007). Juvenile Green Sturgeon may rear for one to three years in the Klamath River system before they migrate to the estuary and Pacific Ocean (NRC 2004, FERC 2007a, CALFED 2007), usually during summer and fall (Emmett et al. 1991, Hardy and Addley 2001).

In the Trinity River Basin, Green Sturgeon are known to spawn in the mainstem from the confluence with the Klamath to as far upstream as Gray’s Falls near Burnt Ranch. Juveniles are captured in rotary screw traps at Willow Creek on the Trinity River (Scheiff et al. 2001, Pinnix and Quinn 2009).

*White Sturgeon*

White Sturgeon are uncommon in the Klamath and Trinity rivers and spawning may not occur (NRC 2004). Historically there may have been small spawning runs in these rivers; almost all of the sturgeon occurring above the Klamath estuary are Green Sturgeon (Moyle 2002).

*Pacific Lamprey*

Pacific Lamprey are the only anadromous lamprey species in the Trinity River Basin. This species is important to local tribes and supports a subsistence fishery on the lower Trinity River. Although no systematic distribution surveys are available for the Trinity River Basin, they are expected to have a distribution similar to anadromous salmonids that use the mainstem Trinity River and accessible reaches of larger tributaries. No current status assessments are available for Pacific Lamprey in the Trinity River, but information from tribal fishermen who catch lampreys in the lower Klamath River suggests a decline that mirrors that observed across the species’ range (Petersen Lewis 2009).

Adult Pacific Lampreys have been documented entering the Klamath River from the ocean during all months of the year, with peak upstream migration to holding areas from December through June (Larson and Belchik 1998, Petersen Lewis 2009). Migration up the Trinity River is expected to begin slightly later. After entering fresh water as sexually immature adults and undergoing an initial migration, Pacific Lampreys hold through summer and most of winter before spawning the following spring when they reach sexual maturity (Robinson and Bayer 2005, Clemens et al. 2012). After the holding period, individuals undergo a secondary migration in the late winter or early spring from holding areas to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012, Lampman 2011). Thus, adult Pacific Lampreys with varying levels of sexual maturity may be in the Trinity River throughout the year. Ammocoetes (the larval stage of lamprey) inhabit fine substrates in depositional areas, rearing in the Trinity River and tributaries year-round for up to 7 years before outmigrating to the ocean (Moyle 2002, Reclamation and Trinity County 2006).

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are affected by many of the same factors as salmon and steelhead, because of parallels in their life cycles. Lack of access to historical spawning habitats caused by the mainstem dams and other migration barriers, modification of spawning and rearing habitat because of downstream impacts from dams, altered hydrology, and predation by nonnative invasive species such as Brown Trout have likely contributed to adverse effects on the Trinity River Pacific Lamprey population.

*American Shad*

American Shad, an introduced, anadromous fish, has become established in the Klamath and Trinity rivers. American Shad occur in the lowermost portions of the Trinity River, but are primarily found in the lower Klamath River. Adult fish enter estuaries or streams in late spring or early summer and spawn soon afterward in fresh water. Juvenile shad have been captured regularly in the rotary-screw traps at the Pear Tree and Willow Creek sites during salmonid outmigrant monitoring (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). Sport fishing for American Shad occurs seasonally throughout the lower Trinity River.

#### 9.3.3.2.2 Hatcheries on the Trinity River

The Trinity River Hatchery is located immediately downstream of Lewiston Dam, and is operated by CDFW and funded by Reclamation to mitigate the loss of salmonid production upstream of Lewiston Dam resulting from the Trinity Dam (Reclamation 2008a). The hatchery produces Coho Salmon, fall-run Chinook Salmon, spring-run Chinook Salmon, and steelhead. The hatchery's Coho Salmon program currently uses only endemic Coho Salmon broodstock and releases approximately 500,000 yearlings annually from March 15 to May 15. The fall-run Chinook Salmon program has a goal of releasing two million sub-yearlings in June and 900,000 yearlings in October from in-river broodstock, and the spring-run Chinook Salmon program has a goal of releasing one million subyearlings in June and 400,000 yearlings in October from in-river broodstock. The steelhead program currently uses only in-river broodstock with a goal to release 800,000 steelhead smolts (approximately six inches) from March 15 to May 1.

#### *9.3.3.3 Lower Klamath River from Trinity River to Pacific Ocean*

The Lower Klamath River begins where the Trinity River flows into it near Weitchpec, which is located about 43 miles upstream from the Pacific Ocean. The Trinity River is the largest tributary of the Klamath River and makes a substantial contribution to the flows in the lower Klamath River. This section of the Klamath River serves primarily as a migration corridor for salmonids, with most spawning and rearing upstream of the confluence with the Trinity River or in the larger tributaries (e.g., Blue Creek) to the mainstem Klamath River.

##### 9.3.3.3.1 Fish in the Lower Klamath River

Focal fish species that occur in the lower Klamath River downstream of the Trinity River confluence are included for analysis in this EIS and include all those found in the Trinity River, as described above, with the exception of Eulachon.

Eulachon is a smelt species in the Klamath River system found upstream of the estuary. Eulachon are anadromous broadcast spawners that spawn in the lower reaches of rivers and tributaries and usually die after spawning. Eulachon are sexually mature at 2 years and spawn at ages 3, 4, and/or 5 (Scott and Crossman 1973). Timing of the spawning migration in the Klamath River is similar to other known runs of Eulachon, beginning in December and continuing until May, with a peak in March and April (YTFP 1998, Larson and Belchik 1998).

In the Klamath River, adult Eulachon generally migrate as high as Brooks Riffle, about 40 kilometers (about 24 miles) upstream of the mouth, but have been observed as high as Pecwan Creek and even Weitchpec during exceptional years (YTFP 1998); specific spawning areas are unknown. Eggs hatch in 20 to 40 days depending on water temperature, taking longer at cooler temperatures. After hatching, the larvae are passively carried from spawning grounds to the ocean via river currents (Scott and Crossman 1973).

This species was historically important to local tribes and supported a subsistence fishery on the lower Klamath River. According to accounts of Yurok Tribal elders, there were annual runs so great that one had no problem catching “as many as you wanted;” however, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Tribal fishers (Larson and Belchik 1998). In 1996, YTFP sampling efforts to capture Eulachon were unsuccessful, although a Yurok Tribal member gave the YTFP a Eulachon he had caught while fishing for lamprey at the mouth of the river (Larson and Belchik 1998). However, it is likely that the Eulachon has been extirpated or nearly so on the lower Klamath River (NMFS 2015).

### 9.3.4 Central Valley Region

Fish and aquatic resources in the Central Valley Region are described in this section in accordance with the following major waterbodies.

- Shasta Lake and Keswick Reservoir
- Whiskeytown Lake
- Clear Creek

- Sacramento River from Keswick Reservoir to the Delta (near Freeport)
- Battle Creek
- Feather River
- Yuba and Bear Rivers
- American River
- Delta
- Yolo Bypass
- Millerton Lake
- San Joaquin River from the Stanislaus River confluence to the Delta (near Vernalis)
- New Melones Reservoir, Tulloch Reservoir, and the reservoir formed by Goodwin Dam
- Stanislaus River
- San Luis Reservoir

#### *9.3.4.1 Shasta Lake and Keswick Reservoir*

Shasta Lake is formed by Shasta Dam, which is located on the Sacramento River just downstream of the confluence of the Sacramento, McCloud, and Pit rivers. Shasta Dam has no fish passage facilities; however, the dam has a fish trapping facility that operates in conjunction with Livingston Stone National Fish Hatchery below Shasta Dam.

##### 9.3.4.1.1 Shasta Lake

Shasta Lake fish species include native and introduced warm-water and cold-water species. Major nonfish aquatic animal species assemblages in Shasta Lake include benthic macroinvertebrates and zooplankton (Reclamation 2013b). Shasta Lake is typically thermally stratified from April through November, during which time the upper layer (epilimnion) can reach a peak water temperature of 80 degrees Fahrenheit (°F) (Reclamation 2003). The upper layer of Shasta Lake supports warm-water game fish, and the lower layers (metalimnion and hypolimnion) support cold-water fishes. Nonnative, warm-water fish species in Shasta Lake include Smallmouth Bass, Largemouth Bass, Spotted Bass, Black Crappie, Bluegill, Green Sunfish, Channel Catfish, White Catfish, and Brown Bullhead (DWR et al. 2013). Cold-water species include Rainbow Trout, Brown Trout, landlocked White Sturgeon, landlocked Coho Salmon (Reclamation et al. 2003), and landlocked Chinook Salmon (Reclamation 2013). Other fish species in Shasta Lake include Golden Shiner, Threadfin Shad, Common Carp, and the native Hardhead, Sacramento Sucker, and Sacramento Pikeminnow (DWR et al. 2013, Reclamation 2013).

Water quality in Shasta Lake is generally considered good, largely because of the continual inflow of cool, high-quality water from the major tributaries to the lake. The primary water quality concerns in the lake is turbidity, typically associated with heavy rainfall events that move soils and runoff from abandoned mines in the area into the lake.

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Reclamation 2003). Water surface elevations in Shasta Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and Sacramento River diversions (Reclamation 2003). Reservoir surface elevation fluctuations can disturb shallow, nearshore habitats, including spawning and rearing habitat for warm-water fish species. The shoreline of Shasta Lake is generally steep, which limits shallow, warm-water fish habitat, and is not conducive to the establishment of vegetation or other shoreline cover (Reclamation 2003).

##### 9.3.4.1.2 Keswick Reservoir

Keswick Reservoir is a re-regulating reservoir for Shasta Lake. The water surface elevation is relatively constant. Residence time for water in Keswick Reservoir is about a day, compared with a residence time of about a year for water in Shasta Lake. Consequently, water temperatures tend to be controlled by releases from Shasta Dam and average less than 55°F. Despite the cool temperatures, the reservoir supports warm-water and cold-water fishes, including Largemouth Bass, crappie and catfish, and Rainbow Trout (Reclamation 2003).

#### *9.3.4.2 Whiskeytown Lake*

Water is diverted from the Trinity River at Lewiston Dam and discharged via the Clear Creek Tunnel into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released into the lower portion of Clear Creek via Whiskeytown Dam and into Keswick Reservoir through the Spring Creek Tunnel. There are two temperature control curtains in Whiskeytown Lake: Oak Bottom and Spring Creek (Reclamation 2008a). The Oak Bottom temperature control curtain serves as a barrier to prevent warm water in the reservoir from mixing with cold water from Lewiston Lake entering through the Carr Powerhouse. The Oak Bottom curtain is damaged and cannot be fully deployed; it is scheduled to be repaired in 2015. The Spring Creek temperature control curtain was replaced in 2011 and aids cold-water movement into the underwater intake for the Spring Creek Tunnel.

The fish assemblage in Whiskeytown Lake includes cold-water and warm-water species. Common fishes known to occur in Whiskeytown Lake include Rainbow Trout, Brown Trout, Kokanee Salmon, Largemouth Bass, crappie, sunfish, catfish, and bullhead (USFWS et al. 2004).

#### *9.3.4.3 Clear Creek*

The project area includes the reach of Clear Creek extending from Whiskeytown Dam to the confluence with the Sacramento River. Since 1995, extensive habitat and flow restoration in Clear Creek has occurred under the Central Valley Project

Improvement Act (CVPIA) and CALFED programs and in accordance with the NMFS 2009 BO. The Clear Creek Technical Team has been working since 1996 to facilitate implementation of CVPIA anadromous salmonid restoration actions (Brown et al. 2012). Restoration efforts have resulted in increased stocks of fall-run Chinook Salmon and re-established populations of spring-run Chinook Salmon and steelhead.

#### 9.3.4.3.1 Fish in Clear Creek

This analysis is focused on Chinook Salmon, steelhead, and Pacific Lamprey in Clear Creek.

*Spring-run Chinook Salmon*

Clear Creek currently supports a modest run of spring-run Chinook Salmon, which since 1998 has ranged from 0 in 2001 to an estimated high of 659 fish in 2013 (CDFW 2014). Adult spring-run Chinook Salmon migrate into Clear Creek from April through September. Adult fish tend to move as far upstream as possible to access cooler temperatures downstream of Whiskeytown Dam and hold over in summer until spawning in September through October. In the NMFS 2009 BO, NMFS expressed concern that spring-run Chinook Salmon unable to enter Clear Creek for spawning could hybridize with fall-run Chinook Salmon spawning in the Sacramento River (NMFS 2009a).

NMFS (2009a) reported that insufficient instream flows could fail to attract adult spring-run holding in the Sacramento River mainstem into Clear Creek. Adult spring-run Chinook Salmon tend to spread downstream of their holding areas prior to spawning (from Whiskeytown Dam downstream to the Clear Creek Road Bridge) from September through October. Egg incubation occurs from September through December, and juveniles rear from October through April (NMFS 2009a).

Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam under the CVPIA Clear Creek Restoration Program and in accordance with the 2009 NMFS BO (Reclamation 2013a). Additionally, water temperature criteria to protect spring-run Chinook Salmon during spawning and incubation are generally met; however, in recent years, water temperatures in Clear Creek during the spawning and incubation period (i.e., September 15 to October 31) have exceeded the temperature targets at times (Brown et al. 2012).

Based on rotary screw trap captures, juvenile spring-run Chinook Salmon outmigrate from Clear Creek from May through February. Peak outmigration occurs over a 9-week period from early December 2008 through early February 2009 (Earley et al. 2010). Trap data indicate that the majority of juveniles identified as spring-run (based on length-at-date size criteria) leave as age-0 fish, less than 40 millimeter (mm) in fork length (USFWS 2008b, Earley et al. 2010).

*Fall-/Late Fall-run Chinook Salmon*

Since 1995, restoration activities implemented in accordance with programs implemented under the CVPIA, CALFED, and the 2009 NMFS BO have increased stocks of fall-run Chinook Salmon by more than 400 percent (Brown

2011). In 2014, fall-run Chinook Salmon estimated escapement was 15,794 compared to the average baseline (1967-1991) estimated escapement of 1,689.

Fall/late fall-run Chinook Salmon primarily use the lower reaches of Clear Creek for all life history phases. Fall-run Chinook migrate into Clear Creek between the spring- and late fall-runs and spawn in October through December (USFWS 2015). A picket weir installed about 7.4 miles upstream of the confluence with the Sacramento River from August 1 to November 1 is used to prevent fall-run Chinook Salmon from spawning in the upper reaches with spring-run.

Late-fall-run Chinook Salmon migrate into Clear Creek from November through April, with peak migration in December; peak spawning occurs in January.

Based on rotary screw trap captures and length-at-date size criteria, fall-run Chinook Salmon make up the vast majority of all Chinook Salmon outmigrating from lower Clear Creek. Late fall-run juveniles constitute a small percentage of juvenile Chinook Salmon leaving Clear Creek. Juvenile fall-/late fall-run Chinook Salmon primarily outmigrate from Clear Creek as age-0 fish less than 40 mm in fork length (USFWS 2008b, Earley et al. 2010). Peak age-0 outmigration in 2008/2009 was from January and February for fall-run Chinook Salmon and during April to May for late fall-run Chinook Salmon (Earley et al. 2010).

*Steelhead*

Operation of Whiskeytown Dam supports cold-water habitat for steelhead in Clear Creek, the amount of which depends on flow releases which range from 30 to 200 cubic feet per second (cfs) depending on water year type (Reclamation 2008a). Steelhead have recolonized the habitat that became accessible with the removal of the McCormick-Saeltzer Dam in 2000. Redd surveys conducted since 2003 indicate that a small, but increasing population of steelhead resides in Clear Creek, with the highest density in the first mile below Whiskeytown Dam (USFWS 2007).

Adult steelhead immigration into Clear Creek usually occurs from August through March, with a peak occurring from September to November (USFWS 2008b). Adult steelhead tend to hold in the upper reaches of Clear Creek from September to December.

Spawning typically begins in December and continues through early March. Peak spawning occurs from late January to early February (USFWS 2007). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through April.

Spawning distribution has recently expanded from the upper 4 miles of lower Clear Creek to the entire 17 miles of lower Clear Creek, although it appears to be concentrated in areas of newly added spawning gravels. Recently, more steelhead were observed spawning in the lowest reach of the creek where resulting juveniles can be subject to warmer water temperatures during summer (Brown 2011).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Instream flow releases are intended to maintain suitable water temperatures throughout most of Clear Creek during summer. Snorkel surveys from 1999 to 2002 indicate that rearing steelhead may be present throughout all of lower Clear Creek (Good et al. 2005). Based on rotary screw trap captures, fry make up the vast majority of all steelhead/Rainbow Trout captured in lower Clear Creek. Peak outmigration of juvenile steelhead fry occurred from mid-March through April of 2009 (Earley et al. 2010).

*Pacific Lamprey*

Pacific Lamprey is expected to inhabit all reaches in Clear Creek upstream to Whiskeytown Dam. The loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate the population is likely reduced compared with historical levels (Moyle et al. 2009). Little information is available on factors influencing populations of Pacific Lamprey in Clear Creek, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adult Pacific Lampreys likely migrate into Clear Creek in summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). No information is available on spawning in Clear Creek; however, spawning period documented by Hannon and Deason (2008) for Pacific Lampreys in the American River of early January to late May, with peak spawning typically in early April, may also apply to Clear Creek. Pacific Lamprey ammocoetes rear in Clear Creek for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in Clear Creek suggest that some outmigration of Pacific Lampreys may occur year-round, but peak outmigration occurs from early winter through spring (Hanni et al. 2006).

#### 9.3.4.3.2 Extent and Status of Aquatic Habitat

Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009a) reported has resulted in riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and considerable loss of spawning gravels. These conditions affect spawning and rearing habitat on Clear Creek. Water flows and temperatures conditions on Clear Creek are presented in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality, respectively.

*Spawning Habitat*

An unpublished study conducted by USFWS (as cited in Brown 2011) suggested that gravel transport blocked by the construction of Whiskeytown Dam reduced spawning habitat in Clear Creek by 92 percent. Plans developed under CVPIA implementation included a goal to create and maintain 347,288 square feet of usable spawning habitat between Whiskeytown Dam to the former McCormick-Saeltzer Dam by 2020. This area is equivalent to the spawning habitat that existed before construction of Whiskeytown Dam (CVPIA 2014).

Brown (2011) noted that much of the degraded habitat has been restored by gravel augmentation, but continued augmentation will be required. Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam, pursuant to CVPIA implementation and Action of I.1.3 of the 2009 NMFS BO Reasonable and Prudent Alternative (RPA). The CVPIA annual spawning gravel target is 25,000 tons per year; however, an average of 9,574 tons has been placed annually since 1996. In 2012, a total of 9,974 tons of gravel was placed at four sites: Guardian Rock site, Placer Bridge, Clear Creek Road Crossing, and at Tule Backwater. A gravel injection project did not occur in 2013 (CVPIA 2014).

Most supplemental spawning gravel is placed into Clear Creek at long-term injection sites awaiting high flows to move gravel into the creek. These gravel addition projects have successfully created habitat suitable for spring-run Chinook Salmon spawning as evidenced by the number of redds directly observed in supplemental gravel or in supplemental gravel integrated into native gravel (USFWS 2007, 2008b). Spawning area mapping performed annually since 2000 indicates the overall amount of area used by spawning fall-run Chinook Salmon has been increasing, despite the adult population abundance remaining stable. The amount of area used in 2008 was the highest measured and more than double the amount used in 2000, suggesting that the gravel augmentation program has been successful in creating new spawning habitat. Gravel augmentation also has increased the amount of steelhead spawning habitat available in the lower reaches of Clear Creek, and NMFS (2009a) has indicated that this directly relates to higher fish abundance in recent years. In most locations, gravel additions created spawning habitat that did not exist or had limited prior use.

Studies to determine the availability of fish habitat, expressed as Weighted Useable Area (WUA), have been conducted by USFWS for Clear Creek (USFWS 2006). For spring-run Chinook Salmon, it was determined that spawning WUA peaked at the highest modeled flow (900 cfs) in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to the Clear Creek Road Bridge) spawning habitat peaked at 650 cfs. The WUA for steelhead/Rainbow Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments, respectively (USFWS 2007). In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

At all flows, the amount of spawning habitat present in Clear Creek is less than the amount needed to achieve the abundance recovery goal of spring-run Chinook Salmon spawning (based on the original USFWS [2007] estimates). However, the increased spawning habitat availability due to gravel additions since 2003 suggests that spawning habitat for spring-run Chinook Salmon is now more than sufficient to support the recovery goal at all flows. At flows greater than 50 cfs, the amount of spawning habitat present in Clear Creek is greater than the amount of spawning habitat needed to achieve the abundance recovery goal for steelhead. In contrast, the amount of spawning habitat present in Clear Creek is less than the amount of spawning habitat needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek (USFWS 2015).

*Rearing Habitat*

The WUA for spring-run Chinook Salmon fry rearing peaked at 600 cfs in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to Clear Creek Road Bridge), fry rearing habitat peaked at the highest modeled flow (900 cfs). The WUA for steelhead/Rainbow Trout fry rearing habitat peaked at 700 cfs and 900 cfs (the maximum flow modeled) in these segments, respectively (USFWS 2011b). The WUA for spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at the highest modeled flow (900 cfs) in the upper alluvial segment and 650 cfs in the canyon segment downstream. In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout fry rearing habitat peaked at 50 cfs; fry rearing habitat for spring-run Chinook Salmon peaked at 900 cfs. Spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at 850 cfs, while fall-run Chinook Salmon juvenile rearing habitat peaked at 350 cfs (USFWS 2013a).

As described above for spawning habitat, USFWS (2015) compared the total amount or rearing habitat available for spring-run Chinook Salmon and steelhead/Rainbow Trout to the amount of rearing habitat needed to support an annual escapement of 833 adults for each species. The total amount of rearing habitat available for fall-run Chinook Salmon was compared to the amount of habitat needed to support an average escapement of 7,920 fall-run Chinook Salmon. At all flows, the amount of rearing habitat present in Clear Creek is greater than the amount needed to achieve the abundance recovery goal for spring-run Chinook Salmon and steelhead. In contrast, the amount of rearing habitat present in Clear Creek is less than the amount needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek.

#### 9.3.4.3.3 Fish Passage

Whiskeytown Dam blocks access to 25 miles of historical spring-run Chinook Salmon and steelhead spawning and rearing habitat (Yoshiyama et al. 1996). Until 2000, the McCormick-Saeltzer Dam was a barrier to upstream migration for anadromous salmonids. After its removal, anadromous salmonids recolonized an additional 12 miles of habitat upstream to Whiskeytown Dam. With the removal of McCormick-Saeltzer Dam, passage of spring-run Chinook Salmon has increased. Stream surveys and juvenile monitoring results also suggest that dam removal has allowed reestablishment of spring-run Chinook Salmon and steelhead. NMFS (2009a) reported that compared to fall-run Chinook Salmon, spring-run Chinook Salmon historically spawned earlier and at locations farther upstream in Clear Creek. However, NMFS (2009a) concluded that the construction of Whiskeytown Dam likely caused a high degree of spatial overlap between the fall-run and spring-run fish during spawning, resulting in a higher probability of hybridization. To address this concern, USFWS has been separating adult fall-run fish from the spring-run fish holding in the upper reaches of Clear Creek with a segregation weir that is operated from August 1 to November 1. After November 1, fall-run Chinook Salmon have access to the entire river for spawning.

#### *9.3.4.4 Sacramento River from Keswick Reservoir to the Delta near Freeport*

Aquatic resources in the Sacramento River are affected by the habitat along the river and along the tributaries that connect to the river. Habitat along the river ranges from artificial structures used for water supply and flood management to open spaces that provide more natural types of habitat. The flow regime in the Sacramento River is managed for water supply and flood management, as described in Chapter 5, Surface Water Resources and Water Supplies. The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

##### 9.3.4.4.1 Fish in the Sacramento River

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Winter-run Chinook Salmon*

Adult winter-run Chinook Salmon return to fresh water during winter but delay spawning until spring and summer. Adults enter fresh water in an immature reproductive state, similar to spring-run Chinook, but winter-run Chinook move upstream much more quickly and then hold in the cool waters downstream of Keswick Dam for an extended period before spawning. Juveniles spend about 5 to 9 months in the river and estuary systems before entering the ocean. This life-history pattern differentiates the winter-run Chinook from other Sacramento River Chinook runs and from all other populations within the range of Chinook Salmon (DFG 1985, 1998b).

Access to approximately 58 percent of the original winter-run Chinook Salmon habitat has been blocked by dam construction (Reclamation 2008a). The remaining accessible habitat occurs in the Sacramento River downstream of Keswick Dam and in Battle Creek. The number of winter-run Chinook Salmon in Battle Creek is unknown, but if they do occur, they are scarce (Reclamation and SWRCB 2003).

Escapement data indicate that the winter-run Chinook Salmon population declined from its levels in the 1970s to relatively low levels through the 1980s and 1990s, with a small rebound in the early 2000s (Azat 2012).

Adult winter-run Chinook Salmon migrate upstream past the location of the Red Bluff Diversion Dam (RBDD) beginning in mid-December and continuing into early August. Most of the run passes RBDD between January and May, with the peak in mid-March (DFG 1985). Winter-run Chinook Salmon spawn only in the Sacramento River, almost exclusively above RBDD, with the majority spawning upstream of Balls Ferry, based on aerial redd survey data collected after passage was provided past the Anderson-Cottonwood Irrigation District (ACID) diversion. Aerial redd surveys have indicated that the winter-run Chinook Salmon spawning distribution has shifted upstream since gravel introductions began in the upper river near Keswick Dam; a high proportion of winter run Chinook spawn on the recently placed gravel (USFWS and Reclamation 2008). Spawning occurs May through July, with the peak in early June. Fry emergence occurs from mid-June through mid-October and fry disperse to areas downstream for rearing. Juvenile migration past RBDD may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). The majority (75 percent) of winter-run Chinook Salmon outmigrate past RBDD as fry (Martin et al. 2001), where they rear before outmigrating to the Delta primarily in December through April (Appendix 9B). Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream of RBDD for nursery habitat, and the relative usage of rearing habitat upstream and downstream of RBDD appeared to be influenced by river flow during fry emergence (Martin et al. 2001). Winter-run Chinook Salmon usually migrate past Knight’s Landing once flows at Wilkins Slough rise to about 14,000 cfs; most juvenile winter-run Chinook Salmon outmigrate past Chipps Island by the end of March (del Rosario et al. 2013).

*Spring-run Chinook Salmon*

Historically, spring-run Chinook Salmon in the Sacramento River Basin were found in the upper and middle reaches (1,000 to 6,000 feet) of the American, Yuba, Feather, Sacramento, McCloud and Pit rivers, as well as smaller tributaries of the upper Sacramento River downstream of present-day Shasta Dam (NMFS 2009a). Estimates indicate that 82 percent of the approximately 2,000 miles of salmon spawning and rearing habitat available in the mid-1800s is unavailable or inaccessible today (Yoshiyama et al. 1996). Naturally spawning populations of spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (DFG 1998b). Most of these reaches are outside the project area; however, all spring-run Chinook Salmon migratory life stages must pass through the project area.

Spring-run Chinook Salmon abundance in the Sacramento River mainstem has apparently declined sharply through time, with escapement estimates ranging from approximately 5,000 to 23,000 fish in the 1980s, 100 to 4,100 fish in the

1990s, and 0 to 621 fish between 2000 and 2014 (CDFW 2015). However, the criteria for run classification at RBDD have changed so no conclusions can be reached about changes in the number of spring-run Chinook Salmon in the Sacramento River. Chinook Salmon expressing spring-run timing do spawn in the mainstem Sacramento River between RBDD and Keswick Dam (NMFS 2009a). The Sacramento River now serves primarily as a migratory corridor for the adult and juvenile life stages of spring-run (and other runs) of Chinook Salmon.

In fresh water, juvenile spring-run Chinook Salmon rear in natal tributaries, the Sacramento River mainstem, and nonnatal tributaries to the Sacramento River (DFG 1998b). Outmigration timing is highly variable, as they may migrate downstream as YOY or as juveniles or yearlings. The outmigration period for spring-run Chinook Salmon extends from November to early May, with up to 69 percent of the YOY fish outmigrating through the lower Sacramento River and Delta during this period (DFG 1998b). Peak movement of juvenile spring-run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and again in March (Snider and Titus 1998, 2000b, c, d; Vincik et al. 2006; Roberts 2007). Migratory cues, such as increased flows, increasing turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (NMFS 2009a). Spring-run juveniles that remain in the Sacramento River over summer are confined to approximately 100 miles of the upper mainstem, where cool water temperatures are maintained by dam releases.

*Fall-/Late Fall-run Chinook Salmon*

The fall-run Chinook Salmon is an ocean-maturing type of salmon adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River; the late fall-run Chinook Salmon is mostly a stream-maturing type (Moyle 2002). Similar to spring-run, adult late fall-run Chinook Salmon typically hold in the river for 1 to 3 months before spawning, while fall-run Chinook Salmon generally spawn shortly after entering fresh water. Fall-run Chinook Salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late fall-run Chinook Salmon migrate upstream past RBDD from August to March and spawn from January to April (NMFS 2009a, TCCA 2008). The majority of young fall-run Chinook Salmon migrate to the ocean during the first few months following emergence, although some may remain in fresh water and migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in fresh water, at 150- to 170 mm in fork length, considerably larger and older than fall-run Chinook Salmon (Moyle 2002).

The primary spawning area used by fall- and late fall-run Chinook Salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for each of the runs are generally highest in this reach.

Annual fall-run and late fall-run Chinook Salmon escapement to the Sacramento River and its tributaries has generally been declining in the last decade, following peaks in the late 1990s to early 2000s (Azat 2012).

*Steelhead*

Although steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry, only winter-run steelhead are currently found in Central Valley rivers and streams. Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in other tributaries, and a few naturally spawning steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996).

Adult steelhead migrate upstream past the Fremont Weir between August and March, primarily from August through October; they migrate upstream past RBDD during all months of the year, but primarily during September and October (NMFS 2009a). The primary spawning area used by steelhead in the Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to outmigration. The Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS 2009a).

Recent steelhead monitoring data are scarce for the upper portion of the Sacramento River system. In 1989, Hallock (1989) reported that steelhead had declined drastically in the Sacramento River upstream of the Feather River confluence. In the 1950s, the average estimated spawning population size upstream of the Feather River confluence was 20,540 fish (McEwan and Jackson 1996). In 1991–1992, the annual run size for the total Sacramento River system was likely fewer than 10,000 adult fish (McEwan and Jackson 1996). From 1967 to 1993, the estimated number of steelhead passing the Red Bluff Pumping Plant ranged from a low of 470 to a high of 19,615 (CHSRG 2012). Steelhead escapement surveys at the site of RBDD ended in 1993.

*Green Sturgeon*

The Sacramento River provides habitat for Green Sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for Green Sturgeon in the Sacramento River upstream and downstream of RBDD (Reclamation 2008a). Although the upstream extent of historical Green Sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as Ink’s Creek confluence and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2013). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, DFG (2002) indicated that Green Sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June.

Spawning migrations and spawning by Green Sturgeon in the Sacramento River mainstem have been well documented over the last 15 years (Beamesderfer et al. 2004). Anglers fishing for White Sturgeon or salmon commonly report catches of Green Sturgeon from the Sacramento River as far upstream as Hamilton City (Beamesderfer et al. 2004). Eggs, larvae, and post-larval Green Sturgeon are now commonly reported in sampling directed at Green Sturgeon and other species (Beamesderfer et al. 2004, Brown 2007). YOY Green Sturgeon have been observed annually since the late 1980s in fish sampling efforts at RBDD and the Glenn-Colusa Irrigation District (GCID) intake (Beamesderfer et al. 2004). Acoustically tagged Green Sturgeon were detected upstream of RBDD from 2004 to 2006 (Heublein et al. 2009). Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam (NMFS 2009b), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible.

Green Sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al. 2004), even though individuals can range widely (Lindley et al. 2008). Larval Green Sturgeon have been regularly captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (DFG 2002a) and at about 3 weeks old when captured at the GCID intake (Van Eenennaam et al. 2001).

Young Green Sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (DFG 2002a). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

Empirical estimates of Green Sturgeon abundance are not available for the Sacramento River population or any west coast population (Reclamation 2008a), and the current population status is unknown (Beamesderfer et al. 2007, Adams et al. 2007). A genetic analysis of Green Sturgeon larvae captured in the Sacramento River resulted in an estimate of the number of adult spawning pairs upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel 2006). NMFS (2009b) noted that, similar to winter-run Chinook Salmon, the restriction of spawning habitat for Green Sturgeon to only one reach of the Sacramento River increases the vulnerability of this spawning population to catastrophic events. This was one of the primary reasons that the Southern DPS of Green Sturgeon was federally listed as a threatened species in 2006.

*White Sturgeon*

In California, White Sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River; a small part of the population is also thought to spawn in the Feather River (Moyle 2002). In addition to spawning, White Sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle 2002, Israel et al. 2008). White Sturgeon are found in the Sacramento River primarily downstream of RBDD (TCCA 2008), with most spawning between Knights Landing and Colusa (Schaffter 1997).

The population status of White Sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Spawning stage adults generally move into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter 1997, McCabe and Tracy 1994). Most spawning in the Sacramento River occurs in April and May (Kohlhorst 1976). YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994, Israel et al. 2008).

*Sacramento Splittail*

Historically, Sacramento Splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908 as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult splittail migrate upstream in the lower Sacramento River to above near the mouth of the Feather River and into the Sutter and Yolo bypasses (Sommer et al. 1997, Feyrer et al. 2005, Sommer et al. 2007b). Each year, mainly during the spring spawning season, a small number of individuals have been documented at the Red Bluff Pumping Plant and the entrance to the GCID intake (Moyle et al. 2004).

Nonreproductive adult splittail are most abundant in moderately shallow, brackish areas, but can also be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in fresh water on inundated floodplains in March and April (Moyle et al. 2004, Sommer et al. 2007b). In the Sacramento drainage, the most important spawning areas appear to be the Yolo and Sutter bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995, Sommer et al. 2007b). The production of YOY Sacramento Splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997, Moyle et al. 2004, Feyrer et al. 2006). Other factors that may affect the Sacramento Splittail adult population include flood control operations and infrastructure, entrainment by irrigation diversion, recreational fishing, changed estuarine hydraulics, pollutants, and nonnative species (Moyle et al. 2004, Sommer et al. 2007b).

*Pacific Lamprey*

Pacific Lampreys are anadromous, rearing in fresh water before outmigrating to the ocean, where they grow to full size prior to returning to their natal streams to spawn. Data from mid-water trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and tributaries from late fall (November) through early-summer (June) (Hanni et al. 2006). Adult Pacific Lampreys, either immature or spawning stage, have been detected at the GCID diversion from December through July and nearly all year at RBDD (Hanni et al. 2006). Hannon and Deason (2008) documented Pacific Lampreys spawning in the American River between early January and late May, with peak spawning typically in early April. Spawning in the Sacramento River is expected to occur during a similar timeframe. Pacific Lamprey ammocoetes rear in parts of the Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that outmigration of Pacific Lamprey peaks from early winter through early summer, but some outmigration is observed year-round at both RBDD and the GCID diversion dam (Hanni et al. 2006).

*Striped Bass*

Striped Bass are anadromous; adult Striped Bass are distributed mainly in the lower bays and ocean during summer, and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al. 2001) at which time Striped Bass swim upstream to spawning grounds. Striped Bass are not believed to spawn or rear in the Sacramento River upstream of RBDD (TCCA 2008). Most Striped Bass spawning occurs in the lower Sacramento River between Colusa and the confluence of the Sacramento and Feather rivers (Moyle 2002). About one-half to two-thirds of the eggs are spawned in the Sacramento River and the remainder in the Delta (Leet et al. 2001). After spawning, most adult Striped Bass move downstream into brackish and salt water for summer and fall.

Eggs are free-floating and negatively buoyant, hatching as they drift downstream with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. The Sacramento River functions primarily as a migration corridor for both adults and drifting eggs/larvae.

#### 9.3.4.4.2 Aquatic Habitat

The mainstem Sacramento River provides habitat for native and introduced (nonnative) fish and other aquatic species. The diversity of aquatic habitats ranges from fast-water riffles and glides in the upper reaches to tidally influenced slow-water pools and glides in the lower reaches (Vogel 2011).

A few miles downstream of Keswick Dam, near Redding, the river enters the valley and the floodplain broadens. Historically, this area likely had wide expanses of riparian forests, but much of the river’s riparian zone is subject to urban encroachment, particularly in the Anderson/Redding area. In the middle Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains (TNC 2007a). In the lower reaches downstream of Verona, much of the Sacramento River is constrained by levees. Dredging, dams, levee construction, urban encroachment, and other human activities in the Sacramento River have modified aquatic habitat, altered sediment dynamics, simplified stream bank and riparian habitat, reduced floodplain connectivity, and modified hydrology (NMFS 2009a). However, some complex floodplain habitats remain in the system such as reaches with setback levees and the Yolo and Sutter bypasses.

*Holding Habitat*

An abundance of deep, cold-water pools in the mainstem Sacramento River provide habitat for holding adult anadromous salmonids during all months of the year (Vogel 2011). Green Sturgeon also use deep pools for holding but can tolerate warmer water temperatures than salmon and, therefore, can hold farther downstream. Large numbers of adult Green Sturgeon have been observed holding during summer in deep pools in the Sacramento River near Hamilton City (Vogel 2011).

*Spawning Habitat*

Spawning habitat on the Sacramento River is affected by lack of sediment and flow patterns as determined by the operations of the CVP and local water diverters.

*Sediment Conditions*

Shasta and Keswick dams substantially influence sediment transport in the upper Sacramento River because they block sediment that would normally have been transported downstream (TNC 2007a, DWR 1985). The result has been a net loss of coarse sediment, including gravel particle sizes suitable for salmon spawning, in the Sacramento River downstream of Keswick Dam (Reclamation 2013b). To address the issue of spawning gravel loss downstream of Keswick Dam, Reclamation has placed approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Reclamation 2010a).

*Spawning Habitat Availability*

Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento River is affected by the operations of the seasonal ACID diversion dam, which involves placement of flashboards in the river between April and May. Flows in the river vary with the operation of the diversion dam and releases of water from Shasta Lake into the river. When the dam is installed in the river, the WUA upstream of the Cow Creek confluence is higher than when the dam is removed. Farther downstream, there is less variability in WUA.

The WUA for winter-run Chinook Salmon spawning peaks at around 10,000 cfs in the upstream reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 5,500 cfs. In the next reach downstream (ACID intake to Cow Creek), spawning WUA also peaked at around 10,000 cfs. In the lower reach (Cow Creek to Battle Creek), WUA spawning habitat peaks at around 5,250 cfs, but there is low variability in spawning WUA from 3,250 to 8,000 cfs

Overall, spawning habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is about the same for the two runs. Upstream of the ACID intake, spawning habitat WUA for fall- and late fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam flashboards out and at about 6,000 cfs with the flashboards in. Between the ACID intake and Cow Creek, spawning habitat WUA peaks at around 5,000 cfs for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for both runs peaks at about 3,500 cfs. The highest density of redds for fall- and late fall-run Chinook Salmon occur in the middle ACID intake to Cow Creek reach.

The spawning habitat WUA values for steelhead peaks at the lowest river flow analyzed (3,250 cfs) in the reach upstream of the ACID intake. This habitat relationship held regardless of whether the flashboards were in or out. In the reach between the ACID intake and Cow Creek, spawning habitat WUA peaks at river flows around 6,000 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning habitat WUA also peaks at river flows of about 6,500 cfs, but do not vary substantially in a flow range between about 4,000 and 8,000 cfs.

USFWS (2005b) conducted limiting life-stage analyses for winter-, fall-, and late-fall-run Chinook Salmon in the Sacramento River upstream of the Battle Creek confluence and found that in most cases, juvenile habitat is limiting. In some cases (fall- and late fall-run in between the ACID intake and Cow Creek), spawning habitat may be limiting at higher flows.

USFWS (2005a) developed spawning flow-habitat relationships for fall-run Chinook Salmon spawning habitat in the Sacramento River between Battle Creek and Deer Creek. Between Battle Creek and RBDD, spawning habitat WUA values for fall-run Chinook Salmon peaked at approximately 3,750 cfs, but showed little variation over flows from 3,250 cfs (the lowest flow evaluated) and 6,000 cfs, but declined substantially at higher flows. Between the Red Bluff Pumping Plant and Deer Creek, spawning habitat WUA values for fall-run Chinook salmon peaked at 5,500 cfs, with little variation at flows from 4,250 to 8,000 cfs (USFWS 2005a).

*Rearing Habitat*

In the Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. Ongoing sediment deposition in these areas provides evidence of continued inundation of floodplains in this reach (DWR 1994). Between Chico Landing and Colusa, the Sacramento River is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees in this portion of the Sacramento River are, for the most part, set back from the mainstem channel such that flooding can be significant within the river corridor (TNC 2007b).

Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaks at around 5,500 cfs in the reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 6,500 cfs. In the next reach downstream (ACID intake to Cow Creek), fry rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek), fry rearing habitat WUA for winter-run Chinook Salmon also peaked at around 31,000 cfs, but there was little variation at flows.

The fry rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship was similar for the two runs. Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam flashboards in. With the flashboards out, fry rearing habitat WUA peaks at around 23,000 cfs for both species. Between the ACID intake and Cow Creek, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked at around 3,750 cfs for both runs, with little variation from 3,250 cfs to 6,000 cfs and only slightly lower WUA values at flows greater than 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing habitat WUA for both runs peaks at 3,250 cfs (the lowest flow evaluated), declining as flows increase.

Juvenile rearing habitat WUA for winter-run Chinook Salmon juvenile rearing habitat peaks at around 8,000 cfs in the upstream reach above the ACID intake when the dam flashboards are in. With the boards out, the peak is around 9,000 cfs. However, there is little variation in juvenile winter-run Chinook Salmon rearing habitat WUA from around 5,500 to 11,000 cfs in this reach. In the next reach downstream between the ACID intake to Cow Creek, juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek), juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around 3,500 cfs but shows only moderate (<50 percent) reductions in WUA over the entire range of flows evaluated.

The juvenile rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is similar for the two runs. Upstream of the ACID intake, juvenile rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked in the 5,000- to 6,000-cfs range with the dam flashboards in or out; there were only moderate (<50 percent) reductions in juvenile rearing WUA over the entire range of flows evaluated. Between the ACID intake and Cow Creek, fry rearing WUA peaked at around 3,250 cfs (the lowest flow evaluated) for both runs, declining to a minimum at around 15,000 cfs and increasing to around 70 percent of the maximum at flows above 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing WUA for both runs peaked at 3,250 cfs (the lowest flow evaluated), declining as flow increased.

Vogel (2011) suggested that the mainstem Sacramento River may not provide adequate rearing areas for fry-stage anadromous salmonids, as evidenced by rapid displacement of fry from upstream to downstream areas and into nonnatal tributaries during increased flow events. Underwater observations of salmon fry in the mainstem Sacramento River suggest that optimal habitats for rearing may be limited at higher flows (Vogel 2011). USFWS (2005) conducted limiting life-stage analyses for winter-, fall-, and late-fall-run Chinook Salmon in the

Sacramento River above Battle Creek and found that in most cases, juvenile habitat is limiting. An important limitation of this analysis is that it did not take into account fry and juvenile rearing habitat below Battle Creek or in the Delta.

The minimum required Sacramento River flow is 3,250 cfs. Flows during summer generally exceed this amount in order to meet temperature requirements for winter-run Chinook Salmon. The water temperature requirements established for winter-run Chinook Salmon result in water temperatures also suitable for year-round rearing of steelhead in the upper Sacramento River.

#### 9.3.4.4.3 Fish Passage and Entrainment

Historically, anadromous salmonids had access to a minimum of approximately 493 miles of habitat in the Sacramento River (Yoshiyama et al. 1996). After completion of Shasta Dam in 1945, access to approximately 207 miles was blocked. Keswick Dam, just downstream of Shasta Dam, is now the upstream extent of available habitat for anadromous fish in the Sacramento River.

Until recently, three large-scale, upper Sacramento River diversions, including the ACID and GCID intakes and RBDD, were of particular concern as potential passage or entrainment problems for Chinook Salmon, steelhead, and other migratory fish species (NRC 2012, NMFS 2009a, McEwan and Jackson 1996). Recently, RBDD was eliminated, the GCID fish screens were installed, and fish passage at the ACID intake was improved (NRC 2012). At the ACID intake, new fish ladders and fish screens were installed around the diversion and were operated starting in the summer 2001 diversion period. However, adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID intake (NMFS 2009a), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Adult Green Sturgeon that pass upstream of the intake before April are delayed for 6 months until the flashboards are pulled before returning downstream to the ocean. Newly emerged Green Sturgeon larvae that hatch upstream of the ACID intake would need to hold for 6 months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the intake (NMFS 2009a).

Numerous other diversions are located on the Sacramento River. Herren and Kawasaki (2001) documented up to 431 diversions from the Sacramento River between Shasta Dam and the City of Sacramento. Hanson (2001) studied juvenile Chinook Salmon entrainment at unscreened diversions at the Princeton Pumping Plant and documented the entrainment of approximately 0.05 percent of juvenile Chinook Salmon passing the diversion. Similar to the results of Hanson (2001), Vogel (2013) found that entrainment of juvenile salmon in 12 unscreened diversions was low relative to other fish species. The study did not discern measurable effects of factors such as size of the diversion, longitudinal location in the river, water temperatures, localized habitat conditions, intake position in the river channel, and depth of the intakes on salmonid entrainment. It appeared that juvenile salmon were entrained in a much lower proportion than the proportion of flow diverted (Vogel 2013), similar to results noted by Hanson (2001). Mussen et al. (2014) examined the risk to Green Sturgeon from unscreened water diversions and found that juvenile Green Sturgeon entrainment susceptibility (in a laboratory setting) was high relative to that estimated for Chinook Salmon, suggesting that unscreened diversions could be a contributing mortality source for threatened Southern DPS Green Sturgeon.

Reclamation is currently coordinating with USFWS to support improvements at other fish screens. In 2013, CVPIA funds were used to construct the Natomas Mutual Sankey Fish Screen on the Sacramento River that replaced two existing diversions on the Natomas Cross Canal. This project also resulted in the removal of an anadromous fish migration barrier (seasonal diversion dam) on the Natomas Cross Canal. The fish screening program also completed construction of four fish screens on the Sacramento River and one fish screen in the Delta.

Potential barriers to migration for adult Green Sturgeon into the upper reaches of the Sacramento River include structures such as the ACID intake, Sacramento River Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC gates on the Sacramento River (70 FR 17386). A set of locks at the end of the Sacramento River Deep Water Ship Channel at the connection with the Sacramento River "blocks the migration of all fish from the deep-water ship channel back to the Sacramento River" (DWR 2005).

#### 9.3.4.4.4 Hatcheries

The Livingston Stone NFH, located at the foot of Shasta Dam, is a conservation hatchery that has been producing and releasing juvenile winter-run Chinook Salmon since 1998. There is growing concern about the potential genetic effects that may result from the use of a conventional hatchery program to supplement winter-run Chinook Salmon populations. To maintain a low risk of compromised genetic fitness, Lindley et al. (2007) recommend that no more than 5 percent of the naturally spawning population should be composed of hatchery fish. Since 2001, more than 5 percent of the winter-run Chinook Salmon run has been composed of hatchery-origin fish, and in 2005 the contribution of hatchery fish was more than 18 percent (Lindley et al. 2007).

The Livingston Stone NFH minimizes hatchery affects in the population by preferentially collecting wild adult winter-run Chinook Salmon for brood stock (USFWS 2011b). Up to 15 percent of the estimated run size for winter-run Chinook Salmon run may be collected for brood stock use (up to a maximum of 120 natural-origin winter-run Chinook Salmon per brood year). Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter-run Chinook Salmon a year in late January or early February. Winter-run Chinook Salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. The pre-smolts are released into the Sacramento River at Caldwell Park in Redding, about 10 miles downstream of the hatchery. All juvenile winter-run Chinook Salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged (CHSRG 2012).

The Delta Smelt propagation program at the Livingston Stone NFH is operated as a captive broodstock program. Delta Smelt propagation at Livingston Stone NFH functions as a backup refugial population. No Delta Smelt from the Livingston Stone NFH are currently released (USFWS 2011b).

#### 9.3.4.4.5 Predation

On the mainstem Sacramento River, high rates of predation have been known to occur at the diversion facilities and areas where rock revetment has replaced natural river bank vegetation (NMFS 2009a). Chinook Salmon fry, juveniles, and smolts are more susceptible to predation at these locations because Sacramento Pikeminnow and Striped Bass congregate in areas that provide predator refuge (Williams 2006, Tucker et al. 2003).

### *9.3.4.5 Battle Creek*

Battle Creek is a tributary that enters the Sacramento River about 20 miles southeast of Redding. The cold, spring-fed waters of Battle Creek historically supported large runs of Chinook Salmon and steelhead. Diversion dams constructed in the early 1900s for hydroelectric power production reduced instream flow and blocked anadromous salmonids from accessing habitat in large portions of the north and south forks of Battle Creek.

Coleman NFH, located on Battle Creek, was established in 1942 by Reclamation to partially mitigate habitat and fish losses from historical spawning areas caused by construction of two CVP features, Shasta and Keswick dams. The hatchery is funded by Reclamation and operated by USFWS. The steelhead program at the hatchery was initiated in 1947 to mitigate losses resulting from the CVP (USFWS 2012). The weir at the hatchery is a barrier to anadromous fish passage, as are various Pacific Gas & Electric Company (PG&E) dams (e.g., Wildcat) located on Battle Creek (Yoshiyama et al. 1996). Yoshiyama et al. (1996) reported that the Coleman South Fork Diversion Dam is the first impassible barrier on Battle Creek.

Beginning in 1995, planning was initiated to restore naturally spawning anadromous fish populations in Battle Creek, and construction began in 2010 on the Battle Creek Salmon and Steelhead Restoration Project (Reclamation 2014a). When complete, the Battle Creek restoration project will restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation, although five dams are decommissioned (Wildcat, Coleman, South, Lower Ripley, and Soap Creek feeder diversion dams). New fish screens and fish ladders that meet NMFS and CDFW criteria will be constructed at three diversion dams (North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams). Connectors are proposed that prevent the discharge of North Fork Battle Creek water to South Fork Battle Creek and the mixing of flow sources. Higher minimum flow requirements will increase instream flows, subsequently cooling water temperatures, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches. The project will result in 42 miles of newly accessible anadromous fish habitat and improved water quality for the Coleman NFH.

#### *9.3.4.6 Lake Oroville and Thermalito Complex*

Lake Oroville on the Feather River is formed by Oroville Dam, approximately 70 miles upstream from its confluence with the Sacramento River. Lake Oroville is fed by the north, middle, and south forks of the Feather River. A portion of the water released from Lake Oroville flows into the Thermalito Complex, as described in Chapter 5, Surface Water Resources and Water Supplies.

##### 9.3.4.6.1 Fish in Lake Oroville

Lake Oroville thermally stratifies in spring, destratifies in fall, and remains destratified throughout winter. FERC (2007b) reports indicate that surface water temperatures of the epilimnion begin to warm in the early spring, reach maximum temperatures (approximately mid-80°F) during late July, and gradually decline to winter minimums. The transition zone (i.e., metalimnion) between the upper warmer and lower colder waters typically ranges from about 30 to 50 feet below the lake surface during midsummer. The deeper water of the hypolimnion can reach a temperature of about 44°F near the reservoir bottom during periods of stratification (FERC 2007b). Cold-water fish species include Coho Salmon, Rainbow Trout, Brown Trout, and Lake Trout. The Lake Oroville cold-water fishery is not self-sustaining, possibly because of insufficient spawning and rearing habitat in the reservoir and accessible tributaries; cold-water spawning is not known to occur in Lake Oroville. The Coho Salmon fishery is sustained by a “put-and-grow” hatchery stocking program (FERC 2007b). The Lake Oroville warm-water fishery is a regionally important self-sustaining recreational fishery and is the site of several annual bass fishing tournaments. Spotted Bass are the most abundant bass species in Lake Oroville, followed by Largemouth Bass, Redeye Bass, and Smallmouth Bass, respectively. Other important warm-water species include catfish, crappie, and sunfish. Common carp are also abundant in Lake Oroville.

##### 9.3.4.6.2 Fish in Thermalito Forebay and Afterbay

Ambient meteorological conditions and the temperature of the water released from Lake Oroville generally affect water temperatures in the Thermalito Diversion Pool and Thermalito Forebay (FERC 2007b). Thermalito Forebay is an open, cold, shallow reservoir that remains cold throughout the year because it is supplied with water from Thermalito Diversion Pool, although pump-back operations from Thermalito Afterbay can increase water temperatures in the forebay. Thermalito Forebay provides habitat primarily for cold-water fish species, although the same warm-water fish species found in Lake Oroville are believed to exist in the forebay in low numbers (FERC 2007b). Additionally, CDFW manages a “put-and-take” trout fishery in Thermalito Forebay.

Thermalito Afterbay provides habitat for cold-water and warm-water fish species including Largemouth Bass, Smallmouth Bass, Rainbow Trout, Brown Trout, Bluegill, Redear Sunfish, Black Crappie, Channel Catfish, carp, and large schools of Wakasagi (FERC 2007b). A popular Largemouth Bass fishery currently exists, large trout are sometimes caught near the inlet, and an experimental steelhead fishery occurs in the Afterbay. Only limited salmonid stocking occurs at the afterbay, so these fish most likely passed through the Thermalito Pumping-Generating Plant from the forebay.

#### 9.3.4.7 Feather River from Lake Oroville and the Thermalito Complex to the Sacramento River

The Feather River is a major tributary to the Sacramento River, providing approximately 25 percent of the flow in the Sacramento River (FERC 2007b). The lower Feather River extends downstream from the Fish Barrier Dam to the confluence with the Sacramento River near Verona. The Fish Barrier Dam is located downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery (FERC 2007b).

##### 9.3.4.7.1 Fish in the Feather River

The Feather River below Oroville supports a variety of anadromous and resident fish species. The distribution of anadromous fish in the Feather River is limited to approximately 67 miles of river downstream from the Fish Barrier Dam. At least 44 species of fish have been reported to historically or currently occur in the lower Feather River system, including numerous resident native and introduced species and several anadromous species (FERC 2007b).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Spring-run Chinook Salmon*

Approximately two-thirds of the natural spring-run and fall-run Chinook Salmon spawning occur in the low-flow channel of the lower Feather River, downstream of the Fish Barrier Dam, and one-third of the spawning occurs in the high-flow channel downstream of the Thermalito Afterbay Outlet (FERC 2007b). NMFS (2009a) indicated that significant redd superimposition occurs in the lower Feather River because of oversaturation of the natural carrying capacity of the available spawning habitat (e.g., Sommer et al. 2001b) with an overproduction of hatchery spring-run Chinook Salmon and a lack of physical separation between spring-run and fall-run Chinook Salmon adults.

Adult spring-run Chinook Salmon typically enter fresh water in spring, hold over summer, and spawn in fall. Juveniles typically spend a year or more in fresh water before outmigrating. Adult spring-run Chinook Salmon begin their upstream migration from the ocean in late January and early February (DFG 1998b) and migrate from the Sacramento River into spawning tributaries primarily between mid-April and mid-June (Lindley et al. 2004). Adult Chinook

Salmon exhibiting the typical life history of the spring-run have been found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (FERC 2007b). Spring-run Chinook Salmon spawning occurs during September and October, depending on water temperatures (NMFS 2012a). Spring-run Chinook Salmon fry emerge from the gravel from November to March (Moyle 2002). Most juvenile spring-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence, and 95 percent of the juvenile Chinook have typically outmigrated from the Oroville facilities project area by the end of May (FERC 2007b).

An independent population of spring-run Chinook Salmon historically occurred in the lower Feather River downstream of Oroville Dam, and a naturally spawning population of spring-run Chinook Salmon may persist in this reach (Lindley et al. 2004). The number of naturally spawning spring-run Chinook Salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run Chinook Salmon and fall-run Chinook Salmon (Good et al. 2005).

Substantial numbers of spring-run Chinook Salmon, as identified by run timing, return to the Feather River Fish Hatchery. From 1986 to 2011, the median number of spring-run Chinook Salmon returning to the Feather River Fish Hatchery was 3,655, compared to a median of 7,869 spring-run Chinook Salmon returning to the entire Sacramento River Basin (NMFS 2012a). Abundance estimates of lower Feather River spring-run Chinook Salmon may be distorted by naturally occurring genetic introgression with fall-run Chinook Salmon, Feather River Fish Hatchery practices, and Federal and state escapement estimation methodology. Coded wire tags obtained from Feather River Fish Hatchery returns indicate substantial introgression has occurred between spring-run Chinook Salmon and fall-run Chinook Salmon populations within the lower Feather River (NMFS 2009a).

*Fall-run Chinook Salmon*

Fall-run Chinook Salmon generally begin upstream migration into the lower Feather River during summer months (FERC 2007b). Although timing of fall-run Chinook Salmon spawning may be influenced by water temperature conditions (FERC 2007b), spawning activity in the lower Feather River occurs from late August through December and generally peaks during mid- to late November (Myers et al. 1998). Concurrent spawning with spring-run Chinook Salmon, which generally occurs from September to October, has led to hybridization between the spring- and fall-run Chinook Salmon in the lower Feather River (NMFS 2012a).

In the lower Feather River, fall-run Chinook Salmon embryo incubation and alevin (yolk-sac fry) emergence generally occurs from mid-October through March, depending on water temperature conditions (FERC 2007b). Fall-run Chinook Salmon fry emergence generally occurs in the lower Feather River downstream of the Fish Barrier Dam from late December through March, and most juvenile fall-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence (FERC 2007b).

*Steelhead*

Steelhead immigrate into the Feather River from July to March (McEwan 2001). Currently, most of the natural steelhead spawning in the lower Feather River occurs in the low-flow channel downstream of the Fish Barrier Dam; however, limited spawning also occurs downstream of the Thermalito Afterbay Outlet (FERC 2007b). Results of a 13-week redd survey conducted between January 6 and April 3, 2003, indicated that redd construction generally occurs in the lower Feather River between late December and March, peaking in late January (FERC 2007b). The FERC (2007b) study suggests that nearly half (48 percent) of all redds were constructed in the uppermost mile of the low-flow channel downstream of the Fish Barrier Dam. Redd density in this 1-mile section of the low-flow channel was approximately 36 redds per mile, more than 10 times more than any other section of the lower Feather River (FERC 2007b).

A moderate percentage of the steelhead fry appear to outmigrate from the lower Feather River soon after emerging from the gravel. Juvenile steelhead that do not outmigrate may rear in the river for up to 1 year. Juvenile steelhead in the Feather River outmigrate from about February through September, with peak outmigration occurring from March through mid-April. In-river juvenile rearing is generally associated with secondary channels in the low-flow channel (e.g., Hatchery Ditch) (FERC 2007b).

*Pacific Lamprey*

The Pacific Lamprey inhabits accessible reaches of the lower Feather River (DWR 2003a). Information on Pacific Lamprey status in the lower Feather River is limited, but the loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate populations are greatly decreased compared with historical levels (Moyle et al. 2009). Little information is available on factors limiting Pacific Lamprey populations in the lower Feather River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean-stage adults likely migrate into the lower Feather River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lamprey spawning in the nearby American River from between early January and late May, with peak spawning typically occurring in early April. Pacific Lamprey ammocoetes rear in the lower Feather River for all or part of their 5-¬ to 7-year freshwater residence. Data from rotary screw trapping suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round as observed in the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

*Sacramento Splittail*

Sacramento Splittail enter the lower Feather River, primarily in wet years, with most individuals collected in the high-flow channel downstream of Thermalito Afterbay Outlet (DWR 2004a). On the lower Feather River, February through May was assumed to encompass the period of splittail spawning, egg incubation, and initial rearing (Sommer et al. 2008, DWR 2004a). Splittail use shallow flooded vegetation for spawning and are infrequently observed in the Feather River from the confluence with the Sacramento River up to Honcut Creek. The majority of spawning activity in the Feather River is thought to occur downstream of the Yuba River confluence (FERC 2007b). The primary factor that likely limits the lower Feather River splittail population is availability of spawning and rearing habitats as related to inundation of floodplains (Moyle et al. 2004, DWR 2004a).

*Green Sturgeon*

Historically, Green Sturgeon likely spawned in the Sacramento, Feather, and San Joaquin rivers (Adams et al. 2007). A substantial amount of habitat in the Feather River was lost with the construction of Oroville Dam. Although the presence of Green Sturgeon in the Sacramento River has been supported by direct angler observations and rotary screw trapping of eggs, larvae, and YOY Green Sturgeon, only intermittent observations of Green Sturgeon have been reported in the lower Feather River (Beamesderfer et al. 2007). The occasional capture of larval Green Sturgeon in outmigrant traps suggests that Green Sturgeon spawn in the lower Feather River (Moyle 2002). However, prior to 2011 only two records of adult Green Sturgeon in the lower Feather River were confirmed (NMFS 2005b). In 2011, videography monitoring conducted by the Anadromous Fish Restoration Program confirmed Green Sturgeon spawning activity in the lower Feather River and found evidence of spawning behavior in the Yuba River (AFRP 2011). Seesholtz et al. (2014) provided the first documentation of Green Sturgeon spawning in the Feather River.

*White Sturgeon*

White Sturgeon are known to use the lower Feather River primarily for spawning, embryo development, and early rearing. Limited quantitative information is available on the status of White Sturgeon in the lower Feather River, but the spawning population was most likely much larger prior to construction of Oroville Dam in 1961 (Israel et al. 2008). Seesholtz (2003) reported no evidence of sturgeon was found in the lower Feather River after an exhaustive search for their presence in 2003. However, 16 White Sturgeon were recorded from creel surveys and sightings during 2006, and more were captured by anglers in 2007 (Israel et al. 2008). Numerous factors likely limit the success of the White Sturgeon population in the lower Feather River, but loss of historical habitat, alteration of temperatures and flows caused by Oroville Dam and other impoundments in the watershed, and recreational fishing and poaching are expected to be among the most important factors.

*Striped Bass*

Striped Bass occur in the lower Feather River and have been reported to occur in the Thermalito Forebay (FERC 2007b). Striped Bass are a popular sport fish in the lower Feather River during periods when they migrate upstream to spawn.

*American Shad*

American Shad enter the Feather River annually in spring to spawn and are popular for sport fishing. American Shad are present in the lower Feather River from May through mid-December during the adult immigration, spawning, and outmigration periods of their life cycle (DWR 2003a).

#### 9.3.4.7.2 Aquatic Habitat

Historically, spawning habitat suitable for anadromous salmonid species likely existed above the current location of Oroville Dam on the Feather River (Yoshiyama et al. 2001). Extensive mining, irrigation, and development of hydroelectric dams significantly reduced the amount of suitable habitat for these species (Yoshiyama et al. 2001). Schick et al. (2005) estimated approximately 71 miles of suitable habitat was historically available for spring-run Chinook Salmon in the lower Feather River.

Most Chinook Salmon and steelhead spawning is concentrated in the uppermost 3 miles of accessible habitat in the lower Feather River downstream of the Feather River Fish Hatchery (FERC 2007b). As a result, salmonid spawning is concentrated to unnaturally high levels in the low-flow channel of the lower Feather River directly downstream of Oroville Dam and the Fish Barrier Dam. A physical habitat simulation analysis conducted by the California Department of Water Resources (DWR) in 2002 indicated that Chinook spawning habitat suitability in the low-flow channel reached a maximum between 800 and 825 cfs, and in the high-flow channel, it reached a maximum at 1,200 cfs. The steelhead spawning habitat index in the low-flow channel had no distinct optimum over the range of flow between 150 and 1,000 cfs. In the high-flow channel, spawning habitat suitability was maximized at a flow just under 1,000 cfs (DWR 2004b).

The FERC (2007b) study reported that an estimated 97 percent of the sediment from the upstream watershed is trapped in Lake Oroville, such that only very fine sediment is discharged from Lake Oroville to the lower Feather River. As a result, gravel and large woody material from upstream reaches are limited along the lower Feather River. The FERC (2007b) study reported that the median gravel diameter (D50) of surface samples suggests that gravels in the low-flow channel generally are too large for successful redd construction by steelhead or salmon and that armoring is particularly evident in this reach; however, suitability of gravel sizes for spawning Chinook Salmon generally increased with distance downstream of Oroville Dam. The study suggested that size distributions of subsurface gravel samples were similar in the low- and high-flow channels. Analyses of fine sediment (less than 6 mm in diameter) suggested that fine sediment within gravels in the lower Feather River were suitable for incubating Chinook Salmon and steelhead embryos (FERC 2007b).

#### 9.3.4.7.3 Fish Passage

The Oroville facilities, including Oroville Dam, Thermalito Diversion Dam, and the Fish Barrier Dam, currently block the upstream migration of anadromous fish to historically available spawning areas in the upstream tributaries of the Feather River. In a study of Green Sturgeon passage impediments, FERC identified three potential physical barriers to upstream migration by Green Sturgeon in the lower Feather River during representative low-flow conditions (approximately 2,074 cfs during November 2002) and high-flow conditions (approximately 9,998 cfs during July 2003) (FERC 2007b). The three potential physical barriers are Shanghai Bench, the Sunset Pumps, and Steep Riffle (located 2 miles upstream of the Thermalito Afterbay Outlet). However, the study also noted that determinations of potential passage barriers in the lower Feather River are speculative.

#### 9.3.4.7.4 Hatcheries

The Feather River Fish Hatchery is part of the SWP Oroville Complex and is a mitigation hatchery for loss of habitat upstream of DWR's Oroville Dam that is no longer accessible to anadromous fish species (NMFS 2009a). Three hatchery programs are conducted here, producing fall-run Chinook Salmon, spring-run Chinook Salmon, and steelhead. The Feather River Fish Hatchery supports the only spring-run Chinook Salmon hatchery program currently in the Central Valley (CHSRG 2012). Spring-run Chinook Salmon produced at the Feather River Fish Hatchery are included in the listed spring-run Chinook Salmon ESU (70 FR 37160). FERC is in consultation with NMFS on the effects of relicensing Oroville Dam (including the effects of Feather River Fish Hatchery).

Fall-run Chinook Salmon in the Feather River are trapped and spawned at the hatchery with a goal of producing 6 million fall-run Chinook Salmon smolts for release into Carquinez Straits between April and June. Up to 2 million additional fish may be reared as part of a separate ocean enhancement program. Feather River fall-run Chinook Salmon are currently marked at a 25 percent rate (constant fractional marking) with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

Adult hatchery-produced spring-run Chinook are intended to spawn naturally or to be genetically integrated with the natural population through artificial propagation. There are no specific goals for the number of adult spring-run Chinook Salmon; however, the juvenile production goal is to release 2 million smolts during April or May. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery). Juvenile hatchery-produced spring-run Chinook Salmon are currently 100 percent marked with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

The steelhead program at the Feather River Hatchery traps and artificially spawns both marked hatchery-origin and unmarked natural-origin steelhead. Only a few unmarked fish are trapped annually. Currently, only fish returning to the Feather River Basin are used for broodstock. There are no specific goals for the number of adult steelhead produced by this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually during late January or February. All Feather River Hatchery steelhead are marked with an adipose fin-clip prior to release. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch or at the confluence of the Feather and Sacramento rivers (Verona Marina) (CHSRG 2012).

Prior to 2004, separation of spring-run and fall-run Chinook Salmon returning to the Feather River Fish Hatchery was solely based on run timing, which resulted in considerable mixing of fall-run and spring-run Chinook Salmon stocks (DWR 2009, NMFS 2012a). In 2005, the Feather River Fish Hatchery implemented a methodology change for distinguishing spring-run Chinook Salmon from fall-run Chinook Salmon (CHSRG 2012). To maintain genetic integrity, fish entering the Feather River Fish Hatchery prior to July 1 receive an external tag, and only these externally tagged fish are used as spring-run Chinook Salmon broodstock (DWR 2009). Since 2005, the hatchery has attempted to mark 100 percent of spring-run Chinook Salmon produced at the hatchery with an adipose fin-clip, coded wire-tag (CHSRG 2012) and race and brood year specific otolith thermal marks (DWR 2009).

The Feather River Fish Hatchery employs best management practices and protocols to avoid the spread of diseases from the hatchery. The hatchery has been successful in adaptively managing disease concerns as they arise by the installing an ultraviolet treatment system, modifying the stocking of Lake Oroville, conducting periodic testing, and using prescribed therapeutic treatments (DWR 2004c).

#### 9.3.4.7.5 Disease

Several endemic salmonid pathogens and diseases occur in the Feather River Basin, including *Ceratomyxa shasta* (salmonid ceratomyxosis), *Flavobacterium columnare* (columnaris), Infectious Hematopoietic Necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease), and *Flavobacterium psychrophilum* (cold-water disease) (DWR 2004c). Each of these diseases has been shown to infect stocked and native salmonids in the Feather River; however, these diseases are not known to infect non-salmonids (FERC 2007b). Whirling disease has never been detected in the lower Feather River downstream of Oroville Dam, but has been found in upstream tributaries such as the north and south forks of the Feather River (DWR 2004c). Of the fish diseases in the Feather River Basin, IHN and salmonid ceratomyxosis are main contributors to fish mortality at the Feather River Fish Hatchery and are of highest concern for fisheries management in the region (DWR 2004c). The Feather River Fish Hatchery experienced severe IHN outbreaks in 2000 and 2001. A study by the University of California at Davis and USFWS indicated that although there were no clinical signs of disease, adult salmonids returning to either the Yuba or the Feather rivers demonstrated IHN infection rates of 28 percent and 18 percent, respectively (Brown et al. 2004).

Salmonid ceratomyxosis is endemic to the Feather River Basin; local salmonid stocks have co-evolved with this pathogen and exhibit some natural resistance. Salmonid ceratomyxosis causes mortality in all ages of anadromous and resident trout and salmon, although Rainbow Trout and steelhead are more susceptible to the disease than are Chinook and Coho Salmon (DWR 2004c). Mortality generally occurs when water temperatures exceed 50°F; however, fish can become infected at temperatures as low as 39°F (Bartholomew 2012).

##### 9.3.4.7.6 Predation

The FERC (2007b) study suggests that the Fish Barrier Dam, which directs most anadromous salmonid spawning to occur in the low-flow channel, concentrates juvenile salmonids within this reach. Counts of known predators on juvenile anadromous salmonids in the low-flow channel are reported to be low; however, significant numbers of predators reportedly do exist in the high-flow channel downstream of Thermalito Afterbay Outlet (Seesholtz et al. 2004). Limited information is available to estimate the current rate of predation on juvenile salmonids in the lower Feather River.

#### *9.3.4.8 Yuba River*

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007), as described in Chapter 5, Surface Water Resources and Water Supplies.

Fish species found in the New Bullards Bar Reservoir include Rainbow Trout, Brown Trout, Kokanee Salmon, bass, Bluegill, crappie, and bullhead (DWR et al. 2007). A similar mix of species is found in Englebright Reservoir. Fall-run and spring-run Chinook Salmon and steelhead occur in the Yuba River downstream of Englebright Dam (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Yuba River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Yuba River (Beamesderfer et al. 2004). Other species found in the lower Yuba River include American Shad, Smallmouth Bass, and Striped Bass (DWR et al. 2007).

#### *9.3.4.9 Bear River*

The Bear River flows into the Feather River downstream of the confluence of the Feather and Yuba rivers. The Bear River includes Nevada Irrigation District's Rollins and Combie reservoirs along the upper and middle reaches of the Bear River and South Sutter Water District's Camp Far West Reservoir along the lower reach of the Bear River (FERC 2013, NID 2005).

Fall-run and spring-run Chinook Salmon and steelhead occur in the Bear River (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Bear River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Bear River (Beamesderfer et al. 2004). Rollins Reservoir is currently managed as a put-and-take fishery for rainbow and Brown Trout. Kokanee reproduce naturally in the lake. Gill net surveys from 1970 to 1983 documented numerous other species including bass, catfish, sunfish, Golden Shiner, Tui Chub, Pond Smelt, crappie, and Bluegill (DFG 1974-1983 in NID 2008). Native fishes found in Combie Reservoir may include Sacramento Pikeminnow, Sacramento Sucker, Hardhead, Tui Chub, Hitch, and Inland Silverside. Nonnative fishes likely include Bluegill, Green Sunfish, Largemouth Bass, Spotted Bass, Smallmouth Bass, common carp, Golden Shiner, Threadfin Shad, Black Crappie, Brown Bullhead, White Catfish, Channel Catfish, Western Mosquitofish, and stocked Rainbow Trout (NID 2009).

#### *9.3.4.10 Folsom Lake and Lake Natoma*

The American River watershed encompasses approximately 2,100 square miles (Reclamation et al. 2006). The three forks of the American River (north, middle, and south forks) converge upstream of Folsom Dam, with the combined flow moving through Lake Natoma and the lower American River for about 23 miles before entering the Sacramento River.

Water surface elevations vary annually as a result of seasonal inflow and water release and are generally the least variable during spring and most variable during summer (USACE et al. 2012). Thermal stratification of the reservoir generally begins during April and usually persists throughout summer until November, when cooler temperatures, winter rains, and high inflows create mixing and result in “turnover” (Reclamation 2005, USACE et al. 2012). During summer, a thermocline develops that separates the epilimnion (i.e., upper layer of warm water) and the hypolimnion (i.e., lower layer of cooler water). This thermal stratification and segregation of habitats allow for both cold-water and warm-water species to coexist in Folsom Lake (USACE et al. 2012). Warm-water fish species include native Hardhead, California Roach, Sacramento Pikeminnow, and Sacramento Sucker, as well as nonnative Largemouth Bass, Smallmouth Bass, Spotted Bass, sunfish, Black Crappie, and White Crappie (Reclamation 2007). Cold-water fish species include native Rainbow Trout and planted Chinook and Kokanee Salmon, as well as nonnative Brown Trout (Reclamation 2007).

Nimbus Dam creates Lake Natoma, which serves as a regulating afterbay to the Folsom power plant, maintaining more uniform flows in the lower American River. Lake Natoma is a shallow reservoir with an average depth of about 16 feet (Reclamation 2005). Surface water elevations in Lake Natoma may fluctuate between 4 and 7 feet daily (USACE et al. 2012). Lake Natoma has relatively low productivity as a fishery due to the effects of wide water temperature variability associated with the lake fluctuating elevation. Reclamation (2007) reports that fish species found in Lake Natoma are generally the same as those in Folsom Lake. Although CDFW annually stocks Lake Natoma with hatchery Rainbow Trout, conditions in Lake Natoma are more favorable for warm-water fish species (Reclamation 2007).

#### *9.3.4.11 Lower American River between Lake Natoma and the Sacramento River*

The lower American River extends approximately 23 miles from Nimbus Dam downstream to the confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam.

##### 9.3.4.11.1 Fish in the Lower American River

The lower American River system supports numerous resident native and introduced species as well as several anadromous species.

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Historically, the American River supported fall-run and perhaps late fall-run Chinook Salmon (Williams 2001). Both naturally and hatchery produced Chinook Salmon spawn in the lower American River. Recent analysis by DFG and USFWS (2010) indicated that approximately 84 percent of the natural fall-run Chinook Salmon spawners in the American River are hatchery-origin fish. Kormos et al. (2012) reported that 79 percent of the fall-run Chinook Salmon entering the Nimbus Fish Hatchery in 2010 and 32 percent of the fish spawning in the American River were of hatchery origin.

Adult fall-run Chinook Salmon enter the lower American River from about mid-September through January, with peak migration from approximately mid-October through December (Williams 2001). Spawning occurs from about mid-October through early February, with peak spawning from mid-October through December. Chinook Salmon spawning occurs within an 18-mile stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 miles (DFG 2012a). Chinook Salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. There is high variability from year to year; however, most incubation occurs from about mid-October through February. Chinook Salmon fry emergence occurs from January through mid-April, and juvenile rearing extends from January to about mid-July (Williams 2001). Most Chinook Salmon outmigrate from the lower American River as fry between December and July, peaking in February to March (Snider and Titus 2002, PSMFC 2014).

*Steelhead*

Natural spawning by steelhead in the American River occurs (Hannon and Deason 2008), but the population is supported primarily by the Nimbus Fish Hatchery. The total estimated steelhead return to the river (spawning naturally and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per year from 2002 to 2010 (CHSRG 2012). Steelhead spawning surveys have shown approximately 300 steelhead spawning in the river each year (Hannon and Deason 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning) population of American River steelhead at a high risk of extinction because it is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. NMFS views the American River population as important to the survival and recovery of the species (NMFS 2009a).

Nielsen et al. (2005) found steelhead in the American River to be genetically different from other Central Valley stocks. Eel River steelhead were used to found the Nimbus Hatchery stock, and steelhead from the American River (collected from both the Nimbus Fish Hatchery and the American River) are genetically more similar to Eel River steelhead than other Central Valley Steelhead stocks. Based on studies by Hallock et al. (1961), Staley (1976), and Neilsen (2005), Lee and Chilton (2007) reported that American River winter-run steelhead are genetically and phenotypically different, and demonstrate a later upstream migration period than Central Valley Steelhead. Zimmerman et al. (2008) also noted that there remains a strong resident component (i.e., fish that do not migrate to the ocean) of the *O. mykiss* population that interacts with and produces anadromous individuals. Steelhead and Rainbow Trout are the same species and when juveniles of the species are found in fresh water, it is unclear if they will exhibit an anadromous (steelhead) or resident (Rainbow Trout) life history strategy. Thus, they are often collectively referred to as *O. mykiss* at this stage to indicate this uncertainty.

Adult steelhead enter the American River from November through April with a peak occurring from December through March (SWRI 2001). Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October. Results of a spawning survey conducted from 2001 through 2007 indicate that steelhead spawning occurs in the lower American River from late December through early April, with the peak occurring in late February to early March (Hannon and Deason 2008). Spawning density is highest in the upper 7 miles of the river, but spawning occurs as far downstream as Paradise Beach. About 90 percent of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008).

Embryo incubation begins with the onset of spawning in late December and generally extends through May, although incubation can occur into June in some years (SWRI 2001). Steelhead embryo and alevin mortality associated with high flows in the American River has not been documented, but flows high enough to mobilize spawning gravels do occur during the spawning and embryo incubation periods (i.e., late December through early April) (NMFS 2009a).

Juvenile *O. mykiss* have been documented year-round throughout the lower American River, with rearing generally upstream of spawning areas. Juveniles reportedly can rear in the lower American River for a year or more before outmigrating as smolts from January through June (Snider and Titus 2000a, SWRI 2001). However, Snider and Titus (2002) reported only 1 yearling steelhead capture, and PSMFC (2014) reported capturing primarily YOY fry and parr. Peak outmigration occurs from March through May (McEwan and Jackson 1996, SWRI 2001, PSMFC 2014).

Rearing habitat for juvenile steelhead in the lower American River occurs throughout the upper reaches downstream to Paradise Beach. In summer, juveniles occur in most major riffle areas, with the highest concentrations near the higher density spawning areas (Reclamation 2008a). The number of juveniles in the American River decreases throughout summer (Reclamation 2008a). Warm water temperatures stress juvenile steelhead rearing in the American River, particularly during summer and early fall (LARTF 2002, Water Forum 2005c, NMFS 2014b). However, laboratory studies suggest that American River steelhead may be more tolerant of high temperatures than steelhead from regions farther north (Myrick and Cech 2004).

*Pacific Lamprey*

The Pacific Lamprey inhabits accessible reaches of the American River. Information on the status of Pacific Lamprey in the American River is limited, but the loss of historical habitat and apparent population declines throughout California indicate populations are greatly decreased compared to historical levels (Moyle et al. 2009).

Hannon and Deason (2008) documented Pacific Lamprey spawning in the American River between early January and late May, with peak spawning typically in early April. Pacific Lamprey ammocoetes rear in the American River for all or part of their 5¬- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Feather River suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

Because of the parallels in their life cycles, particularly spawning, lampreys may be affected by many of the same factors as salmon and steelhead. Little information is available on factors influencing Pacific Lamprey populations in the American River, but the dams likely play an important role. Moyle et al. (2009) suggested that in addition to blocking upstream migration, dams may disrupt upstream sediment inputs required to maintain habitat for ammocoetes and subject ammocoetes to rapid decreases in stream flow. Moyle et al. (2009) also indicated that ramping rates sufficient to protect salmonids may not be adequate to prevent the stranding of ammocoetes and metamorphosing individuals, which are vulnerable to desiccation and avian predation. Additionally, commercial harvest of lampreys on the American River (presumably for bait) may reduce spawning success in some years (Hannon and Deason 2008).

*Sacramento Splittail*

Splittail likely spawn in the lower reaches of the American River (Sommer et al. 1998, 2008; Moyle et al. 2004). During wet years, upstream migration is more directed and fish tend to swim farther upstream (Moyle 2002), thus more individuals are expected to use the American River in wet years. Although juvenile splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks of rearing on floodplain habitat (Reclamation 2008a). Most juveniles move downstream into the Delta from April to August (Meng and Moyle 1995). The primary factor potentially limiting the American River population of Sacramento Splittail is availability of inundated floodplains for spawning and rearing habitats (Moyle et al. 2004).

*White Sturgeon*

Limited quantitative information is available on the distribution and status of White Sturgeon in the American River; however, small numbers of adults apparently use the American River, as evidenced by sturgeon report cards submitted to CDFW by anglers in recent years (e.g., DFG 2012b).

*Striped Bass*

Striped Bass are found in the American River throughout the year, with the greatest abundance in summer (SWRI 2001). Although the occurrence of spawning in the American River is uncertain, the river is believed to serve as a nursery area for YOY and subadult Striped Bass (SWRI 2001). Striped Bass are distributed from the confluence with the Sacramento River to Nimbus Dam (Moyle 2002), and they provide a locally important sportfishing resource.

*American Shad*

Adult American Shad ascend the lower American River to spawn during the late spring. During this period, they provide an important sport fishery. The shortage of adequate attraction flows in major tributaries such as the American River may be contributing to declines in the population (Moyle 2002).

#### 9.3.4.11.2 Aquatic Habitat

Since 1955, Nimbus Dam has blocked upstream passage by anadromous fish and restricted available habitat in the lower American River to the approximately 23 river miles between the dam and the confluence with the Sacramento River. Additionally, Folsom Dam has blocked the downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species.

In 2008, Reclamation, in coordination with USFWS and the Sacramento Water Forum, began implementation of salmonid habitat improvement in the lower American River. An estimated 5,000 cubic yards of gravel and cobble were placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated 7,000 cubic yards adjacent to the Nimbus Fish Hatchery in fall 2009. In September 2010, approximately 11,688 cubic yards (approximately 16,200 tons) of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook Salmon and steelhead in the lower American River (Merz et al. 2012). Additionally, the 2010 augmentation site contained a constructed cobble island

and "scallops" in the substrate designed to add habitat heterogeneity to the main channel and rearing habitat for juvenile Chinook Salmon and steelhead. Additionally, approximately 5,500 tons of cleaned cobble were placed downstream of the 2010 augmentation site. The specific purpose of this placement was to divert flow into an adjacent, perched side channel, thereby preventing the dewatering of salmonid redds in a historically important spawning and rearing area during low-flow conditions.

During higher flows, channel geomorphology in the lower American River is characterized by bar complexes and side channel areas, which may become limited at lower flows (NMFS 2009a). Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization at flows of 50,000 cfs or greater (Reclamation 2008a). At 115,000 cfs (the highest flow modeled), particles up to 70 mm median diameter would be moved in the high-density spawning areas around Sailor Bar and Sunrise Avenue. Flood frequency analysis for the American River at Fair Oaks gage shows that, on average, flood control releases exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (Reclamation 2008a).

In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River to assist in meeting the requirements of the 1992 CVPIA, Section 3406 (b)(13). The side channel at Upper Sunrise was identified as a suitable site for steelhead spawning habitat restoration. In 2008, the CVPIA (b)(13) program cut and widened the side channel so that it inundated at a greater range of flows. The project reduced steelhead stranding, but also inadvertently reduced Chinook Salmon and steelhead spawning and rearing habitat (AFRP 2012). Consequently, the main channel was filled at the head-cut to create greater head pressure, thereby allowing flow once again through the side channel. Monitoring at the Upper Sunrise project revealed immediate response from Chinook Salmon and steelhead moving up into the side channel to spawn after completion of the project. Spawning and rearing habitat enhancement projects occurred each year from 2008 through 2014 in the reach from Nimbus Dam down to River Bend Park. These annual projects are planned to continue.

#### 9.3.4.11.3 Fish Passage

Including the mainstem, north, middle, and south forks, more than 125 miles of riverine habitat historically were available for anadromous salmonids in the American River watershed (Yoshiyama et al. 1996). Access to the upper reaches of the river has been blocked by a series of impassable dams, including Old Folsom Dam, first constructed in the American River between 1895 and 1939.

Reclamation operates a fish diversion weir approximately 0.25 mile downstream of Nimbus Dam, which functions to divert adult steelhead and Chinook Salmon into Nimbus Fish Hatchery. The weir is annually installed during September prior to the arrival of fall-run Chinook Salmon and steelhead and is removed at the conclusion of fall-run Chinook Salmon immigration in early January (Reclamation and DFG 2011). Some steelhead may be trapped prior to weir removal, but they are returned to the river. A new fish passageway is being implemented in the Nimbus Dam stilling basin, commonly referred to as Nimbus Shoals. The passageway will replace the existing fish diversion weir with a new flume and fish ladder that will connect to the existing fish ladder near Nimbus Fish Hatchery.

#### 9.3.4.11.4 Hatcheries

CDFW operates the Nimbus Salmon and Steelhead Hatchery and American River Trout Hatchery, located immediately downstream from Nimbus Dam. Facilities associated with Nimbus Fish Hatchery include a fish weir, fish ladder, gathering and handling tanks, hatchery-specific buildings, and rearing ponds. Nimbus Fish Hatchery was constructed primarily to mitigate the loss of spawning habitat for Chinook Salmon and Central Valley Steelhead that were blocked by the construction of Nimbus Dam (Reclamation and DFG 2011); it does not address lost habitat upstream from Folsom Dam (CHSRG 2012). The hatchery operations include the trapping, artificial spawning, rearing, and release of steelhead and fall-/late fall-run Chinook Salmon. Propagation programs for American River winter-run steelhead and Central Valley fall/ late fall-run Chinook Salmon are operated by CDFW under contract with Reclamation (Lee and Chilton 2007). The Nimbus Fish Hatchery Winter-run Steelhead Program is an isolated-harvest program (i.e., it does not include natural-origin steelhead in the broodstock), designed and implemented to artificially spawn the adipose fin-clipped adult steelhead that seasonally enter the trapping facilities (CHSRG 2012). These fin-clipped fish are not part of the Central Valley Steelhead DPS. The Nimbus Fish Hatchery Winter-run Steelhead Program propagates fish for recreational fishing opportunities and harvest (CHSRG 2012).

Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October; however, since 2000, the ladder has been opened in early November. Trapping of steelhead has continued to occur as late as the second week of March. Presently, winter-run steelhead are trapped at Nimbus Fish Hatchery, and artificially spawned adults are marked with an adipose fin clip (CHSRG 2012). Unmarked steelhead adults are not retained at Nimbus Fish Hatchery for use in the annual broodstock and are released back to the river (CHSRG 2012). In addition, marked or unmarked *O. mykiss* that are less than 16 inches long may be resident hatchery-origin trout and are returned to the river (CHSRG 2012).

On average, the program has raised and released approximately 422,000 yearling steelhead since brood year 1999 (CHSRG 2012). Since 1998, all steelhead/Rainbow Trout produced in Nimbus Fish Hatchery have been marked with an adipose fin-clip to aid in subsequently identifying hatchery-origin fish.

Juvenile steelhead yearlings are not held past March 30 because of increasing hatchery water temperatures and to encourage outmigration during spring. If releases occur during periods of low flows in the Sacramento River and possibly the American River, some released fish migrate back to Nimbus Fish Hatchery and may take up residency rather than migrating downstream (Lee and Chilton 2007). Additionally, juvenile fish are released in February and early March to coincide with State Water Resources Control Board (SWRCB) D-1641 closures of the DCC gates from February 1 through May 20 to reduce straying into the Delta. Reclamation determines the exact timing and duration of the gate closures after discussion with USFWS, CDFW, and NMFS.

Reclamation is implementing a genetic screening study of Nimbus Fish Hatchery steelhead. Reclamation, in contract with NMFS, is conducting a parental-based tagging study of American River steelhead and continuing a study to determine a more genetically appropriate stock.

CDFW releases all hatchery-produced steelhead juveniles into the American River at boat ramps on the American River or at the confluence of the Sacramento and American rivers and releases all unclipped steelhead adults returning to Nimbus Fish Hatchery into the lower American River via the river return tube that is just downstream of the fish ladder. In accordance with California law, the current protocol of Nimbus Fish Hatchery is to destroy all surplus eggs to prevent inter-basin transfer of eggs or juveniles to other hatcheries or waters.

The goal of the Nimbus Fish Hatchery Integrated Fall/Late Fall-run Chinook Salmon Program is to release 4 million smolts. Each fall, Nimbus Hatchery staff collect approximately 10,000 adult fall-run Chinook Salmon, with an annual goal of harvesting 8,000,000 eggs and releasing the 4,000,000 smolts. All adult fall-run Chinook Salmon collected at the hatchery are euthanized, and no trapped salmon are returned to the American River (Reclamation 2008a).

#### 9.3.4.11.5 Disease

The occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as “rosy anus”) of steelhead in the lower American River has been reported by CDFW to be associated with relatively warm water temperatures (Water Forum 2005b). Anal vent inflammation of steelhead in the lower American River was observed in 2004 during periods when water temperatures were measured between 65°F and 68°F (Water Forum 2005a, 2005b). The Water Forum (2005b) suggested that, in addition to possible diminished immune system responses and incidences of diseases associated with elevated water temperatures, disease transmission may be exacerbated by crowding under conditions when water flows are reduced.

#### 9.3.4.11.6 Predation

Reduced cold-water storage in Folsom Lake and using Folsom Lake to meet Delta water quality objectives and demands influence habitat conditions in the lower American River for warm-water predator species that feed on juvenile salmonids and potentially alter predation pressure (Water Forum 2005b). Additionally, isolation of redds in side channels resulting from fluctuations in Folsom Lake releases may increase predation of emergent fry (Water Forum 2005b).

#### *9.3.4.12 Delta*

Ecologically, the Delta consists of three major landscapes and geographic regions: (1) the north Delta freshwater flood basins composed primarily of freshwater inflow from the Sacramento River system; (2) the south Delta distributary channels composed of predominantly San Joaquin River system inflow; and (3) the central Delta tidal islands landscape wherein the Sacramento, San Joaquin, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

##### 9.3.4.12.1 Fish in the Delta

The Delta provides unique and, in some places, highly productive habitats for a variety of fish species, including euryhaline and oligohaline resident species and anadromous species. For anadromous species, the Delta is used by adult fish during upstream migration and by rearing juvenile fish that are feeding and growing as they migrate downstream to the ocean. Conditions in the Delta influence the abundance and productivity of all fish populations that use the system. Fish communities currently in the Delta include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al. 2002, Feyrer and Healey 2003, Nobriga et al. 2005, Brown and May 2006, Moyle and Bennett 2008, Grimaldo et al. 2012).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall-/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad
- Delta Smelt
- Longfin Smelt
- Sacramento Splittail

The Interagency Ecological Program (IEP) has been monitoring fish populations in the San Francisco Estuary for decades. Survey methods have included beach seining, midwater trawls, Kodiak trawls, otter trawls, and other methods (Honey et al. 2004) to sample the pelagic fish assemblage throughout the estuary. Three of the most prominent resident pelagic fishes captured in the surveys (Delta Smelt, Longfin Smelt, and Striped Bass) have shown substantial long-term population declines (Kimmerer et al. 2000, Bennett 2005, Rosenfield and Baxter 2007). Reductions in pelagic fish abundance since 2002 have been recognized as a serious water and fish management issue and have become known as the Pelagic Organism Decline (POD) (Sommer et al. 2007a).

In response to the POD, the IEP formed a study team in 2005 to evaluate the potential causes of the decline. Since completion of the first set of studies in late 2005, alternative models have been developed based on the available data and at professional judgment of the POD-Modeling Team regarding the extent to which individual drivers are likely to affect each species-life stage. The nine drivers identified (Baxter et al. 2010) were: (1) mismatch of larvae and food; (2) reduced habitat space; (3) adverse water movement/transport; (4) entrainment; (5) toxic effects on fish; (6) toxic effects on fish food items; (7) harmful Microcystis aeruginosa blooms; (8) *Potamocorbula amurensis* effects on food availability; and (9) disease and parasites.

An overall negative trend in habitat quality has occurred for Delta Smelt and Striped Bass (and potentially other fish species) as measured by water quality attributes and midwater trawl catch data since 1967, with Delta Smelt and Striped Bass experiencing the most apparent declines in abundance, distribution, and a related index of environmental quality (Feyrer et al. 2007, 2010). More specifically, the position of X2 and water clarity may be important factors influencing the quality of habitat for these species (McNally et al. 2010). Other factors, such as the introduction of nonnative clam species, also contribute to reducing habitat quality. Pelagic habitat suitability in the San Francisco Estuary has been characterized by changes in X2 (Feyrer et al. 2007, 2010). The abundance of several taxa increases in years when flows into the estuary are high and X2 is pushed seaward (Jassby et al. 1995; Kimmerer 2002a, b), implying that the quantity or suitability of estuarine habitat increases when outflows are high. Recent analyses by Kimmerer et al. (2009) indicated that neither changes in area or volume of low salinity water (habitat) account for this relationship, except for striped bass and American shad. This suggests that X2 is indexing other environmental variables or processes rather than simple extent of habitat (Baxter et al. 2010).

*Winter-run Chinook Salmon*

Winter-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles (del Rosario et al. 2013). Adults migrate through the Delta during winter and into late spring (May/June) enroute to their spawning grounds in the mainstem Sacramento River downstream of Keswick Dam (USFWS 2001b, 2003b). Adults are believed to primarily use the mainstem Sacramento River for passage through the Delta (NMFS 2009a). After entry into the Delta, juvenile winter-run Chinook Salmon remain and rear in the Delta until they are 5 to 10 months of age (based on scale analysis) (Fisher 1994, Myers et al. 1998). Although the duration of residence in the Delta is not precisely known, del Rosario et al. (2013) suggested that it can be up to several months. Winter-run Chinook Salmon juveniles have been documented in the north Delta (e.g., Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, Yolo Bypass, and Cache Slough complex); the central Delta (e.g., Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island); south Delta channels, including Old and Middle rivers, and the joining waterways between Old and Middle rivers (e.g., Victoria Canal, Woodward Canal, and Connection Slough); and the western central Delta, including the mainstem channels of the Sacramento and San Joaquin rivers and Threemile Slough (NMFS 2009a).

Sampling at Chipps Island in the western Delta suggests that winter-run Chinook Salmon exit the Delta as early as December and as late as May, with a peak in March (Brandes and McLain 2001, del Rosario et al. 2013). The peak timing of the outmigration of juvenile winter-run Chinook Salmon through the Delta is corroborated by recoveries of winter-run-sized juvenile Chinook Salmon from the SWP Skinner Delta Fish Protection Facility and the CVP Tracy Fish Collection Facility in the south Delta (NMFS 2009a).

*Spring-run Chinook Salmon*

The Delta is an important migratory route for all remaining populations of spring-run Chinook Salmon. Like all salmonids migrating up through the Delta, adult spring-run Chinook Salmon must navigate the many channels and avoid direct sources of mortality (e.g., fishing and predation), but also must minimize exposure to sources of nonlethal stress (e.g., high temperatures) that can contribute to prespawn mortality in adult salmonids (Budy et al. 2002, Naughton et al. 2005, Cooke et al. 2006, NMFS 2009a). Habitat degradation in the Delta caused by factors such as channelization and changes in water quality can present challenges for outmigrating juveniles. Additionally, outmigrating juveniles are subjected to predation and entrainment in the project export facilities and smaller diversions (NMFS 2009a). Further detail is provided later in this section.

Spring-run Chinook Salmon returning to spawn in the Sacramento River system enter the San Francisco Estuary from the ocean in January to late February and move through the Delta prior to entering the Sacramento River. Several populations of spring-run Chinook Salmon occur in the Sacramento River Basin, but historical populations that occurred in the San Joaquin River and tributaries have been extirpated. The Sacramento River channel is the main spring-run Chinook Salmon migration route through the Delta. However, adult spring-run Chinook Salmon may stray into the San Joaquin River side of the Delta in response to water from the Sacramento River Basin flowing into the interconnecting waterways that join the San Joaquin River channel through the DCC, Georgiana Slough, and Threemile Slough. Closure of the DCC radial gates is intended to minimize straying, but some southward net flow still occurs naturally in Georgiana and Threemile sloughs.

Juvenile spring-run Chinook Salmon show two distinct outmigration patterns in the Central Valley: outmigrating to the Delta and ocean during their first year of life as YOY, or holding over in their natal streams and outmigrating the following fall/winter as yearlings. Peak movement of juvenile spring-run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December, and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000b, c, d; Vincik et al. 2006; Roberts 2007).

YOY spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of spring-run fish at that time of year. However, it is difficult to distinguish the YOY spring-run Chinook Salmon outmigration from that of the fall-run due to the similarity in their spawning and emergence times and size. Together, these two runs generate an extended pulse of Chinook Salmon smolts outmigrating through the Delta throughout spring, frequently lasting into June. Spring-run Chinook Salmon juveniles also overlap spatially with juvenile winter-run Chinook Salmon in the Delta (NMFS 2009a). Typically, juvenile spring-run Chinook Salmon are not found in the channels of the eastern side of the Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

*Fall-/Late fall-run Chinook Salmon*

Central Valley fall- and late fall-run Chinook Salmon pass through the Delta as adults migrating upstream and juveniles outmigrating downstream. Adult fall- and late fall-run Chinook Salmon migrating through the Delta must navigate the many channels and avoid direct sources of mortality and minimize exposure to sources of nonlethal stress. Additionally, outmigrating juveniles are subject to predation and entrainment in the project export facilities and smaller diversions.

Adult fall-run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Adult late fall-run Chinook Salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley fall- and late fall-run Chinook Salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway.

Most fall-run Chinook Salmon fry rear in fresh water from December through June, with outmigration as smolts primarily from January through June. In general, fall-run Chinook Salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo bays. A small number of juvenile fall-run Chinook Salmon spend over a year in fresh water and outmigrate as yearling smolts the following November through April. Late fall-run fry rear in fresh water from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000b). Juvenile Chinook Salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002).

Results of mark-recapture studies conducted using juvenile Chinook Salmon released into both the Sacramento and San Joaquin rivers have shown high mortality during passage downstream through the rivers and Delta (Brandes and McLain 2001, Newman and Rice 2002, Buchanan et al. 2013). Juvenile salmon migrating from the San Joaquin River generally experience greater mortality than fish outmigrating from the Sacramento River. In years when spring flows are reduced and water temperatures are increased, mortality is typically higher in both rivers. Closing the DCC gates and installation of the Head of Old River Barrier to reduce the movement of juvenile salmon into the south Delta from the Sacramento and San Joaquin rivers, respectively, may contribute to improved survival of outmigrating juvenile Chinook Salmon from these watersheds (see Section 9.3.4.12.6).

Although not directly comparable to these previous coded-wire tag studies in the San Joaquin River, Buchanan et al. (2013, 2015) found that survival of acoustically tagged hatchery-origin (Feather River) juvenile Chinook Salmon was either not statistically different between routes (2009) or was higher through the south Delta via the Old River route than via the San Joaquin River (2010). Additionally, most fish in the Old River that survived to the end of the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013, SJRGA 2013). Buchanan et al. 2013 indicated that the differences in their results compared to past CWT studies may reflect that an alternative non-physical barrier was being used during their investigation to examine its ability to keep fish out of the Old River instead of the HORB which is a physical barrier that reduces not only the number of fish, but also the majority of flows, from entering the Old River. Nonphysical barriers may deprive smolts routed to the San Joaquin River of the increased flows needed for improved survival and created habitat for increased predation at the site (Buchanan et al. 2013).

Juvenile fall- and late fall-run Chinook Salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook Salmon in the estuarine environment is driven by the interaction between tidally influenced saltwater intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin rivers (Healey 1991).

In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including fall-run Chinook Salmon. Studies have shown that juvenile salmon may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors (Williams 2010). The channeled, leveed, and riprapped river reaches and sloughs common in the Delta typically have low habitat diversity and complexity, have low abundance of food organisms, and offer little protection from predation by fish and birds.

*Steelhead*

Upstream migration of steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996, NMFS 2009a). Populations of steelhead occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams.

Adult steelhead can be present in portions of the Delta with suitable conditions during any month of the year. Upstream migrating adult steelhead enter the Sacramento and San Joaquin River basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the South Delta waterways and enter the San Joaquin River through the Head of Old River.

Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures in the south Delta waterways and water quality impairment because of low dissolved oxygen at Stockton have been suggested as potential barriers to upstream migration (NMFS 2009a). Reduced water temperatures, as well as rainfall runoff and flood control release flows, provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries. Adult steelhead may continue entering the San Joaquin River Basin through winter.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009a). Juvenile steelhead are recovered in trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate there is a difference in the outmigration timing between wild and hatchery-reared steelhead smolts from the Sacramento and eastside tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001, Reclamation 2008a). The timing of wild (unmarked) steelhead outmigration is more spread out, and based on salvage records at the CVP and SWP fish collection facilities, outmigration occurs over approximately 6 months with the highest levels of recovery in February through June (Aasen 2011, 2012). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in 2011) (Aasen 2011, 2012).

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento or San Joaquin River. Mokelumne River steelhead smolts can either follow the north or south branches of the Mokelumne River through the central Delta before entering the San Joaquin River, although some fish may enter farther upstream if they diverge from the south branch of the Mokelumne River into Little Potato Slough. Calaveras River steelhead smolts enter the San Joaquin River downstream of the Port of Stockton. Although steelhead have been routinely documented by CDFW in trawls at Mossdale since 1988 (SJRGA 2011), it is unknown whether successful outmigration occurs outside the seasonal installation of the barrier at the Head of Old River (between April 15 and May 15 in most years). Prior to the installation of the Head of Old River barrier, steelhead smolts exiting the San Joaquin River Basin could follow one of two routes to the ocean, either staying in the mainstem San Joaquin River through the central Delta, or entering the Head of Old River and migrating through the south Delta and its associated network of channels and waterways.

*Green Sturgeon*

Green Sturgeon reach maturity around 14 to 16 years of age and can live to be 70 years old, returning to their natal rivers every 3 to 5 years for spawning (Van Eenennaam et al. 2005). Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations the upper Sacramento River between April and June (Heublein 2006, Kelly et al. 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river before moving back downstream in fall (Vogel 2008, Heublein et al. 2009), or they may migrate immediately back downstream through the Delta. Radio-tagged adult Green Sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulses of flow in the river (Heublein et al. 2009), similar to behavior exhibited by adult Green Sturgeon on the Rogue River and Klamath River systems (Erickson et al. 2002, Benson et al. 2007).

Similar to other estuaries along the west coast of North America, adult and sub-adult Green Sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Specifically, adults and subadults may reside for extended periods in the central Delta as well as in Suisun and San Pablo bays, presumably for feeding, because bays and estuaries are preferred feeding habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae). In part because of their bottom-oriented feeding habits, sturgeon are at risk of harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury (Israel and Klimley 2008, Stewart et al. 2004).

Juvenile Green Sturgeon and White Sturgeon are periodically (although rarely) collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (NMFS 2009a; Aasen 2011, 2012). Green Sturgeon are salvaged from the south Delta Project diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (Reclamation 2008a). NMFS (2005b) suggested that the high percentage of San Joaquin River flows contributing to the Tracy Fish Collection Facility could mean that some entrained Green Sturgeon originated in the San Joaquin River Basin. Jackson (2013) reported spawning by White Sturgeon in the San Joaquin River, and anglers have reported catching a few Green Sturgeon in recent years in the San Joaquin River (DFG 2012b).

After hatching, larvae and juveniles migrate downstream toward the Delta. Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the central Delta and Suisun Bay/Marsh. Project operations at the DCC have the potential to reroute Green Sturgeon as they outmigrate through the lower Sacramento River to the Delta (Israel and Klimley 2008, Vogel 2011).

When the DCC is open, there is no passage delay for adults, but juveniles could be diverted from the Sacramento River into the interior Delta. This has been shown to reduce the survival of juvenile Chinook Salmon (Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2012), but it is unknown whether it has similar effects on Green Sturgeon.

*White Sturgeon*

White Sturgeon are similar to Green Sturgeon in terms of their biology and life history. Like Green Sturgeon and other sturgeon species, White Sturgeon are late-maturing and infrequent spawners, which makes them vulnerable to overexploitation and other sources of adult mortality. White Sturgeon are believed to be most abundant within the San Francisco Bay-Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966, Kohlhorst et al. 1991, Moyle 2002, DWR et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the Bay-Delta (Kohlhorst et al. 1991). The population status of White Sturgeon in the Delta is unclear, but it is not presently listed. Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002, NMFS 2009a).

The Delta population of White Sturgeon spawns mainly in the Sacramento and Feather rivers, with occasional spawning in the San Joaquin River (Moyle 2002, Jackson 2013). Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994, Schaffter 1997).

After absorbing yolk sacs and initiating feeding, YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White Sturgeon larvae have been observed to be flushed farther downstream in the Delta and Suisun Bay in high outflow years, but are restricted to more interior locations in low outflow years (Stevens and Miller 1970).

Salinity tolerance increases with increasing age and size (McEnroe and Cech 1985), allowing White Sturgeon to access a broader range of habitat in the San Francisco Estuary (Israel et al. 2008). During dry years, White Sturgeon have been observed following brackish waters farther upstream, while the opposite occurs in wet years (Kohlhorst et al. 1991). Adult White Sturgeon tend to concentrate in deeper areas and tidal channels with soft bottoms, especially during low tides, and typically move into intertidal or shallow subtidal areas to feed during high tides (Moyle 2002). These shallow water habitats provide opportunities for feeding on benthic organisms, such as opossum shrimp, amphipods, and even invasive overbite clams, and small fishes (Israel et al. 2008, Kogut 2008). White Sturgeon also have been found in tidal habitats of medium-sized tributary streams to the San Francisco Estuary, such as Coyote Creek and Guadalupe River in the south bay and Napa and Petaluma rivers and Sonoma Creek in the north bay (Leidy 2007).

Numerous factors likely affect the White Sturgeon population in the Delta, similar to those for Green Sturgeon. Survival during early life history stages may be adversely affected by insufficient flows, lack of rearing habitat, predation, warm water temperatures, decreased dissolved oxygen, chemical toxicants in the water, and entrainment at diversions (Cech et al. 1984, Israel et al. 2008). Historical habitats, including shallow intertidal feeding habitats, have been lost in the Delta because of channelization. Over-exploitation by recreational fishing and poaching also likely has been an important factor adversely affecting numbers of adult sturgeon (Moyle 2002), although new regulations were implemented in 2007 by CDFW to reduce harvest. Like Green Sturgeon, there are substantial passage problems for White Sturgeon such as the Fremont Weir (Sommer et al. 2014).

*Delta Smelt*

Delta Smelt are endemic to the Delta (Moyle et al. 1992, Bennett 2005). Delta Smelt were once regarded as one of the most common pelagic fish in the Delta, but declines in their population led to their listing under the ESA as threatened in 1993 (USFWS 2008a). Delta Smelt are one of four pelagic fish species (including Longfin Smelt, Threadfin Shad, and juvenile Striped Bass) documented to be in decline based on fall midwater trawl abundance indices (Sommer et al. 2007a). The causes of the declines have been extensively studied and are thought to include a combination of factors, such as decreased habitat quantity and quality, increased mortality rates, and reduced food availability (Feyrer et al. 2007, Sommer et al. 2007a, Moyle and Bennett 2008, Baxter et al. 2010, MacNally et al. 2010, Rose et al. 2013a, b, Sommer and Mejia 2013). Two statistical analyses that used similar data but different statistical methods, (MacNally et al. 2010; Thomson et al. 2010) examined the dynamics of the four fish species. Both analyses identified several covariates that were related to abundance of the fish, but they could not resolve the cause of the recent declines. The analysis of model results and data for 1995–2005 conducted by Rose et al. (2013a) indicated that it has been difficult to ascribe the Delta Smelt's decline to a single cause, either over the long term or as part of the recent 2002 decline.

The status of the Delta Smelt is uncertain, as indicators of Delta Smelt abundance have continued to decline and the number of fish collected in sampling programs, such as the trawl surveys conducted by the IEP, have dropped even lower in recent years. The Fall Midwater Trawl (FMWT) Survey is recognized by some as the best available long-term index of Delta Smelt relative abundance (USFWS 2008). Figure 9.1 presents the FMWT abundance indices for Delta Smelt from 1967 to 2013 (CDFW 2014b). Fewer than 10 Delta Smelt were collected in these surveys in 2014; the 2014 Delta Smelt index was 9, making it the lowest in FMWT history (CDFW 2014a, 2015). Results for Delta Smelt from the 2015 spring Kodiak trawl, 20-mm survey, and summer townet survey reported in the June 2015 Smelt Working Group meeting summary were similarly low (Smelt Working Group 2015).

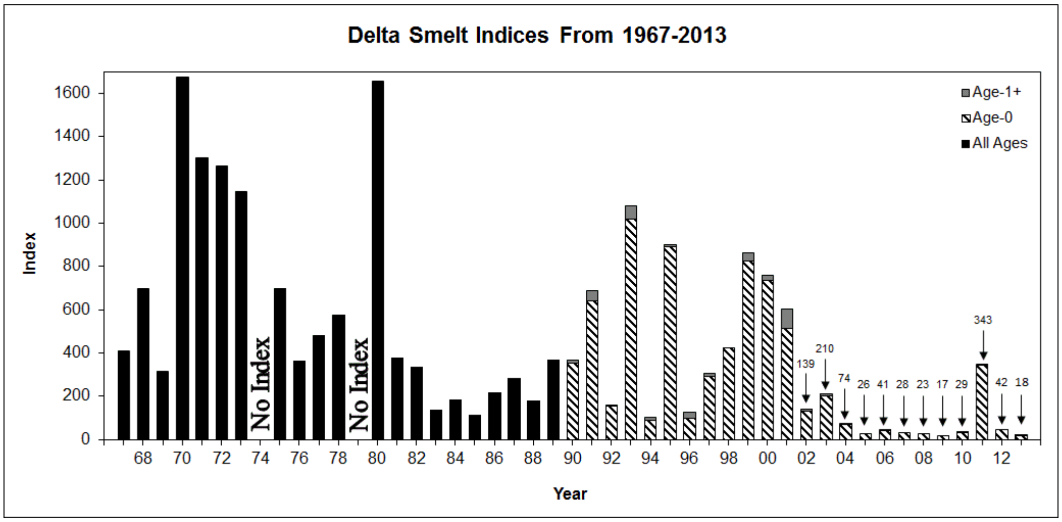



**Figure 9.1 Fall Midwater Trawl Abundance Indices for Delta Smelt from 1967 to 2013**

Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

Studies conducted to synthesize available information about Delta Smelt indicate that Delta Smelt have been documented throughout their geographic range during much of the year (Merz et al. 2011, Sommer and Mejia 2013, Brown et al. 2014). Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta, Suisun and San Pablo bays, the Sacramento River and San Joaquin River confluence, Cache Slough, and the lower Sacramento River (Murphy and Hamilton 2013). By spring, they move to freshwater areas of the Delta region, including the Sacramento River and San Joaquin River confluence, the Upper Sacramento River, and Cache Slough (Brown et al. 2014, Murphy and Hamilton 2013).

Sommer et al. 2011 described that during winter, adult Delta Smelt initiate upstream spawning migrations in association with “first flush” freshets. Others report this seasonal change as a multi-directional and more circumscribed dispersal movement to freshwater areas throughout the Delta region (Murphy and Hamilton 2013). After arriving in freshwater staging habitats, adult Delta Smelt hold until spawning commences during favorable water temperatures in the late winter-spring (Bennett 2005, Grimaldo et al. 2009, Sommer et al. 2011). Delta Smelt spawn over a wide area throughout much of the Delta, including some areas downstream and upstream as conditions allow. Although the specific substrates or habitats used for spawning by Delta Smelt are not known, spawning habitat preferences of closely related species (Bennett 2005) suggest that spawning may occur in shallow areas over sandy substrates. The nonpelagic habitats used by larval Delta Smelt before they move into the pelagic areas also are not known (Swanson et al. 1998, Sommer et al. 2011).

During and after larval rearing in fresh water, many young Delta Smelt move with river and tidal currents to remain in favorable rearing habitats, often moving increasingly into the low salinity zone to avoid seasonally warm and highly transparent waters that typify many areas in the central Delta (Nobriga et al. 2008). Bennett and Burau (2014) showed that during winter, delta smelt aggregate near frontal zones at the shoal-channel interface moving laterally into the shoals on ebb tides and back into the channel on flood tides. They suggest that this migration strategy can minimize the energy spent swimming against strong river and tidal currents, as well as predation risks by remaining in turbid water.

During summer and fall, many juvenile Delta Smelt continue to grow and rear in the low salinity zone until maturing the following winter (Bennett 2005). Some Delta Smelt also rear in upstream areas such as the Cache Slough complex and Sacramento Deepwater Ship Channel, depending on habitat conditions (Sommer and Mejia 2013).

During summer and fall, the distribution of juvenile Delta Smelt rearing is influenced by the position of the low salinity zone (as indexed by the position of X2), although their distribution can also be influenced by temperature and turbidity (Bennett 2005; Feyrer et al. 2007, 2010; Kimmerer et al. 2009; Sommer and Mejia 2013). The geographical position of the low salinity zone varies primarily as a function of freshwater outflow; thus, X2 typically lies farther east in summer and fall during low outflow conditions and drier water years and farther west during high outflow conditions (Jassby et al. 1995).

Higher outflow causes X2 and the low salinity zone to more frequently overlap with the Suisun Bay/Marsh region, which is broader and shallower and typically has greater turbidity than the mainstem Sacramento and San Joaquin rivers. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a dramatic increase in the habitat index (Feyrer et al. 2010); however others (see Manly et al. 2015) have questioned the use by Feyrer et al. (2010) of outflow and X2 location as an indicator of Delta Smelt habitat because other factors may be influencing survival.

In addition to salinity, turbidity is an important factor associated with habitat use; Delta Smelt show a strong preference for higher turbidity water (Feyrer et al. 2007, 2010; Sommer and Mejia 2013) and turbidity may be a key habitat feature and cue initiating the delta smelt spawning migration (Bennett and Burau 2014). Turbidity has decreased in recent decades within the Delta (Kimmerer 2004, Schoellhamer 2011), which has likely contributed to declines in environmental quality of Delta Smelt habitat (Feyrer et al. 2007, 2010). Higher turbidities are believed to allow Delta Smelt to hide from open-water predators, such as Striped Bass (Gregory and Levings 1998, Nobriga et al. 2005), and contribute to feeding success (Lindberg et al. 2000, IEP 2015).

Water temperature is another important environmental factor that affects Delta Smelt habitat and population dynamics (Sommer and Mejia 2013). A longer period of optimal water temperatures in cooler years increases the number of spawning events and cohorts produced (Bennett 2005). During rearing, summer water temperatures also have been shown to be an important predictor of Delta Smelt occurrence, based on multi-decadal analyses of summer tow net survey data (Nobriga et al. 2008).

The quality and availability of food also have important effects on the abundance and distribution of Delta Smelt (Sommer and Mejia 2013, Kimmerer 2008). Delta Smelt feed primarily on zooplankton, and Nobriga (2002) showed that Delta Smelt larvae with food in their guts typically co-occurred with higher calanoid copepod densities. Food quality and availability have varied substantially, largely because of the history of nonnative species introduction into the San Francisco Estuary (Baxter et al. 2008, Winder and Jassby 2011). The decline of zooplankton in the western Delta has been hypothesized to be related to several factors, including increased ammonium concentrations from wastewater effluent and agricultural runoff (Wilkerson et al. 2006; Dugdale et al. 2007; Miller et al. 2012; Glibert 2010; Glibert et al. 2011, 2014).

In 2011 and 2012, an unanticipated change in water management operations led to relatively large phytoplankton blooms in the western Delta, including in the Sacramento River near Rio Vista. Historically, rice fields along the Colusa Basin Drain are flooded in fall to decompose the rice stubble, and the water is released through the Knights Landing Outfall gates into the Sacramento River. In 2011 and 2012, construction at the outfall gates required the water to be diverted into the Yolo Bypass, resulting in higher than normal flows. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014). Concurrently, a substantial increase in nutrients, phytoplankton, and zooplankton was observed in the Yolo Bypass and Cache Slough. In 2013, the fall pulse flow of rice drainage water did not occur in the Yolo Bypass, and nutrient concentrations did not increase. These nutrient inputs, when they occur, and corresponding increases in phytoplankton and zooplankton production, could contribute to improved foraging opportunities for Delta Smelt.

Results in prior years indicate that entrainment and salvage-related mortality of Delta Smelt associated with water pumping and CVP/SWP exports from the Delta occur primarily from December to July (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010). Entrainment occurs when migrating and spawning adult Delta Smelt and their larvae overlap in time and space with reverse (southward, or upstream) flows in the Old and Middle river channels (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010).

In January 2015, the IEP Management Analysis and Synthesis Team (MAST) published a report to provide an assessment and conceptual model of factors affecting Delta Smelt throughout its life cycle. One focus of the report was an evaluation of a notable increase in abundance of all Delta Smelt life stages in 2011, which indicated that the Delta Smelt population could potentially rebound when conditions are favorable for spawning, growth, and survival.

The IEP MAST updated conceptual model described the habitat conditions and ecosystem drivers affecting each Delta Smelt life stage, across seasons and how the seasonal effects contributed to the annual success of the species. The conclusions of the report highlighted some key points about Delta Smelt and their habitat, using 2011 as the example year. In summary, the report concluded that Delta Smelt likely benefitted from the following favorable habitat conditions in 2011:

1) Adults and larvae benefitted from high winter 2010 and spring 2011 outflows, which reduced entrainment risk and possibly improved other habitat conditions, prolonged cool spring water temperatures, and possibly good food availability in late spring.

2) Juvenile Delta Smelt benefitted from cool water temperatures in late spring and early summer as well as from relatively good food availability and low levels of harmful Microcystis.

3) Subadults benefitted from good food availability and from favorable habitat conditions in the large low salinity zone, located more toward Suisun Bay in 2010.

*Longfin Smelt*

Longfin Smelt populations occur along the Pacific Coast of North America, and the San Francisco Estuary represents the southernmost population. Longfin Smelt generally occur in the Delta; Suisun, San Pablo, and San Francisco bays; and the Gulf of the Farallones, just outside San Francisco Bay. Longfin Smelt are not a focus of any specific RPA actions. However, RPA actions that benefit Delta Smelt, salmonids, and sturgeon, including increasing Delta outflow, have the potential to benefit other fish, including Longfin Smelt, given their similar habitat requirements and trophic feeding levels.

Longfin Smelt are anadromous and spawn in fresh water in the Delta, generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (DFG 2009a). Spawning in the Sacramento River is believed to occur from just downstream of the confluence of the Sacramento and San Joaquin rivers upstream to about Rio Vista. Spawning on the San Joaquin River extends from the confluence upstream to about Medford Island (Moyle 2002). Spawning likely also occurs in Suisun Marsh and the Napa River (DFG 2009a).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). The geographic distribution of Longfin Smelt larvae is closely associated with the position of X2; the center of distribution varies with outflow conditions, but not with respect to X2 (Dege and Brown 2004). This pattern is consistent with juveniles migrating downstream to low salinity, brackish habitats for growth and rearing. Larger Longfin Smelt feed primarily on opossum shrimps and other invertebrates (Feyrer et al. 2003). Copepods and other crustaceans also can be important food items, especially for smaller fish (Reclamation 2008a).

Longfin Smelt in the San Francisco Estuary are broadly distributed in both time and space, and interannual distribution patterns are relatively consistent (Rosenfield and Baxter 2007). Seasonal patterns in abundance indicate that the population is at least partially anadromous (Rosenfield and Baxter 2007), and the detection of Longfin Smelt within the estuary throughout the year suggests that, similar to Striped Bass, anadromy is one of several life history strategies or contingents in this population.

The relative population size of Longfin Smelt in the San Francisco Estuary is measured by indices of abundance generated from different sampling programs. The abundance of age 0 and older fish is best indexed by the Fall Midwater Trawl and Bay Study, while the abundance of larvae and young juveniles is best indexed by the 20-mm survey. The relationship between these indices and actual population sizes is unknown. Although the Fall Midwater Trawl data suggest a sharp decline in Longfin Smelt abundance during the last decade, some of that decline might be attributable to a downstream movement in the longfin distribution into regions better covered by the Bay Study fish survey. The Bay Study uses two types of trawls, an otter trawl and a midwater Trawl. The Longfin Smelt abundance index created from the Fall Midwater Trawl is consistent with the trend in the Bay Study midwater trawl but not the Bay Study otter Trawl. In addition, there have been an increasing proportion of false zeros in the survey data where the Bay Study midwater trawl failed to detect any Longfin Smelt when they were detected in the otter trawl.

The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically significant step-declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). A synthesis of prior studies conducted by USFWS in its 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened (USFWS 2012) reported that increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance. The trend in Longfin Smelt abundance from 1967 through 2013 is presented on Figure 9.2.

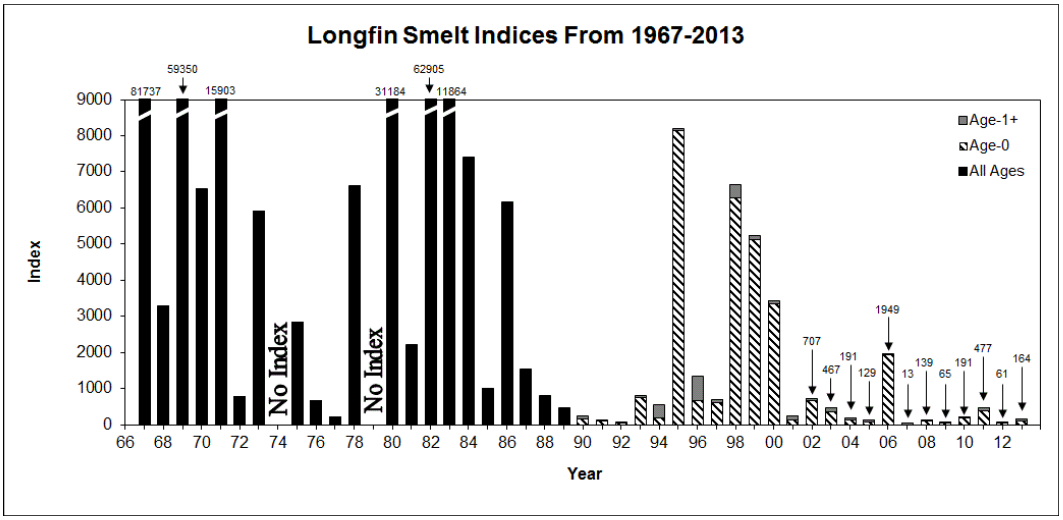



**Figure 9.2 Fall Midwater Trawl Abundance Indices for Longfin Smelt from 1967 to 2013**

Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

Habitat for Longfin Smelt is open water, largely away from shorelines and vegetated inshore areas except perhaps during spawning. This includes all of the large embayments in the estuary and the deeper areas of many of the larger channels in the western Delta; habitat suitability in these areas for Longfin Smelt can be strongly influenced by variation in freshwater flow (Jassby et al. 1995, Bennett and Moyle 1996, Kimmerer 2004, Kimmerer et al. 2009).

Water exports and inadvertent entrainment at the SWP and CVP export facilities are anthropogenic sources of mortality for Longfin Smelt. The export facilities are known to entrain most species of fish in the Delta (Brown et al. 1996). Longfin Smelt entrainment mainly occurs from December to May, with peak adult entrainment from December to February (Grimaldo et al. 2009). In water year 2011, Aasen (2012) reported four adult Longfin Smelt were salvaged at the project export facilities, compared with much higher numbers in the early 2000s and late 1980s. The entrainment of Longfin Smelt in recent years has been reduced likely because of changes in export operations and a decline in abundance.

*Sacramento Splittail*

Sacramento Splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento Splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas, but they also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004).

Adult Sacramento Splittail typically migrate upstream from brackish areas in January and February and spawn in fresh water, particularly on inundated floodplains when they are available, in March and April (Sommer et al. 1997, Moyle et al. 2004, Sommer et al. 2008). A substantial amount of splittail spawning occurs in the Yolo and Sutter bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn as evidenced by spawning in the Napa and Petaluma rivers (Feyrer et al. 2005).

Although juvenile Sacramento Splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995, Feyrer et al. 2005). Sacramento Splittail recruitment is largely limited by extent and period of inundation of floodplain spawning habitats, with abundance observed to spike following wet years and dip after dry years (Moyle et al. 2004). However, the 5- to 7-year life span buffers the adult population abundance (Sommer et al. 1997, Moyle et al. 2004). Other factors that may adversely affect the splittail population in the Delta include entrainment, predation, changed estuarine hydraulics, nonnative species (Moyle et al. 2004), pollutants (Greenfield et al. 2008), and limited food.

*American Shad*

American Shad is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin in the 1870s (Moyle 2002). American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Sacramento-San Joaquin estuary (Painter et al. 1979).

Fertilized eggs are slightly negative buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile shad rear in the Sacramento River below Knights Landing, the Feather River below Yuba City, and the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing occurs in the American and Yuba rivers (Painter et al. 1979). Some juvenile shad may rear in the Delta for up to a year before outmigrating to the ocean (USFWS 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Juvenile American Shad are frequently encountered in the Delta during the FMWT Survey and in fish salvage monitoring at the south Delta SWP and CVP fish facilities (DWR et al. 2013). American Shad use of the Delta has been observed to vary with salinity (e.g., X2 position) and outflows (Kimmerer 2002).

American Shad are entrained at the Tracy Fish Collection Facility (Bowen et al. 1998) and in the Clifton Court Forebay, mostly during May through December when young American Shad migrate downstream. The American Shad population in the Sacramento-San Joaquin River Basin has declined since the late 1970s, most likely because of increased diversion of water from rivers and the Delta, combined with changing ocean conditions, and possibly pesticides (Moyle 2002). Salvage of American Shad at project export facilities in water year 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly lower salvage in 2010 (545,125 fish) (Aasen 2011).

*Striped Bass*

Striped Bass is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin between 1879 and 1882 (Moyle 2002). Despite their nonnative status and piscivorous feeding habits, Striped Bass are considered important because they are a major game fish in the Delta. Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped Bass spend the majority of their lives in salt water, returning to fresh water to spawn. When not migrating for spawning, adult Striped Bass in the San Francisco Bay-Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult Striped Bass spend about 6 to 9 months of the year in San Francisco and San Pablo bays (Hassler 1988). Striped Bass also use deeper areas of many of the larger channels in the Delta, in addition to large embayments such as Suisun Bay.

Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento-San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

YOY Striped Bass distribute themselves in accordance with the estuarine salinity gradient (Kimmerer 2002, Feyrer et al. 2007), indicating that salinity is a major factor affecting their habitat use and geographic distributions. Kimmerer (2002) found that distributions of fish species, including Striped Bass, substantially overlapped with the low salinity zone. Older Striped Bass are increasingly flexible about their distribution relative to salinity (Moyle 2002).

The entrainment of Striped Bass has been observed at the project export facilities, including Clifton Court Forebay (Stevens et al. 1985, Bowen et al. 1998, Aasen 2012). In water year 2011, salvage of Striped Bass at export facilities (approximately 550,000 fish) continued a generally low trend observed since the mid-1990s. Prior to 1995, annual Striped Bass salvage was generally above 1 million fish (Aasen 2012). DWR et al. (2013) reported that Striped Bass longer than 24 mm were effectively screened at Tracy Fish Collection Facility and bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller than 24 mm in length received no protection from entrainment.

Striped Bass, primarily YOY, are one of the pelagic fish of the upper estuary that have shown substantial variability in their populations, with evidence of long-term declines (Kimmerer et al. 2000, Sommer et al. 2007a). As discussed earlier for Delta Smelt, a substantial portion of the abundance patterns has been associated with variation of outflow in the estuary (Jassby et al. 1995, Kimmerer et al. 2001, Loboschefsky et al. 2012), although this is disputed by some stakeholders (Bourez 2011). However, surveys showed that population levels for YOY Striped Bass began to decline sharply around 1987 and 2002 (Thomson et al. 2010), despite relatively moderate hydrology, which typically supports at least modest fish production (Sommer et al. 2007a). Moyle (2002) cites causes of decline in Striped Bass to include climatic factors, entrainment at project export facilities in the south Delta, other diversions, pollutants, reduced estuarine productivity, invasions by alien species, and human exploitation. Kimmerer et al. (2000, 2001) attribute the decline in juvenile YOY Striped Bass to declining carrying capacity, likely related to food limitation. Loboschefsky et al. (2012) showed that there had been no long-term decline for age 1 and older Striped Bass as of 2004.

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed species that uses the Delta for upstream migration as adults, for downstream migration as juveniles, and for rearing as ammocoetes (larval form) (Hanni et al. 2006, Moyle et al. 2009). Pacific Lampreys are present in the north, central, and south Delta, and ammocoetes are present year-round in all of the regions (DWR et al. 2013). Limited information on status of Pacific Lamprey in the Delta exists, but the number of lampreys inhabiting the Delta is likely greatly suppressed compared with historical levels, as suggested by the loss of access to historical habitat and apparent population declines throughout California and the Sacramento-San Joaquin River Basin (Moyle et al. 2009).

Limited data indicate most adult Pacific Lamprey migrate though the Delta enroute to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005, Hanni et al. 2006, Moyle et al. 2009, Clemens et al. 2012, Lampman 2011). Data from the FMWT Survey in the lower Sacramento and San Joaquin rivers and Suisun Bay suggest that peak outmigration of Pacific Lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some outmigration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006), and in other river systems (Moyle 2002). Some Pacific Lamprey ammocoetes likely spend part of their extended (5 to 7 years) freshwater residence rearing in the Delta, particularly in the upstream, freshwater portions (DWR et al. 2013).

#### 9.3.4.12.2 Aquatic Habitat

Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing reverse flows in channels leading to project export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales as influenced by the region’s dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive or outmigration timing associated with historical peak flows during spring (Moyle 2002).

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions, largely because of the region’s Mediterranean climate, with alternating cool-wet and hot-dry seasons. Currently in the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta because of high summer ambient air temperatures, the increased temperature of river inflows, and to a lesser extent, reduced quantities of freshwater inflow and modified tidal and groundwater hydraulics (Kimmerer 2004, Mount et al. 2012, NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances (e.g., 20 to 25° Centigrade [C]) for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt. This is especially true in parts of the south Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (NRC 2012).

Landscape-scale changes resulting from flood management infrastructure, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al. 2012). The large reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species that have further degraded conditions for native species. Due to the combination of these factors, the Delta appears to have undergone an ecological regime shift unfavorable to many native species (Moyle and Bennett 2008, Baxter et al. 2010). The major species influenced by current Delta hydrology include Delta Smelt, Longfin Smelt, Sacramento Splittail, White Sturgeon, juvenile Chinook Salmon, and Striped Bass (Jassby et al. 1995, Kimmerer 2002, Rosenfield and Baxter 2007, Kimmerer et al. 2009, Fish 2010, Perry et al. 2012, Thomson et al. 2010, Feyrer et al. 2010, Loboschefsky et al. 2012, Mount et al. 2012).

Salinity is a critical factor influencing plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, this varies by species and lifestage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life history stages. Although the Delta is tidally influenced, most of the Delta is fresh water year-round, due to inflows from rivers. The south Delta can have low salinity because of agricultural return water. The tidally influenced low salinity zone can move upstream into the central Delta.

An important measure of the spatial geography of salinity in the western Delta is X2. The X2 has also been correlated with the amount of suitable habitat for Delta Smelt in fall (Feyrer et al. 2007, 2010; USFWS 2008a). It is also helps define the extent of habitat available for oligohaline pelagic organisms and their prey. An analysis of historical monitoring data by Feyrer et al. (2007) revealed that the abiotic habitat of Delta Smelt can be defined as a specific envelope of salinity and turbidity that changes over the course of the species' life cycle. Project operations and other potential factors (e.g., lower outflows) have tended to shift the X2 position in fall farther upstream out of the wide expanse of Suisun Bay into the much narrower channels near the confluence of the Sacramento and San Joaquin rivers (near Collinsville), reducing the spatial extent of low salinity habitat important for relevant species such as Delta Smelt (USFWS 2008a, 2011a; Kimmerer et al. 2009; Baxter et al. 2010). However, there is emerging information suggesting that a comparison of the Delta outflow during pre-project and post-project time periods do not support the conclusion that project operations have significantly moved X2 more easterly in September and October compared to pre-project conditions and project operations have only potentially impacted X2 location in November (Hutton et al. in press).

#### 9.3.4.12.3 Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically in freshwater aquatic environments, phosphorous is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to eutrophication and a suite of problems in aquatic ecosystems, such as low dissolved oxygen concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Van Nieuwenhuyse 2007; Glibert 2010; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which in turn affects fish production and abundance. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh, this appears to result from turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006, Van Nieuwenhuyse 2007, Glibert 2010, Glibert et al. 2014).

There has been a significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity to low levels in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as high levels of ammonium and nitrogen to phosphorus ratio may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al. 2005, 2008b, 2010; Glibert 2010; Glibert et al. 2014). Low and declining primary productivity in the estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

The introductions of two clams from Asia have led to major alterations in the food web in the Delta. *Potamocorbula* is most abundant in the brackish and saline water of Suisun Bay and the western Delta, and *Corbicula* is most abundant in the fresh water of the central Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007, Kimmerer 2002).

Additionally, introduction of the clams led to the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta after its introduction in 1993 (Hennessy and Enderlein 2013). This species is hypothesized to be a low-quality food source and intraguild predator of native and nonnative calanoid copepods (CRA 2005). The clam *Potamocorbula* also has been implicated in the reduction of the native opossum shrimp, a preferred food of Delta native fishes such as Sacramento Splittail and Longfin Smelt (Feyrer et al. 2003). Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Studies on food quality have been relatively limited in the San Francisco Estuary, with even less information on long-term trends. Nonetheless, several studies have documented or suggested the food limitations for aquatic species in the estuary, including zooplankton (Mueller-Solger et al. 2002, Kimmerer et al. 2005), Delta Smelt (Bennett 2005, Bennett et al. 2008), Chinook Salmon (Sommer et al. 2001a), Sacramento Splittail (Greenfield et al. 2008), Striped Bass (Loboschefsky et al. 2012), and Largemouth Bass (Nobriga 2009).

#### 9.3.4.12.4 Turbidity

Turbidity is an important water quality component in the Delta that affects physical habitat through sedimentation and food web dynamics through attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur and the ability of predators to locate prey and for prey to escape predation.

Turbidity has been declining in the Delta, as indicated by sediment data collected by the U.S. Geological Survey since the 1950s (Wright and Schoellhamer 2004), with important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams (*Potamocorbula amurensis*) and other benthic organisms (Kimmerer 2004, Greene et al. 2011). High nutrient loads, coupled with reduced sediment loads and higher water clarity, could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the south Delta during reverse flow conditions in the Old and Middle rivers. Delta Smelt may follow turbid waters into the southern Delta, increasing their proximity to project export facilities and, therefore, their entrainment risk (USFWS 2008a).

#### 9.3.4.12.5 Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. Trends in contaminant loadings and their ecosystem effects are not well understood. Efforts are underway to evaluate direct and indirect toxic effects on the POD fishes of manmade contaminants and natural toxins associated with blooms of *Microcystis aeruginosa*, a cyanobacterium or blue-green alga that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al. 2005, 2008b, 2010.)

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay (see Chapter 6, Surface Water Quality, for additional detail on these constituents). Additional study is needed to avoid increases in mercury exposure resulting from tidal wetlands restoration; methylmercury is produced at a relatively high rate in wetlands and newly flooded aquatic habitats (Davis et al. 2003). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (bass) and sturgeon, as described in Chapter 6, Surface Water Quality. It has not been shown to be a direct problem for fish in the Delta, but studies of other fish summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. With regard to selenium, benthic foragers like diving ducks, sturgeon, and splittail have the greatest risk of selenium toxicity; the invasion of the nonnative bivalves (e.g., *P. amurensis*) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD Progress Report, including a summary of prior studies of contaminants in the Delta. The summary included studies that suggested that phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999).

Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995, Weston et al. 2004). The 2004 Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish (Chinook Salmon and Striped Bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium and sulfates) and trace elements (e.g., chromium, mercury, and selenium) (Saiki et al. 1992).

#### 9.3.4.12.6 Fish Passage and Entrainment

The Delta presents a challenge for anadromous and resident fish during upstream and downstream migration, with its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports. These complex conditions can lead to straying, extended exposure to predators, and entrainment during outmigration. Tidal elevations, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival, which is the subject of extensive research and adaptive management efforts (IRP 2010, 2011). Michel et al. (2010, 2015) used acoustic telemetry to examine survival of late fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. Survival was lowest in the freshwater portion (Delta) and the brackish portion of the estuary relative to survival in the riverine portion of the migration route.

*North Delta Fish Passage and Entrainment*

In the north Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. Marston et al. (2012) studied stray rates for in-migrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates. The DCC, when open, can divert fish as they outmigrate along this route. The opening of the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. In recent years, experimental DCC closures have been scheduled during the fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River hatchery (EBMUD 2012).

Outmigrating juvenile fish moving down the mainstem Sacramento River also can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin river channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Kjelson and Brandes 1989, Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2010, 2012). Steel et al. (2012) found that the best predictor of which route was selected was the ratio of mean water velocity between the two routes. Salmon migration studies show losses of approximately 65 percent for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps Island increased by nearly 50 percent for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile Green Sturgeon, steelhead, and winter and spring-run Chinook Salmon (NMFS 2009a).

However, analysis by Perry et al. (2015) suggests that the mechanisms governing route selection are more complex. Their analysis revealed the strong influence of tidal forcing on the probability of fish entrainment into the interior Delta. The probability of entrainment into both Georgiana Slough and the Delta Cross Channel was highest during reverse-flow flood tides, and the probability of fish remaining in the Sacramento River was near zero during flow reversals (Perry et al. 2015). The magnitude and duration of reverse flows at this river junction decrease as inflow of the Sacramento River increases. Consequently, reduced Sacramento River inflow increases the frequency of reverse flows at this junction, thereby increasing the proportion of fish that are entrained into the interior Delta, where mortality is high (Perry 2010).

Fish passage in the north Delta also can be affected by water quality. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include dissolved oxygen, water temperatures, and, for some species, salinity (e.g., Delta Smelt). For adult Chinook Salmon, dissolved oxygen concentration less than 3 to 5 milligrams per liter (mg/L) can impede migration (Hallock et al. 1970) as can mean daily water temperatures of 21 to 23°C, depending on whether water temperatures are rising or falling (Strange 2010). Dissolved oxygen levels are generally >5 mg/L throughout the Delta, but water temperatures can exceed these thresholds during summer and fall.

The SWP Barker Slough Pumping Plant, located on a tributary to Cache Slough, may cause larval fish entrainment. The intake is equipped with a positive barrier fish screen to prevent fish at least 25 mm in size from being entrained. CDFW has monitored entrainment of larval Delta Smelt less than 20 mm at Barker Slough since 1995. When the presence of Delta Smelt larvae is indicated, pumping rates from Barker Slough are reduced to a 5-day running average rate of 65 cfs, not to exceed a 75-cfs daily average for any day, for a minimum of 5 days and until monitoring shows no Delta Smelt are present.

*Central and South Delta Fish Passage and Entrainment*

The south Delta intake facilities include the CVP and SWP export facilities; local agency intakes, including Contra Costa Water District intakes; and agricultural intakes. Contra Costa Water District intakes and the CVP Contra Costa Canal Pumping Plant include fish screens; however, most of the remaining intakes do not include fish screens. Water flow patterns in the south Delta are influenced by the water diversion actions and operations of the south Delta seasonal temporary barriers and tides and river inflows to the Delta (Kimmerer and Nobriga 2008). Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009). While swimming through southern Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low dissolved oxygen, high water transparency, and *Microcystis* blooms) and slow water velocities in lake-like habitats. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011).

Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook populations. An increase in total exports of 1 standard deviation (SD) from the 1967 to 2010 average was predicted to result in a 68.1 percent reduction in the survival of Deer, Mill, and Butte Creek spring-run Chinook. Similarly, an increase in the ratio of Delta water exports to Delta inflow of 1 SD was expected to reduce survival of the four fall-run populations by 57.8 percent (Cunningham et al. 2015). Although a mechanistic explanation for the reduction in survival remains elusive, "*direct entrainment mortality seems an unlikely mechanism given the success of reclamation and transport procedures, even given increased predation potential at the release site. Changes to water routing may provide a more reasonable explanation for the estimated survival influence of Delta water exports*" (Cunningham et al. 2015). Although not directly comparable, this contrasts with the results of Zeug and Cavallo (2012) that found there was little evidence that large-scale water exports or inflows influenced CWT recovery rates in the ocean from 1993 to 2003.

Delaney et al. (2014) reported on a mark-recapture experiment examining the survival and movement patterns of acoustically tagged juvenile steelhead emigrating through the central and southern Delta. Their results indicated that most tagged steelhead remained in the mainstem San Joaquin River (77.6 percent); however, approximately one quarter (22.4 percent) of them entered Turner Cut. Route-specific survival probability for tagged steelhead using the Turner Cut route was 27.0 percent. The survival probability for tagged steelhead using the Mainstem route was 56.7 percent (Delaney et al. 2014). Travel times for tagged steelhead also differed between these two routes with steelhead using the mainstem route reaching Chipps Island significantly sooner than those that used the Turner Cut route. Travel time was not significantly affected by the limited OMR flow treatments examined in their study. While not significant, there was some evidence that fish movement toward each export facility could be influenced by relative flow entering the export facility (Delaney et al. 2014).

Water from the San Joaquin River mainly moves downstream through the Head of Old River and through the channels of Old and Middle rivers and Grant Line and Fabian-Bell canals toward the south Delta intake facilities. Conversely, when water to the north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the pumps. When the temporary barriers are installed from April through November, internal reverse circulation is created within the channels isolated by the barriers from other portions of the south Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years also reduce the frequency of net downstream flows in the south Delta and mainstem San Joaquin River.

A portion of fish that enter the CVP Jones Pumping Plant approach channel and the SWP Clifton Court Forebay are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. NMFS (2009a) estimates that the direct loss of fish from the screening and salvage process is in the range of 65 to 83.5 percent for fish from the point they enter Clifton Court Forebay or encounter the trash racks at the CVP facilities. Additionally, mark-recapture experiments indicate that most fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in Clifton Court Forebay) (Gingras 1997, Clark et al. 2009, Castillo et al. 2012). Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al. 2002, Kimmerer et al. 2008, Brown et al. 1996). Fish entrainment and salvage are particular concerns during dry years when the distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other migratory fish species shift closer to the project facilities (Stevens et al. 1985, Sommer et al. 1997).

Salvage estimates reflect the number of fish entrained by project exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include prescreen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras 1997, Clark et al. 2009, Castillo et al. 2012). For Delta Smelt, prescreen losses appear to be where most mortality occurs (Castillo et al. 2012). In addition, actual salvage numbers do not include the entrainment of fish larvae, which cannot be collected by the fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta.

The life stage of the fish at which entrainment occurs may be important for population dynamics (IRP 2011). For example, winter entrainment of Delta Smelt, Longfin Smelt, and Threadfin Shad may correspond to migration and spawning of adult fish, and spring and summer exports may overlap with development of larvae and juveniles. The loss of prespawning adults and all their potential progeny may have greater consequences than entrainment of the same number of larvae or juvenile fish. Entrainment risk for fish tends to increase with increased reverse flows in Old and Middle rivers (Kimmerer 2008, Grimaldo et al. 2009).

Research conducted during 2010 and 2011 showed that upriver movements of adult Delta Smelt are achieved through a form of tidal rectification or active tidal transport by using lateral movement to shallow edges of channels on ebb tides to maintain their position (IRP 2010, 2011). Turbidity gradients could be involved in the lateral positioning of Delta Smelt within the channels, but large-scale turbidity pulses through the system may not be necessary to trigger upriver migrations of Delta Smelt if they are already occupying sufficiently turbid water (IRP 2011). The new understanding of potential tidal and turbidity effects on Delta Smelt behavior may have important implications for the Delta Smelt monitoring programs that are the basis for biological triggers for RPA Actions 1 and 2 by understanding the catch efficiency of mid-water trawl data in relation to the lateral positioning of Delta Smelt within channels.

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 centimeter pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta Smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of Delta Smelt measured in the study reflected habitat use by Delta Smelt and relatively small hydrodynamic influence of the diversion.

#### 9.3.4.12.7 Disease

Preliminary results of several histopathological studies have found evidence of significant disease in Delta fish species (Reclamation 2008a). For example, massive intestinal infections with an unidentified myxosporean were found in yellowfin goby collected from Suisun Marsh (Baxa et al. 2013). Studies by Bennett (2005) and Bennett et al. (2008) show that exposure to toxic chemicals may cause liver abnormalities and cancerous cells in Delta Smelt, and stressful summer conditions, warm water, and lack of food may result in liver glycogen depletion and liver damage. Studies of Sacramento Splittail suggest that liver abnormalities in this species are more linked to health and nutritional status than to pollutant exposure (Greenfield et al. 2008).

Additionally, preliminary evidence suggests that contaminants and disease may impair Striped Bass. Studies by Lehman et al. (2010) suggest that the liver tissue and health of Striped Bass and Mississippi Silverside were adversely affected by tumors, particularly at sampling stations where concentrations of tumor-promoting microcystins were elevated. Exposure of Sacramento Splittail and Threadfin Shad to microcystins in experimental diets resulted in severe liver damage; shad also exhibited ovarian necrosis, indicating impairment of health and reproductive potential (Acuna et al. 2012).

In contrast, histopathological and viral evaluation of juvenile Longfin Smelt and Threadfin Shad collected in 2006 indicated no histological abnormalities and no evidence of viral infections or high parasite loads (Foott et al. 2006). Parasites were noted in Threadfin Shad gills at a high frequency, but the infections were not considered severe. Thus, both Longfin Smelt and Threadfin Shad were considered healthy in 2006 (a high-flow year). Adult Delta Smelt collected from the Delta during winter 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Reclamation 2008a). However, there was some evidence of low frequency endocrine disruption. In 2005, 9 of 144 (6 percent) of adult Delta Smelt males were intersex, having immature oocytes in their testes (Reclamation 2008a).

#### 9.3.4.12.8 Nonnative Invasive Species

Nonnative invasive species influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Not all nonnative species are considered invasive[2]. Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad, and Largemouth Bass).

Many nonnative fishes have been introduced into the Delta for sport fishing (game fish such as Striped Bass, Largemouth Bass, Smallmouth Bass, Bluegill, and other sunfish), as forage for game fish (Threadfin Shad, Golden Shiner, and Fathead Minnow), for vector control (Inland Silverside, Western Mosquitofish), for human food use (Common Carp, Brown Bullhead, and White Catfish), and from accidental releases (Yellowfin Goby, Shimofuri Goby, and Shokihaze Goby) (Moyle 2002). Introduced fish may compete with native fish for resources and, in some cases, prey on native species.

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region during the period of monitoring (Matern et al. 2002, Brown and Michniuk 2007, Sommer et al. 2007a, Mount et al. 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al. 2012, Moyle et al. 2012).

#### 9.3.4.12.9 Predation

Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and

[2] DFG (2008) defines "invasive species" as "species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat."

the introduction of nonnative predators, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel 2011). Predation occurs by fish, birds, and mammals, including sea lions. The alternatives considered in this EIS are not anticipated to modify predatory actions of birds and mammals on the focal species. Therefore, the predation discussion is focused on fish predators.

A panel of experts recently convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and dissolved oxygen limitations, and the overall reduction in salmon population size, it was unclear what proportion of the juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Striped Bass, White Catfish, Largemouth Bass and other centrarchids, and silversides are among the introduced, nonnative species that are notable predators of smaller-bodied fish species and juveniles of larger species in the Delta. Along with Largemouth Bass, Striped Bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the primary predator of juvenile and adult Delta Smelt (DWR et al. 2013) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento Pikeminnow may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007), but this does not mean that Sacramento Pikeminnow do not prey on salmonids in the Delta.

Largemouth Bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although Largemouth Bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume pelagic fishes. The increase in salvage of Largemouth Bass occurred during the time period when Brazilian waterweed was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for Largemouth Bass and other species of centrarchids. Largemouth Bass have a much more limited distribution in the estuary than Striped Bass, but a higher per-capita impact on small fishes (Nobriga and Feyrer 2007). Increases in Largemouth Bass may have had a particularly important effect on Threadfin Shad and Striped Bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004, Nobriga and Feyrer 2007).

Invasive Mississippi silversides are another potentially important predator of larval and pelagic fishes in the Delta. This introduced species was not believed to be an important predator on Delta Smelt, but recent studies using DNA techniques detected the presence of Delta Smelt in the guts of 41 percent of Mississippi silversides sampled in mid-channel trawls (Baerwald et al. 2012). This finding may suggest that predation impacts could be significant, given the increasing numbers of Mississippi silversides in the Delta.

Predation of fish in the Delta is known to occur in specific areas, for example at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). Sabal (2014) found similar results at Woodbridge Dam on the Mokelumne River where the dam was associated with increased Striped Bass per capita salmon consumption and attracted larger numbers of Striped Bass, decreasing migrating juvenile salmon survival by 10 to 29 percent. DFG (1992) identified subadult Striped Bass as the major predatory fish in Clifton Court Forebay. In 1993, for example, Striped Bass made up 96 percent of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook Salmon in the south Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts. Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012).

#### 9.3.4.12.10 Aquatic Macrophytes

Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and dissolved oxygen fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two nonnative invasive aquatic plants, water hyacinth and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access by native juvenile fish to shallow water habitat. Additionally, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators, such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as Delta Smelt, Chinook Salmon, and Sacramento Splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012; Nobriga et al. 2005).

Invasive aquatic macrophytes are still equilibrating within the Delta and resulting habitat changes are ongoing, with negative impacts on habitats and food webs of native fish species (Toft et al. 2003, Grimaldo et al. 2009). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand.

#### *9.3.4.13 Yolo Bypass*

The Yolo Bypass conveys flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, Sutter Bypass, and west side streams

The Yolo Bypass provides habitat for a wide variety of fish and aquatic species, including temporary migration corridors and juvenile rearing habitat for anadromous salmonids and other native and anadromous fishes. Species captured as adults and subsequently collected as YOY suggest that the Yolo Bypass provides spawning habitat for these species, including splittail, American Shad, Striped Bass, Threadfin Shad, Largemouth Bass and carp (Harrell and Sommer 2003, Sommer et al. 2014). The Yolo Bypass lacks suitable gravel substrate that would support salmon spawning.

##### 9.3.4.13.1 Aquatic Habitat

Aquatic habitats in the Yolo Basin include stream and slough channels for fish migration, and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001a; CALFED 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook Salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al. 2001a, 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001a). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of greater availability of invertebrate prey in the floodplain (Sommer et al. 2001a, 2005). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex (McLain and Castillo; DWR, unpublished data).

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento Splittail. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, seasonal inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004, Lehman et al. 2008a).

#### 9.3.4.13.2 Fish Passage

The Fremont Weir is a major impediment to fish passage and a source of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (NMFS 2009a, Sommer et al. 2014). The Fremont Weir creates a migration barrier for a variety of species, although fish with strong jumping capabilities such as salmonids may be able to pass the weir at higher flows. Although there is a fish ladder maintained by CDFW at the center of the weir, the ladder is small, outdated, and inefficient. Additionally, there are no facilities at the weir to pass upstream migrants at lower flows. Some adult winter-run, spring-run, and fall-run Chinook Salmon and White Sturgeon migrate into Yolo Bypass when there is no flow into the floodplain via the Fremont Weir. Therefore, these fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003, Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Toe Drain, Lisbon Weir, and irrigation dams in the northern end of the Tule Canal, also may impede upstream passage of adult anadromous fish (NMFS 2009a).

Fish are also attracted into the bypass during periods when water is not flowing over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003, Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is blocked by roads or other higher ground at several locations. Sturgeon and salmonids attracted by high flows into the basin become concentrated behind the Fremont Weir, where they are subject to heavy legal and illegal fishing pressure.

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (NMFS 2009a, Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon outmigrated off the floodplain as it drained.

### *9.3.4.14 Suisun Marsh*

Suisun Bay and Marsh are ecologically linked with the central Delta, although with different tidal and salinity conditions than found upstream. Suisun Bay and Marsh are the largest expanse of remaining tidal marsh habitat within the greater San Francisco Bay-Delta ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

#### 9.3.4.14.1 Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. Most of its marsh area consists of diked wetlands managed for waterfowl, with the rest of the acreage consisting of tidally influenced sloughs (Suisun Ecological Workgroup 2001). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats also are found in the waters of Suisun Bay.

Tides reach Suisun Bay and Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Although the fish assemblages in Suisun Bay and Marsh can differ substantially from the fish assemblages in the Delta, all the species that use the Delta also use Suisun Bay and Marsh.

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with higher turbidity known as the estuarine turbidity maximum. Burau et al. (2000) reports that the estuarine turbidity maximum occurs near the Benicia Bridge and in Suisun Bay near Garnet Point on Ryer Island. Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Bay and Marsh system is a major water quality characteristic that strongly influences physical and ecological processes. Fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001; Kimmerer 2004; Feyrer et al. 2007, 2010; Nobriga et al. 2008). The Suisun Bay and Marsh usually contain both the maximum estuarine salinity gradient and the low salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Marsh. The location of the low salinity zone gradient and X2 can be influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater discharges from the upper sloughs and wastewater effluent.

The Suisun Bay and Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but, like the Delta, these habitats also have been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic habitat were identified as part of the Suisun Marsh Plan development process and were defined using physical boundaries; habitats include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal habitats total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs, with major sloughs of Suisun Marsh having a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open-water tidal areas for breeding, foraging, rearing, or migrating.

#### 9.3.4.14.2 Fish Entrainment

Several facilities have been constructed by DWR and Reclamation to provide lower-salinity water to managed wetlands in the Suisun Marsh, including the Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the Roaring River Distribution System is screened to prevent entrainment of fish larger than approximately 25 mm (approximately 1 inch). DWR monitored fish entrainment from September 2004 to June 2006 at the Morrow Island Distribution System to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on Delta Smelt and salmonids. Over 20 species were identified during the sampling, but only 2 fall-run-sized Chinook Salmon (at the South Intake in 2006) and no Delta Smelt from entrained water were caught (Reclamation 2008a). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (Reclamation 2008a). Conical fish screen have been installed on the Lower Joice Island diversion on Montezuma Slough.

### *9.3.4.15 San Joaquin River from Confluence of the Stanislaus River to the Delta*

Since the construction of Friant Dam, significant changes in physical (fluvial geomorphic) processes and substantial reductions in streamflows in the San Joaquin River have occurred, resulting in large-scale alterations to the river channel and associated aquatic, riparian, and floodplain habitats. Throughout the area, there are physical barriers, reaches with poor water quality or no surface flow, and false migration pathways that have reduced habitat connectivity for anadromous and resident native fishes (Reclamation and DWR 2011). As a result, there has been a general decline in both the abundance and distribution of native fishes, with several species extirpated from the system (Moyle 2002).

Moyle (2002) reported that of the 21 native fish species historically present in the San Joaquin River, at least 8 are now uncommon, rare, or extinct. The deep-bodied fish assemblage (e.g., Sacramento Splittail, Sacramento Blackfish) has been replaced by nonnative species like carp and catfish.

The San Joaquin River from the Stanislaus River to the Delta is dominated by nonnative species such as Largemouth Bass, Inland Silverside, carp, and several species of sunfish and catfish (Moyle 2002). Anadromous species include fall-run Chinook Salmon, steelhead, Striped Bass, American Shad, White Sturgeon, and several species of lamprey (Reclamation et al. 2003). The fall-run Chinook

Salmon population is supported in part by hatchery stock in the Merced River. Spawning by anadromous salmonids in the San Joaquin River Basin occurs only in the tributaries to the San Joaquin River, including the Merced, Tuolumne, and Stanislaus rivers (Brown and Moyle 1993). Spring-run Chinook Salmon no longer exist in the San Joaquin River, but are targeted for restoration in this system under Reclamation's San Joaquin River Restoration Program. In early 2015, the program experimentally released juvenile spring-run Chinook Salmon into the San Joaquin River near the Merced River. Surviving adults may return to the San Joaquin River as early as spring 2017. Because of the uncertainty of future restoration success and the current lack of natural presence in the San Joaquin River, spring-run Chinook Salmon is not included in the analysis of San Joaquin River fish.

#### 9.3.4.15.1 Fish in the San Joaquin River

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Fall-run Chinook Salmon are present in the San Joaquin River and its major tributaries upstream to and including the Merced River. Spawning and rearing occur in the major tributaries (Merced, Tuolumne, and Stanislaus rivers) downstream of the mainstem dams. Weir counts in the Stanislaus River suggest that adult fall-run Chinook Salmon in the San Joaquin River Basin typically migrate into the upper rivers between late September and mid-November and spawn shortly thereafter (Pyper et al. 2006; Anderson et al. 2007; FISHBIO 2010a, 2011).

The San Joaquin River downstream of the Stanislaus River primarily provides upstream passage for adult fall-run Chinook Salmon and downstream passage for juveniles and smolts as they outmigrate from the tributary spawning and rearing areas to the Delta to the Pacific Ocean. The juvenile fall-run Chinook Salmon outmigration in the San Joaquin River Basin typically occurs during winter and spring, extending primarily from January through May. The outmigration consists primarily of fry in winter and smolts in spring (FISHBIO 2007, 2013). Trawl sampling in the lower San Joaquin River from Mossdale to the Head of Old River (the Mossdale Trawl) captures Chinook Salmon from February into July, with peak catches generally during April and May (Speegle et al. 2013).

*Steelhead*

Steelhead were historically present in the San Joaquin River, though data on their population levels are lacking (McEwan 2001). The current steelhead population in the San Joaquin River is substantially reduced compared with historical levels, although resident Rainbow Trout occur throughout the major San Joaquin River tributaries. Additionally, small populations of steelhead persist in the lower San Joaquin River and tributaries (e.g., Stanislaus, Tuolumne, and possibly the Merced rivers) (Zimmerman et al. 2009, McEwan 2001). Steelhead/Rainbow Trout of anadromous parentage occur at low numbers in all three major San Joaquin River tributaries. These tributaries have a higher percentage of resident Rainbow Trout compared to the Sacramento River and its tributaries (Zimmerman et al. 2009).

Presence of steelhead smolts from the San Joaquin River Basin is estimated annually by CDFW based on the Mossdale Trawl (SJRGA 2011). The sampling trawls capture steelhead smolts, although usually in small numbers. One steelhead smolt was captured and returned to the river during the 2009 sampling period (SJRGA 2010), and three steelhead were captured and returned in both 2010 and 2011 (Speegle et al. 2013).

*Sacramento Splittail*

Historically, Sacramento Splittail were widespread in the San Joaquin River and found upstream to Tulare and Buena Vista lakes, where they were harvested by native peoples (Moyle et al. 2004). Today, Sacramento Splittail likely ascend the San Joaquin River to Salt Slough during wet years (Baxter 1999). During dry years, Sacramento Splittail are uncommon in the San Joaquin River downstream of the Tuolumne River (Moyle et al. 2004). Most spawning takes place in the flood bypasses, along the lower reaches of the Sacramento and San Joaquin rivers and major tributaries, and lower Cosumnes River and similar areas in the western Delta.

Most juveniles apparently move downstream into the Delta from April to August (Meng and Moyle 1995). Factors influencing the Sacramento Splittail population are unclear, but the population is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Moyle et al. 2004). Other factors that may influence the San Joaquin River portion of the population include flood control, entrainment by diversion, recreational fishing, pollutants, and nonnative species (Moyle et al. 2004).

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed anadromous species found in accessible reaches of the San Joaquin River and many of its tributaries.

Data from mid-water trawls in the lower San Joaquin River near Mossdale indicate that adults likely migrate into the San Joaquin River in spring and early summer (Hanni et al. 2006). In other large river systems, the initial adult migration from the ocean generally stops in summer, and Pacific Lampreys hold until the following winter or spring before undergoing a secondary migration to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012). Midwater trawl surveys in the San Joaquin River suggest that peak ammocoete outmigration occurs in January and February (Hanni et al. 2006).

Little information is available on factors influencing Pacific Lamprey in the San Joaquin River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles. Lack of access to historical spawning habitats because of the mainstem dams and other migration barriers, modification of spawning and rearing habitats, altered hydrology, entrainment by water diversions, and predation by nonnative invasive species such as Striped Bass all likely influence Pacific Lamprey in the San Joaquin River and tributaries.

*Striped Bass*

Striped Bass are regularly found in San Joaquin River tributaries, including in lower mainstem deep pools of the Stanislaus and Tuolumne rivers (e.g., Anderson et al. 2007). Ainsley et al. (2013) reported that Striped Bass were collected at two locations between the Head of the Old River and the mouth of the Stanislaus River on the mainstem San Joaquin River in May.

*American Shad*

Little is known about American Shad populations inhabiting the San Joaquin River. American Shad may spawn in the San Joaquin River system, but their abundance is unknown. Sport fishing for American Shad occurs seasonally in the San Joaquin River.

*Sturgeon*

Little is known about White Sturgeon populations inhabiting the San Joaquin River. Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning, then migrate upstream to spawn in response to higher flows (Schaffter 1997, McCabe and Tracy 1994). Based on tag returns from White Sturgeon tagged in the Sacramento-San Joaquin Estuary and recovered by anglers, Kohlhorst et al. (1991) estimated that over 10 times as many White Sturgeon spawn in the Sacramento River as in the San Joaquin River.

CDFW fisheries catch information for the San Joaquin River obtained from fishery report cards (DFG 2008b, 2009b, 2010, 2011, 2012b; CDFW 2013, 2014) documented that anglers upstream of Highway 140 caught between 8 and 25 mature White Sturgeon annually between 2007 and 2013. Below Highway 140 downstream to Stockton, anglers caught between 2 and 35 mature White Sturgeon annually over the same time period; most of the White Sturgeon caught were released.

White Sturgeon spawning in the San Joaquin River was documented for the first time in 2011 and confirmed in 2012. Viable White Sturgeon eggs were collected in 2011 at one sampling location downstream of Laird Park (Gruber et al. 2012) and in 2012 at four sampling locations generally between Laird Park and the Stanislaus River confluence (Jackson and Van Eenennaam 2013). Although the majority of sturgeon likely spawn in the Sacramento River, the results of these surveys confirm that White Sturgeon do spawn in the San Joaquin River in both wet- and dry-year conditions and may be an important source of production for the White Sturgeon population in the Sacramento-San Joaquin river system.

Green Sturgeon are also present in the San Joaquin River, but at considerably lower numbers than White Sturgeon. Between 2007 and 2012, anglers reported catching six Green Sturgeon in the San Joaquin River (Jackson and Van Eenennaam 2013). Although the reported presence of Green Sturgeon in the San Joaquin River coincides with the spawning migration period of Green Sturgeon within the Sacramento River, no evidence of spawning has been detected (Jackson and Van Eenennaam 2013).

#### 9.3.4.15.2 Aquatic Habitat

Aquatic habitat conditions vary spatially and temporally throughout the lower San Joaquin River because of differences in habitat availability and connectivity, water quantity and quality (including water temperature), and channel morphology.

Downstream of the Stanislaus River confluence, the San Joaquin River is more sinuous than upstream reaches and contains oxbows, side channels, and remnant channels. It conveys the combined flows of the major tributaries, including the Merced, Tuolumne, Stanislaus, and Calaveras rivers. Flood control levees closely border much of the river but are set back in places, creating some off-channel aquatic habitat areas when inundated (Reclamation and DWR 2011). The channel gradient in this portion of the San Joaquin River is low, and the lack of gravel or coarser substrate precludes spawning by salmonids.

#### 9.3.4.15.3 Fish Passage

In the reach of the river downstream of the confluence of the Stanislaus River, fish encounter passage challenges associated with water diversions, and adult salmon migrating upstream from the Delta also may encounter prohibitively high stream temperatures that delay migration until temperatures decline (McBain and Trush 2002). Installation of seasonal barriers in the Delta also can impair fish passage.

#### 9.3.4.15.4 Hatcheries

No hatcheries in the San Joaquin River Basin are affected by CVP or SWP operations. The Merced River Hatchery, located on the Merced River, is operated by CDFW to supplement the fall-run Chinook Salmon population. It is not included in the CVP or SWP service areas. As part of the San Joaquin River Restoration Program, CDFW has begun operation of a conservation hatchery downstream of Friant Dam to produce spring-run Chinook Salmon (Reclamation and DWR 2010).

#### 9.3.4.15.5 Predation

Recent studies of predation in the San Joaquin River are limited to the major tributaries, where largemouth and Smallmouth Bass have been identified as the most important predators of juvenile Chinook Salmon (McBain and Trush and

Stillwater Sciences 2006). Striped Bass also have been identified as salmon predators, though recent evidence for the San Joaquin River is lacking.

#### *9.3.4.16 New Melones Reservoir, Tulloch Reservoir, and Goodwin Dam*

The north, middle, and south forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010b). Downstream of Tulloch Reservoir, the Stanislaus River flows through the reservoir formed by Goodwin Dam and then approximately 40 miles to the confluence with the San Joaquin River.

New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus and San Joaquin rivers and is operated by Reclamation. New Melones Reservoir is an artificial environment and does not support a naturally evolved aquatic community. Most of the species in the reservoir were introduced, although a few native species may still be present. From a fisheries perspective, recreational fishing is the most important use of New Melones Reservoir. Fish species in New Melones Reservoir include Rainbow Trout, Brown Trout, Largemouth Bass, sunfishes such as Black Crappie and Bluegill, and three species of catfish (Reclamation 2010b). Rainbow Trout, Brown Trout, and large Channel Catfish are generally restricted to colder, deeper water during summer, when New Melones Reservoir has two distinct thermal layers of water, although large Brown Trout and Channel Catfish are found in shallow water near steep banks at night when they ascend to feed.

Tulloch Reservoir is operated as an afterbay for the New Melones Reservoir and is subject to fluctuating water levels that occur on a daily and seasonal basis. Tulloch Reservoir stratifies weakly during summer and contains a reserve of relatively cold, well-oxygenated water that is released downstream. Tulloch Reservoir supports both warm and cold freshwater habitat. Goodwin Power (2013) reported that DFG captured 15 species in Tulloch Reservoir from 1969 through 1998. Five dominant species made up almost 80 percent of the catch; White Catfish (31 percent of the total), Bluegill (20 percent), Sacramento Sucker (11 percent), Smallmouth Bass (10 percent), and Black Crappie (7 percent). Of these, only the Sacramento Sucker is native. Other native species in the catch were Sacramento Hitch, Hardhead, Sacramento Pikeminnow, and Rainbow Trout (now stocked). Other nonnative fish found in Tulloch reservoir include Largemouth Bass and Threadfin Shad (DFG 2002b).

Little information exists regarding aquatic resources in the reservoir formed by Goodwin Dam. It is assumed that fish assemblies are similar to those described for Tulloch Reservoir.

#### *9.3.4.17 Stanislaus River from Goodwin Dam to the San Joaquin River*

##### 9.3.4.17.1 Fish in the Stanislaus River

Steelhead and fall-run Chinook Salmon currently occur in the lower Stanislaus River. Historically, spring-run Chinook Salmon were believed to be the primary salmon run in the Stanislaus River. Native spring-run Chinook salmon have been extirpated from all tributaries in the San Joaquin River Basin, which represents a large portion of their historic range and abundance (NMFS 2014b). Other anadromous fish species that occur in the lower Stanislaus River include Striped Bass, American Shad, and an unidentified species of lamprey (SRFG 2003). The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Data collected by private fishery consultants, nonprofit organizations, and DFG demonstrate the majority of fall-run Chinook Salmon adults migrate upstream from late September through December with peak migration from late October through early November. Most Chinook Salmon spawning occurs between Riverbank (River Mile 33) and Goodwin Dam (River Mile 58.4) (Reclamation 2012b). Based on redd surveys conducted by FISHBIO, peak spawning typically occurs in November with roughly 7 percent of spawning occurring prior to November 1, and 2 percent prior to October 15. The few redds created during late September and early October are typically in the reach just below Goodwin Dam. By late October, the amount of spawning in downstream locations increases as water temperatures decrease, and the median redd location is typically around Knights Ferry (SWRCB 2015).

In 2010, over 20 percent of the fall-run Chinook Salmon observed passing the Stanislaus River weir had adipose fin clips, indicating the presence of a coded-wire-tag (CWT) in their snout. Since there is no hatchery on the Stanislaus River and no hatchery releases have been conducted into this tributary since 2006, it is apparent that straying from other rivers is occurring (FISHBIO 2010b).

Rotary screw trap data indicate that about 99 percent of salmon juveniles migrate out of the Stanislaus River from January through May (SRFG 2004). Fry migration generally occurs from January through March, followed by smolt migration from April through May (Reclamation 2012). Watry et al. (2012) found that in both 2010 and 1011, peak passage during the pre-smolt period generally corresponded with flow pulses. Zeug et al. (2014) examined 14 years of rotary screw trap data on the lower Stanislaus River and found a strong positive response in survival, the proportion of pre-smolt migrants and the size of smolts when cumulative flow and flow variance were greater and concluded that the data suggested that periods of high discharge in combination with high discharge variance are important for successful emigration as well as migrant size and the maintenance of diverse migration strategies.

Mesick (2001) surmised that when water exports are high relative to San Joaquin River flows, little, if any, San Joaquin River water reaches San Francisco Bay where it may be needed to help attract the salmon back to the Stanislaus River. During mid-October from 1987 through 1989, when export rates exceeded

400 percent of Vernalis flows, Mesick (2001) found that straying rates ranged between 11 and 17 percent. In contrast, straying rates were estimated to be less than 3 percent when Delta export rates were less than about 300 percent of San Joaquin River flow at Vernalis during mid-October.

One of the limiting factors appears to be the high rates of mortality for juveniles migrating through dredged channels in the Stanislaus River and Delta, particularly the Stockton Deep Water Ship Channel (Newcomb and Pierce 2010). Pickard et al. (1982) reported that the survival of juvenile fish in the deep-water ship channel is highest during flood flows or when a barrier is placed at the head of the Old River that more than doubles the flow in the ship channel. The Stanislaus River Fish Group (SRFG) (2004) noted that escapement is also directly correlated with springtime flows when each brood migrates downstream as smolts. However, the cause of the mortality in the ship channel has not been studied. It is possible that mortality results from the combined effects of warm water temperatures, low dissolved oxygen concentrations, ammonia toxicity, and predation.

As discussed earlier, dredging for gravel and gold, regulated flows, and the diking of floodplains for agriculture have substantially limited the availability of spawning and rearing habitat for fall-run Chinook Salmon. Reclamation has conducted spawning gravel augmentation to improve spawning and rearing habitats in the reach between Goodwin Dam and Knights Ferry most years since 1999. The dredged areas also contain an abundance of large predatory fish, although the SRFG concluded that there is uncertainty about whether predation is a substantial source of mortality for juvenile salmon.

The SRFG also concluded that water diversions for urban and agricultural use in all three San Joaquin River tributaries, which reduce flows and potentially result in unsuitably warm water temperatures during spring and fall, affect fall-run Chinook Salmon juvenile rearing and adult and juvenile migration in the lower San Joaquin River and Delta.

*Steelhead*

Steelhead were thought to be extirpated from the San Joaquin River system (NMFS 2009a). However, monitoring has detected small self-sustaining (i.e., non-hatchery origin) populations of steelhead in the Stanislaus River and other streams previously thought to be devoid of steelhead (SRFG 2003, McEwan 2001). There is a catch-and-release steelhead fishery in the lower Stanislaus River between January 1 and October 15. Surveys of *O. mykiss* (resident trout and the anadromous steelhead) abundance and distribution conducted annually since 2009 have documented a relatively stable population. River-wide abundance estimates from 2009 to 2014 have averaged just over 20,220 (all life stages combined) and have never been estimated to be less than about 14,000 (2009). The highest densities and abundances of *O. mykiss* are consistently found in Goodwin Canyon. Key factors that may contribute to higher-than average abundances in the Stanislaus River (relative to other San Joaquin River tributaries) include high gradient reaches that are typically associated with higher amount of fast-water habitats, particularly in Goodwin Canyon (SWRCB 2015).

Historically, the distribution of steelhead extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Steelhead currently can migrate more than 58 miles up the Stanislaus River to the base of Goodwin Dam. In the Stanislaus River, there is little data regarding the migration patterns of adult steelhead since adults generally migrate during periods when river flows and turbidity are high making fish difficult to observe with standard adult monitoring techniques. Stanislaus River weir data indicate that steelhead migrate upstream, through the South Delta and lower San Joaquin river, between September and March with numbers ranging from 6 to 85[3] between 2008-2011 and 2013 (Reclamation 2014e). High Delta export rates relative to San Joaquin River flows at Vernalis, when adults are migrating through the Delta (presumably December through May), may result in adults straying to the Sacramento River Basin.

It is believed that steelhead spawn primarily between December and March in the Stanislaus River. Although steelhead few steelhead spawning surveys have been conducted in the Stanislaus, spawning *O. mykiss* were documented between Goodwin Dam and Horseshoe Bar in a 2014 spawning survey (Reclamation and DWR 2015). The spawning adults require holding and feeding habitat with cover adjacent to suitable spawning habitat. These habitat features are relatively rare in the lower Stanislaus River because of in-river gravel mining and the scouring of gravel from riffles in Goodwin Canyon.

Juvenile steelhead rear in the Stanislaus River for at least 1 year, and usually 2 years, before migrating to the ocean. As a result, flow, water temperature, and dissolved oxygen concentration in the reach between Goodwin Dam and the Orange Blossom Bridge (their primary rearing habitat) are critical during summer (Reclamation 2012b).

Small numbers of steelhead smolts have been captured in rotary screw traps at Caswell State Park and near Oakdale (FISHBIO 2007; Watry et al. 2007, 2012), and data indicate that steelhead outmigrate primarily from February through May. Rotary screw traps are generally not considered efficient at catching fish as large as steelhead smolts, and the number captured is too small to estimate capture efficiency, so no steelhead smolt outmigration population estimate has been calculated. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles might migrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial (they migrate within fresh water). Resident populations of steelhead/rainbow in large streams are typically fluvial, and migratory juveniles look much like smolts.

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed anadromous species that inhabits accessible reaches of the Stanislaus River (SRFG 2003). Limited information on Pacific Lamprey status in the Stanislaus River exists, but the species has

[3] Numbers presented are for all *O. mykiss* passing upstream of the Stanislaus Weir and do not differentiate between adult steelhead and resident rainbow trout that are moving within the river; therefore, actual numbers of steelhead may be lower than those presented.

experienced loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins (Moyle et al. 2009). Little information is available on factors influencing Pacific Lamprey populations in the Stanislaus River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adults likely migrate into the Stanislaus River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lampreys spawning in the American River from between early January and late May, with peak spawning typically in early April. Spawning time is presumably similar in the Stanislaus River. Pacific Lamprey ammocoetes are expected to rear in the Stanislaus River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Mokelumne and Tuolumne rivers suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006). Catches of juvenile Pacific Lampreys in trawl surveys of the mainstem San Joaquin River, near the mouth of the Stanislaus River at Mossdale, occurred during winter and spring. Some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006). Significant numbers of lampreys of unknown species and unspecified life stage have been captured during rotary screw trapping on the Stanislaus River at Oakdale (FISHBIO 2007) and Caswell (Watry et al. 2007).

*Striped Bass*

Striped Bass occur in the Stanislaus River, and they support a sport fishery when adult fish migrate upstream to spawn. Striped Bass have been observed at Lovers Leap and at Knights Ferry from May through the end of June. These adult fish were observed in all habitats (USFWS 2002, Kennedy and Cannon 2005). The distribution of Striped Bass in the Stanislaus River is thought to be limited to downstream of the historic Knights Ferry Bridge due to a set of falls about 3 feet tall in the area (USFWS 2002).

*American Shad*

American Shad migrate up the Stanislaus River to spawn in the late spring and support a sport fishery during that period. American Shad have been observed on occasion from June through July at Lovers Leap (USFWS 2002, Kennedy and Cannon 2005). American Shad were found primarily in the faster habitats and were observed in schools of 20 or more (USFWS 2002).

#### 9.3.4.17.2 Aquatic Habitat

Schneider et al. (2003) conducted hydrologic analysis of the Stanislaus River and found that New Melones Dam (built in 1979) and more than 30 smaller dams cumulatively impound 240 percent of average annual unimpaired runoff. Schneider et al. (2003) concluded that this has reduced winter floods and spring snow melt runoff, and increased summer base flows to supply irrigation demand. As a result, the frequency and extent of overbank flooding has been reduced.

Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel had incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled.

With respect to the related need for geomorphic flows, Kondolf et al. (2001) estimated bedload mobilization flows in the Stanislaus River to be around 5,000 to 8,000 cfs to mobilize the median particle size of the channel bed material. Flows necessary to mobilize the bed material increased downstream from a minimal 280 cfs where gravel had been recently added near Goodwin Dam to about 5,800 cfs at Oakdale Recreation Area (Reclamation 2008a). Before construction of New Melones Dam, a bed-mobilizing flow of 5,000 to 8,000 cfs was equivalent to a 1.5- to 1.8-year return interval flow. Following construction of the dam, 5,000 cfs represents approximately a 5-year return interval flow, and 8,000 cfs exceeds all flows within the 21-year study period, 1979 to 1999 (maximum flow = 7,350 cfs on January 3, 1997). The probability of occurrence for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is 0.01 per year.

Low dissolved oxygen (DO) levels have been measured in the San Joaquin River, in particular in the Deep Water Ship Channel (DWSC) from the Port of Stockton seven miles downstream to Turner Cut (Lee and Jones-Lee 2003). These conditions are the result of increased residence time of water combined with high oxygen demand in the anthropogenically modified channel, which leads to DO depletion, particularly near the sediment-water interface (SJTA 2012). Despite these conditions, adult salmon and steelhead migration does not appear to be adversely impacted (Pyper et. al 2006). However, during the 1960s, Hallock et al. (1970) found that adult radio-tagged Chinook Salmon delayed their upstream migration whenever dissolved oxygen concentrations were less than 5 mg/L at Stockton. SWRCB D-1422 requires water to be released from New Melones Reservoir to maintain dissolved oxygen standards in the Stanislaus River, as described in Chapter 6, Surface Water Quality. It has been shown that low DO conditions in the San Joaquin River can be ameliorated somewhat through installation of the Head of the Old River Barrier which increases San Joaquin River flows (SJTA 2012).

*Spawning and Rearing Habitat*

Upstream dams have suppressed channel-forming flows that replenish spawning beds in the Stanislaus River (Kondolf et al. 1996). The physical presence of the dams impedes normal sediment transportation processes. Kondolf (et al. 2001) identified levels of sediment depletion at 20,000 cubic yards per year as a result of a variety of factors, including mining, and geomorphic processes associated with past and ongoing dam operations. In 2011, 5,000 tons of gravel were placed in Goodwin Canyon downstream of Goodwin Dam, of which around 70 percent was transported into nearby downstream areas during high flows (SOG 2012).

Extensive instream gravel mining removed large quantities of spawning habitat (Kondolf et al. 2001). Gravel mining also has resulted in instream mine pits that occur in the primary salmonid spawning areas, including a large, approximately

1-mile-long pit called the Oakdale Recreation Pond. Instream mine pits trap bedload sediment, store large volumes of sand and silt, and pass sediment-starved water downstream, where it typically erodes the channel bed and banks to regain its sediment load (Kondolf et al. 2001). Reclamation restores and replenishes spawning gravel and rearing habitat lost from the construction and operation of dams in the Stanislaus River to restore spawning habitat and remediate sediment related loss of geomorphic function, such as channel incision.

*Floodplain Habitat*

Kondolf et al. (2001) identified that floodplain terraces and point bars inundated before operation of New Melones Reservoir have become fossilized with fine material and thick riparian vegetation that is never rejuvenated by scouring flows. Channel forming flows in the 8,000-cfs range have occurred only twice since New Melones Reservoir began operation 28 years ago.

Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled. Without inundation, the floodplains cannot provide terrestrial food for juvenile salmon or organic matter that helps produce more food within the river. Increased flows required for inundation also have had the effect of further isolating floodplains from the channel, leading to the loss of floodplain habitats.

In 2011, a habitat restoration project to increase spawning habitat also restored 640 feet of remnant side channel habitat, allowing water to flow at the current 1.5-year return interval (575 cfs), in addition to three cross channels designed to inundate at higher flows (SOG 2011).

#### 9.3.4.17.3 Fish Passage and Entrainment

Constructed in 1913, Goodwin Dam was probably the first permanent barrier to significantly affect anadromous fish access to upstream habitat in the Stanislaus River. Goodwin Dam had a fishway, but Chinook Salmon could seldom pass it, and other salmonids may have been similarly affected. Yoshiyama et al. (1996) estimated that historically Chinook Salmon and other salmonids had access to 113 miles of habitat, compared with 58 miles under current conditions.

There are numerous small, unscreened diversions on the lower Stanislaus River (Herren and Kawasaki 2001). The effects of these diversions on fish is not clear; however, in tracking the fate of 49 radio tagged fish, S.P. Cramer and Associates (1998) did not detect any entrainment at several moderately sized unscreened pumps in the lower Stanislaus River.

#### 9.3.4.17.4 Predation

Areas of the Stanislaus River, including spawning riffles in the active channel, were mined for gravel and gold primarily between 1940 and 1970. The mined areas consist of long, deep ditches and large ponds that provide habitat for predators, such as Striped Bass, Sacramento Pikeminnow, Largemouth Bass, and Smallmouth Bass (Mesick 2002). Studies by S.P. Cramer and Associates (1998) documented predation on juvenile salmonids by bass in the Tuolumne and Stanislaus rivers. However, in its review of information, the SRFG (2004) concluded that the available studies and observations suggest that fish predators in the Stanislaus River may be limited to adult pikeminnow and Riffle Sculpin feeding on newly emerged fry, whereas Smallmouth Bass, Largemouth Bass, and possibly American Shad probably feed on relatively few parr that remain in the river during late spring and summer when water temperatures are high.

It is possible that predation is high for juveniles rearing in the deep-water ship channel in the Delta as observed by Pickard et al. (1982). Predation rates on hatchery-reared juveniles and tagged juveniles may be higher than those for naturally produced fish. TID/MID (1992, 2013), and TRTAC et al. (2006), have documented predation on salmonids by nonnative predatory fishes in the Tuolumne River, primarily in run-of-river gravel mining ponds and dredged areas. Sonke and Fuller (2012) reported the number of juvenile Chinook Salmon passing the rotary screw traps at Waterford (2006 to 2012) and Grayson (1995 to 2012) on the Tuolumne River. FISHBIO (2013) calculated the potential consumption of juvenile Chinook Salmon by predators in the reach between the Waterford and Grayson rotary screw traps in 2012 and found that consumption of juvenile Chinook Salmon in this reach could equal or exceed the number passing the Waterford trap. Based on their consumption calculations and the difference in estimated numbers of juvenile Chinook Salmon passing the Waterford and Grayson rotary screw traps, FISHBIO (2013) concluded that it is plausible that the majority of juvenile Chinook Salmon losses in this reach are due to predation. NMFS (2009a) noted that losses on the Stanislaus River have not been similarly quantified, but predation on fall-run Chinook Salmon smolts and steelhead by Striped Bass and Largemouth Bass has been documented.

#### *9.3.4.18 San Luis Reservoir*

San Luis Reservoir is located at the base of the foothills on the west side of the San Joaquin Valley in Merced County, as described in Chapter 5, Surface Water Resources and Water Supplies. Water from the Delta is delivered to San Luis Reservoir via the California Aqueduct and Delta-Mendota Canal for storage.

San Luis Reservoir and O’Neill Forebay support several species of fish that have become established within the system, either by direct introduction or from the Delta system via pumping from the California Aqueduct and Delta-Mendota Canal. Striped Bass are the predominant species in San Luis Reservoir (DWR 1987) and support a recreational fishery. Other species include Sacramento Blackfish, American Shad, Threadfin Shad, Largemouth Bass, Kokanee Salmon, Green Sunfish, Bluegill, White Sturgeon, and White Crappie.

There are no sensitive fish species in the San Luis Reservoir except, possibly, individuals entrained by the CVP and SWP projects in the Delta. These individuals have already been lost to their populations, as they cannot return to the Delta once entrained. Potentially occurring fish species with special status that may have been imported from the Delta include Chinook Salmon, Delta Smelt, Hardhead, and Sacramento Splittail (Reclamation and CSP 2013).

## 9.3.5 San Francisco Bay Area Region

Fish and aquatic habitat resources in the San Francisco Bay Area Region include habitat through San Francisco Bay and along the Pacific Ocean coast. The anadromous fish species discussed above use the Pacific Ocean as part of their life cycles. In addition, the Pacific Ocean supports the killer whale which relies upon Chinook Salmon (e.g., fall-run Chinook Salmon) for food.

The San Francisco Bay Area Region also includes fish habitat within reservoirs that store CVP and SWP water. CVP and SWP water supplies are stored in Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District (EBMUD) Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. Many of these reservoirs also store water from local and regional water supplies. CVP and SWP water is generally not stored in reservoirs within Santa Clara County (SCVWD 2010).

### *9.3.5.1 Pacific Ocean Habitat of the Killer Whale*

The Pacific Ocean along the coast of California is included in this description of the affected environment because of it provides habitat for the Southern Resident killer whale population. The effect of the action, however, is limited to changes in the number of Chinook Salmon produced in the Central Valley entering the Pacific Ocean, which contribute an important component of the killer whale diet.

Southern Resident killer whales are found primarily in the coastal waters offshore of British Columbia and Washington and Oregon in summer and fall (NMFS 2008). During winter, killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Independent Hilborn et al. 2012).

The 2005 NMFS endangerment listing (70 FR 69903) for the Southern Resident killer whale distinct population segment lists several factors that may be limiting the recovery of killer whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. In the Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*), NMFS (2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (NMFS 2008).

The Independent Science Panel reported that Southern Resident killer whales depend on Chinook Salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook Salmon were the most frequent prey item for killer whales in two regions of the whale's summer range off the coast of British Columbia and Washington state, representing over 90 percent of the diet in July and August. Samples indicated that when Southern Residents are in inland waters from May to September, they consume Chinook Salmon stocks that originate from regions including the Fraser River, Puget

Sound, the Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al. 2010).

Significant changes in food availability for killer whales have occurred over the past 150 years, largely due to human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident killer whales, from British Columbia to California. The Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*) (NMFS 2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts to rebuild depleted salmon populations and other prey to ensure an adequate food base for Southern Resident killer whales.

Central Valley streams produce Chinook Salmon that contribute to the diet of Southern Resident killer whales. The number of Central Valley salmon that annually enter the ocean and survive to a size susceptible to predation by killer whales is not known. However, estimates of total Chinook Salmon production produced by the Comprehensive Assessment and Monitoring Program, administered by USFWS and Reclamation, provide an approximation of the size of the ocean population of Central Valley Chinook Salmon potentially available to killer whales. Since 1992, total production of fall-run Chinook Salmon ranged from 53,129 in 2009 to 1,436,928 in 2002 (Table 9.2). The term “total production” here represents the number of fish that returned from the ocean plus those that were taken as part of the commercial and sport fishery. It does not include natural mortality in the ocean, including salmon taken by killer whales.

**Table 9.2 Total Production (Number of Individuals) of Central Valley Fall-run Chinook Salmon in the Pacific Ocean and Ocean Harvest 1992-2011**

| Year | Total Production | Ocean Harvest |
|---|---|---|
| 1992 | 333,087 | 203,318 |
| 1993 | 553,617 | 352,913 |
| 1994 | 711,654 | 449,060 |
| 1995 | 1,391,357 | 994,194 |
| 1996 | 891,739 | 471,865 |
| 1997 | 1,146,471 | 679,151 |
| 1998 | 557,433 | 263,935 |
| 1999 | 795,768 | 316,873 |
| 2000 | 1,156,596 | 571,829 |
| 2001 | 976,034 | 218,424 |
| 2002 | 1,436,928 | 418,785 |
| 2003 | 1,019,686 | 297,140 |
| 2004 | 977,463 | 500,929 |
| 2005 | 874,670 | 356,514 |
| 2006 | 453,274 | 110,540 |
| 2007 | 202,311 | 87,528 |
| 2008 | 71,870 | 0 |
| 2009 | 53,129 | 0 |
| 2010 | 208,050 | 13,851 |
| 2011 | 329,092 | 57,224 |

Source: DOI 2012

#### *9.3.5.2 Contra Loma Reservoir*

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal. The 80-acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014b). There are currently 20 known fish species, including 8 species of game fish, in Contra Loma Reservoir. The East Bay Parks and Recreation District (EBRPD) and CDFW stock Rainbow Trout and Channel Catfish in the reservoir. The reservoir also supports self-sustaining populations of Largemouth Bass, crappie, Redear Sunfish, and Bluegill, which are also popular with anglers (Reclamation 2014b). Other species found include White Catfish, Threadfin Shad, Bigscale Logperch, Common Carp, Sacramento Blackfish, Warmouth, Green Sunfish, Goldfish, Prickly Sculpin, and Inland Silversides (Reclamation 2014b).

Many of the fish species present have been unintentionally introduced from the Delta via the Contra Costa Canal. Recently, the Rock Slough Fish Screen at the head of Contra Costa Canal was constructed to prevent the entrainment of federally protected species such as Delta Smelt at the Rock Slough Intake of the Contra Costa Canal. The new screen also minimizes fish entrainment and significantly reduces the potential for fish introductions into Contra Loma Reservoir from the Contra Costa Canal (Reclamation 2014b).

#### *9.3.5.3 San Justo Reservoir*

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. Other than stocked Rainbow Trout, all of the fish and other aquatic organisms that have been observed in San Justo Reservoir are nonnative species (SBCWD 2012).

#### *9.3.5.4 South Bay Aqueduct Reservoirs*

Bethany Reservoir, Patterson Reservoir, and Lake Del Valle are SWP facilities associated with the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies. At Bethany Reservoir, anglers catch five types of bass (Spotted, White, Largemouth, Smallmouth, and Striped), crappie, catfish, and trout (CSP 2013). Presumably, many of the same species would be found in Patterson Reservoir. Lake Del Valle is stocked regularly with trout and catfish. Largemouth and Smallmouth Bass, Striped Bass, and panfish are also caught (EBPRD 2014).

#### *9.3.5.5 Los Vaqueros Reservoir*

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. Aquatic habitat quality for fish is low to moderate due to poorly developed cover vegetation along the shoreline. The reservoir has been stocked with more than 300,000 game fish, primarily Rainbow Trout and Kokanee Salmon. Other fish introduced to the reservoir include Striped Bass, Largemouth Bass, sunfish, Brown Bullhead, and Channel Catfish (Reclamation and CCWD 2011).

#### *9.3.5.6 East Bay Municipal Utility District Reservoirs*

The EBMUD reservoirs in Alameda and Contra Costa County used to store water within and near the EBMUD service area include Briones Reservoir, San Pablo Reservoir, Lafayette Reservoir, Upper San Leandro Reservoir, and Lake Chabot. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies. San Pablo Reservoir is regularly stocked with trout and catfish (EBMUD 2014). Other species caught in the reservoir include crappie, Largemouth Bass, Smallmouth Bass, Spotted Bass, and carp (OEHHA 2009).

CDFW annually stocks trout in Lafayette Reservoir. Other species found in the reservoir include Bluegill, black bass, Black Crappie, and several species of catfish (Lafayette Chamber of Commerce 2014).

Lake Chabot is stocked with hatchery-raised Rainbow Trout and Channel Catfish by EBRPD and CDFW for recreational fishing. The lake also supports a popular nonnative, warm-water recreational fishery for Largemouth Bass, Bluegill, and Black Crappie. Some native trout escape from the Upper San Leandro Reservoir during spill events and likely end up in Lake Chabot (EBMUD 2013).

### 9.3.6 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. SWP water is delivered to southern Santa Barbara County communities through Cachuma Lake.

#### *9.3.6.1 Cachuma Lake*

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County. Cachuma Lake provides a variety of habitats for fish species, including deep-water areas, rocky drop-offs, shallow areas, and weed beds (wetland areas). Cachuma Lake and the upper Santa Ynez River are popular fishing areas that have been stocked with game fish by CDFW and the County of Santa Barbara. Native fish species in Cachuma Lake include steelhead/Rainbow Trout, Armored Three-Spine Stickleback, and Prickly Sculpin. Key game fish include Largemouth Bass, Smallmouth Bass, Bluegill, Green Sunfish, Redear Sunfish, Black Crappie, and White Crappie. Other species that have been identified in the lake include Channel Catfish, Black Bullhead, Threadfin Shad, goldfish, carp, and Mosquitofish (Reclamation 2010c).

### 9.3.7 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs store SWP water, including United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente Reservoir and Lower Otay Reservoir; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

#### *9.3.7.1 State Water Project Reservoirs*

The SWP reservoirs include Quail Lake, Pyramid Lake, and Castaic Lake in Los Angeles County; Silverwood Lake and Crafton Hills Reservoir in San Bernardino County; and Lake Perris in Riverside County.

Although small compared to nearby Pyramid and Castaic lakes, Quail Lake's 290 acres and 3 miles of shoreline offer shoreline fishing. Striped Bass, Channel Catfish, Blackfish, Tule Perch, Threadfin Shad, and Hitch have been found at Quail Lake (DWR 1997).

Pyramid Lake is located in the Angeles and Los Padres National Forests, about 60 miles northwest of downtown Los Angeles. Largemouth Bass, Smallmouth Bass, and Striped Bass as well as Bluegill, crappie, Brown Bullhead, Channel Catfish, and trout are caught by anglers in Pyramid Lake (OEHHA 2013a). Rainbow Trout, Bluegill, Green Sunfish, Largemouth Bass, catfish, and Prickly Sculpin are found in Piru Creek below the dam (DWR 2004d).

Castaic Lake supports a warm-water fishery for Striped Bass and Largemouth Bass. Bluegill and assorted minnows provide a forage base for the bass as well as being caught by anglers. CDFW maintains a Rainbow Trout fishery in Castaic Lake through stocking (DWR 2007).

Silverwood Lake is located in the San Bernardino National Forest and surrounded by the Silverwood Lake State Recreation Area at the edge of the Mojave Desert and at the base of the San Bernardino Mountains. Common sport fish caught in Silverwood Lake include stocked Rainbow Trout, Largemouth Bass, Bluegill, carp, crappie, catfish, and Striped Bass (CSP 2010, OEHHA 2013b). Other species found in the lake include blackfish, Brown Bullhead, Tui Chub, and Tule Perch (OEHHA 2013b).

The Crafton Hills Reservoir area includes 4.5 acres of open water and 1.9 acres of open space. One fish species, Mosquitofish, was observed in the reservoir (DWR 2009b).

Lake Perris is located within the Lake Perris State Recreation Area, which provides extensive recreational opportunities, as described in Chapter 15, Recreation Resources. Lake Perris is stocked with Rainbow Trout and managed as a recreational fishery. Common fish species in the lake include Largemouth Bass, Channel Catfish, Bluegill, Spotted Bass, Flathead Catfish, Green Sunfish, Redear Sunfish, and Black Crappie (DWR 2010). Other species found in the lake include Inland Silversides and Threadfin Shad (DWR 2007).

#### *9.3.7.2 Non-SWP Reservoirs in Riverside County*

Diamond Valley Lake and Lake Skinner in Riverside County are offstream storage facilities owned and operated by Metropolitan Water District of Southern California. These lakes are major reservoirs used to store SWP water. Diamond Valley Lake supports Largemouth Bass, Striped Bass, catfish, Redear Sunfish, Bluegill, and stocked Rainbow Trout (DVM 2014). Fish species found in Lake Skinner include Striped Bass, Largemouth Bass, carp, and Bluegill. The Metropolitan Water District also stocks catfish in summer and trout in winter (Riverside County 2014).

#### *9.3.7.3 Non-SWP Reservoir in Ventura County*

Lake Piru, located in Ventura County, is used to store SWP water by United Water Conservation District. Like Pyramid Lake upstream on Piru Creek, sport fish species in Lake Piru include trout, Largemouth Bass, catfish, crappie, Bluegill, and Redear Sunfish (CA Lakes 2014). Other species found there include Bigscale Logperch, Black Bullhead, carp, goldfish, Golden Shiner, Green Sunfish, and Inland Silversides (CalFish 2014).

#### *9.3.7.4 Non-SWP Reservoirs in San Diego County*

Reservoirs in San Diego County that are used to store SWP water include the City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, and Lower Otay reservoirs; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

Dixon Lake is located in the hills above the City of Escondido within the Escondido Multiple Habitat Conservation Plan area (City of Escondido 2012). Fish species found in Dixon Lake include Rainbow Trout, Channel Catfish, Bluegill, Largemouth Bass, Striped Bass, and Black Crappie (SDFish 2014).

San Vicente Reservoir has been stocked with various sport fish including sunfish, Largemouth Bass, Black Crappie, catfish, and Rainbow Trout. Other species found in the reservoir include Threadfin Shad and Prickly Sculpin (SDCWA and USACE 2008). El Capitan reservoir is stocked with Largemouth Bass, crappie, Bluegill, Channel Catfish, Blue Catfish, Green Sunfish, and Common Carp (City of San Diego 2014a). Fish species in Lower Otay Reservoir include Largemouth Bass, Bluegill, Black Crappie, White Crappie, Channel Catfish, Blue Catfish, White Catfish, and bullheads (City of San Diego 2014b).

Lake Jennings is regularly stocked with trout and Channel Catfish. Other species found in the lake are Bluegill, Largemouth Bass and Blue Catfish (SDFish 2015).

Eleven fish species were observed in Sweetwater Reservoir during biological surveys for the wetlands habitat recovery project, all of which were nonnative and typical of southern California warm-water lakes. Species observed include Channel Catfish, Threadfin Shad, Bluegill, and Largemouth Bass (Sweetwater Authority 2013).

#### *9.3.7.5 Non-SWP Reservoir in San Bernardino County*

Lake Arrowhead, in San Bernardino County, is used to store SWP water by the Lake Arrowhead Community Services District (County of San Bernardino 2011; LACSD 2014a, 2014b). Lake Arrowhead is a private lake, and its use is restricted to homeowners in a tract of land roughly 1 mile around the perimeter of the lake, known as Arrowhead Woods. Fish species found in the lake include trout, Kokanee Salmon, bass, catfish, crappie, sunfish, and carp.

#### *9.3.7.6 Fish and Aquatic Resources During Drought*

California is contending with its fourth consecutive year of drought where significant shortages in water supplies have profoundly influenced water use in the state, including environmental uses. The reduced water availability has depleted reservoir storage and the ability for operations to provide flow levels needed to support fish habitat within the river systems.  In addition, the limited cold water held in CVP and SWP reservoirs has impaired the ability to manage water temperatures downstream.  Similarly, the reduced flows in the Delta have resulted in shifts in salinity and water quality that influence the availability and quality of habitat for pelagic fishes as well as the factors that influence entrainment.  As a consequence, the reduction in runoff and available water has likely compromised an already stressed aquatic ecosystem and may have further imperiled species that are threatened with or in danger of extinction.

As described in the sections above, many fish populations have been in decline over the last several years.  There are undoubtedly multiple factors influencing this decline; however, the recent drought and actions taken to address the drought are clearly contributors.  In the recent conditional approval by the SWRCB of Reclamation's Temporary Urgency Change Petition (SWRCB 2015), the SWRCB summarized the effects of the recent drought conditions on aquatic resources based on a biological review conducted for the purposes of consultation with NMFS and USFWS.  The summaries from that document (SWRCB 2015) for several key species are paraphrased below.

The population of winter-run Chinook salmon is currently at extreme risk. In 2014, due to a lack of ability to regulate water temperatures in September and October, high water temperatures in the Sacramento River reduced early life stage survival from Keswick to Red Bluff from a recent average of approximately 27 percent down to 5 percent in 2014.  Consequently, 95 percent of the year class of wild winter-run Chinook was lost last year (Reclamation and DWR 2015). Temperature management was difficult again in 2015, which reduces this population's ability to withstand environmental perturbations, especially during a prolonged drought when each of the existing brood years has been already negatively affected by drought conditions.

The 2014 spawning run of spring-run Chinook Salmon returning to the upper Sacramento River system also experienced significant impacts due to drought conditions as well as elevated temperatures on the Sacramento River and other tributaries. Similar to winter-run, spring-run Chinook Salmon eggs in the Sacramento River experienced significant and potentially complete mortality starting in early September 2014 due to high water temperatures downstream of Keswick.  Extremely few juvenile spring-run Chinook Salmon were observed migrating downstream of the Sacramento River during high winter flows in 2015, when spring-run originating from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed, indicating that the population was significantly impacted. Similar concerns for spring-run Chinook Salmon exist this year as for winter-run.  While spring-run have greater distribution and inhabit locations in addition to the Sacramento River, conditions on those streams are also expected to be poor due to the drought.

Steelhead have also likely been affected by the drought, but given the difficulty in sampling for these fish it is difficult to determine exactly how the species have been affected.  Adult steelhead abundance is not estimated in the mainstem

Sacramento River or any waterways of the Central Valley. The drought conditions are causing increased stress to steelhead populations (with or without water project operations) from low flows causing reduced rearing and migratory habitat, increased water temperatures affecting survival, and likely higher than normal juvenile predation.

The effects of the drought are also reflected in Delta species. For example, recent population indices for Delta Smelt are at record low numbers. This is of particular concern given that most Delta Smelt do not survive to spawn more than one season and are thus for the most part an annual species. The fifth Spring Kodiak Trawl survey conducted the week of May 4, 2015, identified 4 adults in the Sacramento Deep Water Ship Channel, and one in Cache Slough. The fourth Spring Kodiak Trawl survey, conducted during the week of April 6, 2015, identified one adult, which was a record low for that survey (Smelt Working Group (SWG); 4 May 13 notes). According to the SWG, it appears fish density has become so low that the Spring Kodiak Trawl has reached or gone below its minimum effective detection ability (SWG; April 13 Notes). Additionally, in the final week (March 30) of supplemental USFWS sampling in the lower San Joaquin River, catch of adult Delta Smelt declined precipitously to zero in the final month of sampling.

In response to the drought and its adverse effects on aquatic resources, Reclamation is currently conditionally operating under the terms of a temporary urgency change petition that allows temporary changes to license and permit requirements imposed pursuant to SWRCB D-1641 to meet flow-dependent and water quality objectives to protect fish and wildlife beneficial uses. In compliance with the provisions of the BOs, Reclamation and the SWRCB have received concurrence on the changes from USFWS and NMFS (USFWS 2015, NMFS 2015).[4]

## 9.4 Impact Analysis

This section describes the potential mechanisms and analytical methods; results of the impact analyses; potential mitigation measures; and cumulative effects.

### 9.4.1 Potential Mechanisms and Analytical Methods

The impact analysis considers changes in the ecological attributes that affect fish and aquatic resources related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

[4] Additional information regarding CVP and SWP operations under a TUC Order issued on July 3, 2015, by the State Water Resources Control Board is provided at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/tucp_order070315.pdf.

#### ***9.4.1.1 CVP and SWP Reservoirs***

Changes in CVP and SWP operations under the alternatives could result in changes in reservoir storage volumes, elevations, and water temperatures in the primary water supply reservoirs (i.e., Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir). Variation in reservoir storage, elevation, and temperature is a function of water demand, water quality requirements, and inflow; these attributes also change based on the water-year type.

The downstream reservoirs (i.e., Lewiston Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, Lake Natoma, and Tulloch Reservoir) are operated to maintain relatively stable water elevations. These types of operations would result in similar conditions in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes at these reservoirs are not evaluated in this EIS.

##### **9.4.1.1.1 Changes in CVP and SWP Reservoir Storage Volume**

To evaluate changes in operation, changes in reservoir storage and elevation were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II for the entire 82-year period under the operations defined for each alternative, as described in Appendix 5A, CalSim II and DSM2 Modeling. The output of CalSim II served as input to the quantitative procedures described below for evaluation of changes in fish habitat and bass nesting success in CVP and SWP reservoirs.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, includes a summary of the monthly storage in each major upstream reservoir in combination with a frequency of exceedance analysis for each month. Reservoir storage values are characterized based on results of CalSim II hydrologic modeling and presented as average monthly storage by water year type. Although aquatic habitat within the CVP and SWP water supply reservoirs is not thought to be limiting, storage volume is used as an indicator of how much habitat is available to fish species inhabiting these reservoirs.

##### **9.4.1.1.2 Changes in CVP and SWP Reservoir Elevation**

Seasonal temperature stratification is a dominant feature of these reservoirs. There are relatively distinct fish assemblages within the upper (warm water) and lower (cold water) habitat zones, with different feeding and reproductive behaviors. Flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold water species. Drawdown of reservoir storage from June through October can diminish the volume of cold water, thereby reducing the amount of habitat for cold water fish species within these reservoirs during these months.

Reservoir storage and surface water elevations in the reservoirs from the CalSim II model were used to analyze potential effects on reservoir fishes. Water surface elevation in each reservoir was calculated from storage values and is presented as average end-of-month elevation by water year type.

Warm water fish species that inhabit the upper layer of these reservoirs may be affected by fluctuations in storage through changes in reservoir water surface elevations (WSELs). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm water species, including the black basses. Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding behaviors. Increases in WSEL are not thought to result in adverse effects on these species unless there is a corresponding decrease in water temperatures that can result in nest abandonment.

A conceptual approach was used to evaluate the effects of water surface elevation fluctuations on bass nests, based upon a relationship between black bass nest success and water surface elevation reductions developed by CDFW (Lee 1999) from research conducted on five California reservoirs. Lee (1999) examined the relationship between water surface elevation fluctuation rates and nesting success for black bass, and developed nest survival curves for Largemouth, Smallmouth, and Spotted bass. The equations corresponding to the curves are the following:

Largemouth Bass $Y = -56.378*\ln(X)-102.59$

Smallmouth Bass $Y = -46.466*\ln(X)-83.34$

Spotted Bass $Y = -79.095*\ln(X)-94.162$

Where: X is the fluctuation rate (m/day) and Y is the percentage of successful nests.

Based on the work by Lee (1999), the maximum receding water level rate providing 100 percent successful nesting varied among species, with receding water level rates of <0.02, <0.01, and <0.065 meters per day providing successful nesting of 100 percent of the Largemouth, Smallmouth, and Spotted bass nests, respectively. For this analysis, water surface elevations at the end of each month from the CalSim II model were used to calculate the monthly fluctuation rates, and derive the daily fluctuation rates used to compute the percentage of successful nests using the equations from Lee (1999).

CalSim II reports end-of-month (EOM) water surface elevations; therefore, water surface elevations from February to June were used in this analysis (i.e., March fluctuation rate = March EOM elevation – February EOM elevation). It was further assumed that the monthly change in elevation divided by the number of days in that month reflected the average daily fluctuation rate that was used as “X” in the above equations to compute the percentage of successful nests during that month. The percentages of successful bass nests were computed based on the equations from Lee (1999) for each month of the potential spawning season for these species.

Review of the available literature suggests that bass nest failure is highly variable between water bodies and between years but it is not uncommon to have up to 40 percent of bass nests fail (approximately 60 percent survival) (Scott and Crossman 1973). Many self-sustaining black bass populations in North America experience a nest success (i.e., the nest produces swim-up fry) rate of 21 to 96 percent, with many reporting survival rates in the 40 to 60 percent range (Forbes 1981; Hunt and Annett 2002; Steinhart 2004). This would suggest that much less than 100 percent survival is required to have a self-sustaining population. Based on the literature review, bass nest survival probability in excess of 40 percent is assumed to be sufficient to provide for a self-sustaining bass fishery. For this analysis, differences between alternatives were evaluated using the exceedance probability corresponding to the 40 percent level of survival based on the probability of exceedance over the 82-year CalSim II modeling time period.

#### *9.4.1.2 Rivers*

By altering reservoir storage and releases, changes in CVP and SWP operations under the alternatives would change flow and temperature regimes in downstream waterways. In turn, these alterations could affect fishery resources and important ecological processes on which the fish community depends.

##### 9.4.1.2.1 Changes in Flows

Changes in flows, in and of themselves, do not constitute an effect on aquatic resources. However, changes in flow can affect the quantity and quality of aquatic habitats in rivers and have direct effects on fish species through stranding or dewatering events that occur when flows are reduced. In addition, changes in flows can result in a reduction in ecologically important geomorphic processes resulting from reduced frequency and magnitude of intermediate to high flows.

Changes in flow also can influence the frequency and duration of inundated floodplains (e.g., Yolo Bypass) that support salmonid rearing and conditions for other native fish species. With implementation of the physical actions under NMFS RPA Action I.6.1, the inundation regime in the Yolo Bypass will be modified and managed to better coincide with the presence of juvenile salmonids and with a greater frequency. While this action is included in every alternative, changes in flows in the Sacramento River at the Freemont Weir associated with the various alternatives could result in slight differences in the flows entering the bypass and changes in the amount of habitat available to rearing salmonids and other native fish species.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, includes a summary of the monthly flows at various points downstream of the reservoirs in each major stream affected by project operations. Instream flows are characterized based on results of CalSim II hydrologic modeling and presented as both average monthly flows by month and water year type and monthly frequency of exceedance plots to allow examination of the entire range of simulation results for each of the alternatives as a means of evaluating differences among alternatives. Because the CalSim II model uses a monthly time step, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, flow changes of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis.

To compare the operational flow regime and evaluate the potential effects on habitat for anadromous species inhabiting streams, it was necessary to determine the relationships between streamflow and habitat availability for each life stage of these species in the rivers in which flows may be altered by CVP and SWP operations.

A number of studies have been conducted using the models and techniques contained within the Instream Flow Incremental Methodology (IFIM) to establish these relationships in streams within the study area. The analytic variable provided by the IFIM is total habitat, in units of Weighted Useable Area (WUA), for each life stage (fry, juvenile and spawning) of each evaluation species (or race as applied to Chinook Salmon). Habitat (WUA) incorporates both macro- and microhabitat features. Macrohabitat features include changes in flow, and microhabitat features include the hydraulic and structural conditions (depth, velocity, substrate or cover) affected by flow which define the actual living space of the organisms. The total habitat available to a species/life stage at any streamflow is the area of overlap between available microhabitat and macrohabitat conditions. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow differ substantially for the species and life stages evaluated.

WUA-flow relationships were available only for some rivers for which simulated flows were available. Therefore, flow dependent habitat availability was evaluated quantitatively only for Clear Creek and the Sacramento, Feather, and American rivers, and was not reported for other rivers evaluated in this Draft EIS. Tables of the spawning habitat-discharge relationships used in the calculations of spawning WUA for these rivers are provided in Appendix 9E, Weighted Useable Area Analysis. Because the WUA-flow relationships developed by the most recent IFIM studies present WUA values within particular flow ranges at particular variable steps, it was often the case that the monthly flow for a particular reach fell between two flows for which there were WUA values. In these cases, the value was determined by linear interpolation between the available WUA values for the flows immediately below and above the target flow. When the target flow was lower than the lowermost flow for which a WUA value exists, the corresponding WUA value was determined by linear interpolation between a flow of zero and the lowermost flow for which a WUA value exists. When the target flow was higher than the highest flow for which a WUA value exists, the corresponding WUA value was determined by assuming the WUA value for the highest flow.

WUA values are calculated and presented only on a monthly time-step, and not as seasonal or annual values. WUA values based on the monthly CalSim II flows were prepared for detailed evaluation of the alternatives. Monthly WUA values are presented as the average total WUA in each river segment, for the entire 82-year simulation period and the average total WUA in each of five water year types for each alternative. Differences between the alternatives and the two bases of comparison (No Action Alternative and Second Basis of Comparison) are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river. These comparisons were made only for the months in which the species and life stage are anticipated to be present in each river/reach based on the life history timing presented in Appendix 9B.

The ability to estimate sub-monthly WUA values is limited due to the monthly time-step of the CalSim II results. The monthly time-step is most limiting during the fall through spring seasons in areas downstream of tributaries, when flows can vary significantly on a daily basis due to hydrologic conditions. Hydrologic variability in the runoff and tributary flows cause significant variability of flows in the areas of interest for the WUA computations. During the periods of low flows, regulated flows from reservoir releases dampen the impact of daily variability of flows on WUA estimates. Because the WUA analysis uses output from the monthly time step CalSim II model, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in WUA values of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

##### 9.4.1.2.2 Changes in Water Temperatures

Water temperatures in the rivers and streams downstream of the CVP and SWP reservoirs are influenced by factors such as reservoir cold water pool, elevation of reservoir release outlets, and seasonal atmospheric conditions. The level of water storage in a reservoir has a strong effect on the volume of cold water (cold water pool) in the reservoir and, in combination with the elevation of reservoir release outlets, the temperature of water released downstream. Storage levels are often lowest in the late summer and early fall, resulting in warmer waters released from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. The summer and early fall are the times of year when river temperatures are most likely to rise above tolerance thresholds for steelhead and salmon.

The analysis of the effects of water temperature changes on fish was conducted using two approaches: 1) a comparison of average monthly water temperatures between the alternatives and the two bases of comparison (No Action Alternative and Second Basis), and 2) a comparison of average monthly water temperatures to established temperature objectives intended to be protective of fish. In addition, Reclamation’s salmon mortality model was applied in certain water bodies to examine the effects of temperature on salmon spawning and incubation. These approaches are described below.

*Comparison of Average Monthly Water Temperatures between Alternatives*

The analysis uses average water monthly temperatures to provide a comparison of the ability of operations considered under alternatives to meet water temperature objectives for various species. As described in Appendix 5A, Section 5A.A.3.6, water temperature modeling is subsequent to CalSim II modeling that simulates operations on a monthly basis; there are certain components in the temperature models that are downscaled to a daily time step (simulated or approximated hydrology). The results of those daily conditions are averaged to a monthly time step.

The effects analysis in Chapter 6, Surface Water Quality, includes a summary of the average monthly water temperature in each major stream downstream of CVP and SWP reservoirs in combination with a frequency of temperature exceedance analysis (see below) for each month. Water temperatures at various locations in each river were compared to determine whether mean monthly temperatures by water-year type were different between the alternatives and the two bases of comparison (No Action Alternative and Second Basis). Because the temperature models use inputs from the monthly-time-step CalSim II model, effects of real-time daily temperature management cannot be captured, even though the temperature models are capable of simulating on a sub-monthly timestep. Therefore, the analysis is based on monthly average temperature results. For this monthly analysis that uses two cascading models, it was determined that incremental changes of 0.5°F or less in mean monthly water temperatures would be within the model uncertainty. Therefore, changes of 0.5°F or less are considered to be not substantially different, or “similar” in this comparative analysis.

*Comparison to Established Water Temperature Thresholds*

The average monthly water temperature output from CalSim II does not allow a direct comparison to the temperature objectives identified in Table 9.3, and the effects of daily (or hourly) temperature swings are likely masked by the averaging process. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature objectives (Table 9.3) would be exceeded. These objectives are used as thresholds in the temperature exceedance analysis where the frequency of exceedance (percent of years) is calculated over the 82-year CalSim II modeling period (Appendix 9N). Because average monthly water temperatures likely mask daily temperatures that could exceed important thresholds, any difference in the frequency of threshold exceedance was considered important and could be indicative of a biological effect on the species/life stage for which the objective was established. While likely effects from temperature on early life stages occur at a shorter temporal scale than can be captured in these models, comparative analyses are useful for looking at long term impacts over numerous water years and types.

**Table 9.3 Water Temperature Objectives**

| Compliance Location | Year Types | Dates | Temperature Objective (°F) | Purpose |
|---|---|---|---|---|
| **Trinity River** | | | | |
| Lewiston Dam Release | All Year Types | July–Sep | < 60 | Spring-run Chinook Salmon holding |
| | | Sep | < 56 | Spring-run Chinook Salmon spawning |
| Lewiston Dam Release | All Year Types | Oct–Dec | < 56 | Chinook Salmon, Coho Salmon, and steelhead spawning |
| **Clear Creek** | | | | |
| Igo W | All Year Types | June–Sep 15 | 60 | Spring-run Chinook Salmon holding and rearing |
| | | Sep 15-Oct | 56 | Spring-run and fall-run Chinook Salmon spawning and egg incubation |
| **Sacramento River** | | | | |
| Keswick Release | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| Balls Ferry | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| Bend Bridge | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| | | | 63 | Green sturgeon spawning, incubation, and rearing |
| Red Bluff | All Year Types | Oct–Apr | 56 | Spring-, fall-, and late fall–run Chinook Salmon spawning and egg incubation |
| Hamilton City | All Year Types | Mar–Jun | 61 (optimal), 68 (lethal) | White Sturgeon spawning and egg incubation |
| **Feather River** | | | | |
| Robinson Riffle | All Year Types | Sep–Apr | 56 | Spring-run Chinook Salmon and steelhead spawning and incubation |
| | | May–Aug | 63 | Spring-run Chinook Salmon and steelhead rearing |

| Compliance Location | Year Types | Dates | Temperature Objective (°F) | Purpose |
|---|---|---|---|---|
| Gridley Bridge | All Year Types | Oct–Apr | 56 | Fall- and late fall–run Chinook Salmon spawning and steelhead rearing |
| | | May–Sep | 64 | Green sturgeon spawning, incubation, and rearing |
| **American River** | | | | |
| Watt Avenue Bridge | All Year Types | May–Oct | 65 | Juvenile steelhead rearing |
| **Stanislaus River** | | | | |
| Orange Blossom Bridge | All Year Types | Oct–Dec | 56 | Adult steelhead migration |
| | | Jan– May | 57 | Steelhead smoltification |
| | | Jan-May | 55 | Steelhead spawning and incubation |
| | | Jun-Sep | 65 | Juvenile steelhead rearing |
| Knights Ferry | All Year Types | Jan-May | 52 | Steelhead smoltification |

*Changes in Egg Mortality*

Water temperatures also affect the survival of various life stages of the focal species. Reclamation's salmon mortality model (Appendix 9C, Reclamation Salmon Mortality Model Analysis Documentation) was used to estimate water temperature induced mortality in the early life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) of salmonids in five rivers: Trinity, Sacramento, Feather, American, and Stanislaus, based on output from the temperature models. The salmon mortality model is limited to temperature effects on early life stages of Chinook Salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, and ocean harvest. Differences between alternatives are assessed based on changes in the percent egg mortality by river over the entire 82-year CalSim II simulation period and by water year type (based on 40-30-30 indexing). Because the salmon mortality model uses output from the temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in egg mortality of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in egg mortality of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis.

### *9.4.1.3 Delta*

Changes in CVP and SWP operations under the alternatives would affect Delta conditions primarily through changes in volume and timing of upstream storage releases and diversions, Delta exports and diversions, and DCC operations. Environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on aquatic resources in the Delta.

#### 9.4.1.3.1 Changes in Volume and Timing of Flows through the Delta

Operations of the CVP DCC and intake facilities owned by the CVP, SWP, local agencies, and private parties affect Delta hydrologic flow regimes. The largest effects of flow management in the Delta related to aquatic resources are the modification of winter and spring inflows and outflows of the Delta, and the introduction of net cross-Delta and net reverse flows in some Delta channels that can alter fish movement patterns. Seasonal flows play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, Striped Bass, American Shad, Delta Smelt, Longfin Smelt, and Sacramento Splittail. In addition, changes in Delta outflow influence the abundance and distribution of fish and invertebrates in the bay through changes in salinity, currents, nutrient levels, and pollutant concentrations. Altered flows through the Delta as a result of changes in CVP and SWP operations affect water residence time, an important physical property that can influence the ability of phytoplankton biomass to build up over time, with implications for higher trophic level consumers such as fish.

#### 9.4.1.3.2 Changes in Water Quality

Changes in water quality due to CVP and SWP operations under the alternatives would affect aquatic resources in the Delta primarily through changes in water temperatures, salinity, nutrient levels, pollutant concentrations and turbidity. Changes in CVP and SWP operations can increase Delta water temperatures by warmer reservoir releases and to a lesser extent, by reducing quantities of freshwater inflow and by modifying tidal and ground water hydraulics. Changes in CVP and SWP operations also can affect the location of the low salinity zone (position of X2), especially during periods of low inflows and high water exports (i.e., low outflow conditions) in drier water years. Nutrients, essential components of terrestrial and aquatic environments because they provide a resource base for primary producers, and pollutants such as selenium and mercury could be affected by changes in CVP and SWP operations. Turbidity is an important water quality component in the Delta that could be affected by changes in operation. Changes in turbidity affect food web dynamics through attenuation of light in the water column and altering predation success.

The DSM2, a one-dimensional hydrodynamic and water quality simulation model, is used to evaluate changes in salinity (as represented by EC) in the Delta and at the CVP/SWP export locations. CalSim II outputs are used to evaluate changes in location of X2 in the Delta. A more detailed overview of the DSM2 model and input assumptions is presented in Appendix 5A, CalSim II and DSM2 Modeling.

The Delta boundary flows and exports from CalSim II are used as input to the DSM2 Delta hydrodynamic and water quality models to estimate tidally-based flows, stage, velocity, and salt transport within the estuary. Because CalSim II operations are simulated on a monthly basis, the DSM2 model would not be able to capture daily operations and therefore the DSM2 outputs are presented on a monthly basis, as described in Appendix 5A, CalSim II and DSM2 Modeling.

DSM2 HYDRO outputs are used to predict changes in flow rates and depths. The QUAL module of DSM2 simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Chloride and bromide concentrations are estimated using relationships based on DSM2 EC results, as described in Appendix 6E, Analysis of Delta Salinity Indicators.

The CalSim II outputs described above that estimate the position X2 were used along with temperature to generally assess effects on Striped Bass and American Shad. Kimmerer (2002) noted that Striped Bass survival is negatively correlated with April – June X2 values, although the analysis was inconclusive on the mechanisms contributing to this relationship. Kimmerer (2009) noted that Delta Smelt and Striped Bass had more negative slopes in the habitat-X2 relationship for surveys conducted in spring to early summer months than other surveys. They also noted that the slopes for abundance–X2 and habitat–X2 were similar for American Shad and for Striped Bass, and that the habitat relationships to X2 appeared consistent with their relationships of abundance (or survival) to X2. Thus, Kimmerer et al. (2009) contended that this similarity provides some support for the notion that increasing habitat quantity as defined by salinity could be one mechanism to explain the X2 relationship for these species. Based on this relationship, the position of X2 was used as general indicator of habitat for Striped Bass and American Shad. Alternatives that resulted in a more westerly position of X2 relative to the bases of comparison were considered to have less potential for adverse effect, whereas those with a more easterly position would have a greater potential for adverse effect.

#### 9.4.1.3.3 Changes in Fish Entrainment

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in the level of entrainment at CVP and SWP export pumping facilities. The south Delta CVP and SWP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle rivers.

The potential for entrainment of salmonids migrating through the Delta was analyzed using predicted monthly salvage of salmonids from January through June using statistical relationships reported in Zeug and Cavallo (2014). In that analysis, salvage at the State Water Project and Central Valley Project was modeled as a function of physical, biological and hydrologic variables (see Appendix 9M for additional detail).

Results of the analysis are presented in box-whisker plots showing the median, central 50 percent probability, and range of simulated data. The comparison between alternatives relied on interpretation of these plots to distinguish differences in the median values as follows: (1) when the medians are nearly identical or the central 50 percent probabilities (i.e., the boxes) overlap completely, the medians were considered “similar;” (2) when the medians and box were offset, but the median values were within the range represented by the contrasting alternative’s box, the medians were considered “slightly” different; (3) when the median of one alternative was outside of the contrasting alternative’s box, but the boxes overlapped, the alternatives were considered “moderately” different; and (4) when the median of one alternative was outside of the contrasting alternative’s box, and the boxes did not overlap, the medians were considered “substantially” different.

In evaluating the potential for entrainment of Delta Smelt, as influenced by OMR flows under the alternatives, the USFWS (2008) regression model based on Kimmerer (2008) was used to estimate potential entrainment of Delta Smelt. The equation developed by Kimmerer (2008) is based on the average December through March OMR flow (in units of cfs) as predicted by the CalSim II model, and yields the percentage of adult Delta Smelt that may become entrained in the pumps. Further review by Kimmerer (2011) determined that the above equation has an upward bias, such that the results were reduced by 24 percent to correct this bias. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

Changes in CVP and SWP operations under the alternatives could also change entrainment of larvae and early juvenile Delta Smelt. Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. The USFWS (2008) regression model based on Kimmerer (2008) was used to calculate the percentage entrainment of larval and early juvenile Delta Smelt in Banks and Jones Pumping Plants. This regression is dependent on two variables: March through June average OMR flow (in cfs) and March through June average X2 position (in km). OMR and X2 values predicted by the CalSim II model for each alternative were used in estimating the entrainment loss. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

In this study, the percent entrainment values estimated for Delta Smelt are used as a tool to compare the alternatives, as one of the factors that would indicate conditions that might benefit or contribute to adverse effects on Delta Smelt. Because the regression analysis uses flow output from the monthly time step CalSim II model and the confidence intervals on the regression parameters are somewhat broad, it was determined that incremental changes in entrainment estimates of 5 percent or less were within the model uncertainty. Therefore, changes in entrainment of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis. One limitation of this approach is that it does not reflect the benefit that some of the alternatives might realize through adaptive management of OMR flows to further reduce potential entrainment, based on input from the Smelt Working Group.

#### 9.4.1.3.4 Changes in Fish Passage and Routing

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in passage conditions and routing. For example, changes in operation of the DCC affects the volume of water diverted into the Mokelumne River distributary channels toward the central and south Delta. Operation of the south Delta intake facilities, including facilities owned by the CVP and SWP and Contra Costa Water District, contribute to reverse flow conditions in Old and Middle rivers.

Changes in salmonid passage and routing were evaluated using the Delta Passage Model (DPM) and an analysis of Delta hydrodynamics and junction entrainment, as described below. The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions (see Appendix 9J for additional detail). Model output is expressed as through Delta survival of salmon smolts.

The key assumption in the Delta Hydrodynamic analysis is that the proportion of positive velocities in a channel, measured at a monthly time step, is an indicator of the likelihood that juvenile anadromous fish will successfully migrate through that channel towards the ocean (see Appendix 9K for additional detail). The analysis of junction entrainment used a regression based on predicted entrainment into a distributary and the proportion of flow into the distributary to predict the daily probability of fish entrainment (see Appendix 9L for additional detail).

Results of the Delta hydrodynamics and junction entrainment analysis are presented in box-whisker plots showing the median, central 50 percent probability, and range of simulated data. The comparison between alternatives relied on interpretation of these plots to distinguish differences in the median values as described above for changes in fish entrainment.

#### 9.4.1.3.5 Changes in Delta Smelt Habitat (X2 Location)

Changes in CVP and SWP operations under the alternatives could change the location of Fall X2 position (in September through December) as an indicator of available habitat for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity and water transparency for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al 2010); however others (see Manly et al. 2015) have questioned the use of outflow and X2 location as an indicator of Delta Smelt habitat because other factors may be influencing survival.

To evaluate fall abiotic habitat availability for Delta Smelt under the alternatives, X2 values (in km) simulated in the CalSim II model for each alternative were averaged over September to December, and compared for differences. There are uncertainties and limitations associated with this approach, e.g., it does not evaluate other factors that influence the quality or quantity of habitat available for Delta Smelt (e.g., turbidity, temperature, food availability), nor does it take into account the relative abundance of Delta Smelt that might benefit from the available habitat in the simulated X2 areas, in any given year. Other scientists have developed and described life cycle models to evaluate Delta Smelt population responses to changes in flow-related variables (e.g., Maunder and Deriso 2011; Rose et al. 2013 a, b), but these life cycle modeling approaches were not selected for use in the current study. The life cycle model developed by Rose et al. (2013a, b) could not be used in this analysis because it uses a wide array of daily data, many of the assumptions and parameter values were based on judgment, and the model was not designed for forecasting future Delta Smelt population abundances. The model was designed mostly for exploring hypothesis about factors affecting Delta smelt populations dynamics, which is not suitable for a comparative analysis of operational scenarios under the alternatives. Moreover, Reed et al. (2014) noted that "*To date, these models have not been fully vetted and evaluated sufficiently to be used for direct management applications*." In this study, simulated fall X2 values are used as a tool to compare the alternatives, as one of the factors that would indicate available suitable habitat to benefit Delta Smelt.

#### 9.4.1.3.6 Changes in Salmonid Production

Collectively, factors such as flow, temperature, and habitat availability affect the population dynamics of anadromous fish species during their freshwater life stages. Three different models were used to assess changes in salmonid production potential: 1) SALMOD; 2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook Salmon; and 3) the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook Salmon.

*Comparison of Annual Production Using SALMOD*

The SALMOD model (Appendix 9D, SALMOD Analysis Documentation) was used to assess changes in the annual production potential of four races of Chinook Salmon in the Sacramento River. The primary assumption of the model is that egg and fish mortality is directly proportional to spatially and temporally variable habitat limitations, such as water temperatures, which themselves are functions of operational variables (timing and quantity of flow) and meteorological variables, such as air temperature. SALMOD is a spatially explicit model that characterizes habitat value and carrying capacity using the hydraulic and thermal properties of individual habitat units. Inputs to SALMOD include flow, water temperature, spawning distributions, spawn timing by salmon race, and the number of spawners provided by the user (e.g., recent average escapement).

Annual production potential or the number of outmigrants, annual mortality, length, and weight of the smolts are some of the reporting metrics available from SALMOD. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Differences between alternatives are assessed based on changes in the annual production potential for each species by river by water year type. Because SALMOD uses flows and output from the water temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in production of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in production of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

*Comparison of Annual Winter-run Chinook Salmon Escapement Using IOS*

IOS is a stochastic life cycle simulation model for winter run Chinook Salmon in the Sacramento River. The IOS model is composed of six model stages that are arranged sequentially to account for the entire life cycle of winter run, from eggs to returning spawners. The primary output from the IOS model is escapement, the total number of winter-run Chinook Salmon that leave the ocean and return to the Sacramento River to spawn. Differences between alternatives are assessed based on changes in the median annual escapement and the range of escapement values encompassed in the first and second quartiles (25 to 75 percent of years) over the 82-year CalSim II simulation period. The IOS model uses scenario-specific daily DSM2, CalSim II, and Sacramento River Basin Water Temperature Model (HEC-5Q) data as model input. Because IOS uses output from the monthly time step CalSim II model, or other models downscaled from CalSim II, as input, it was determined that incremental changes in escapement estimates of 5 percent or less in were related to the uncertainties in the model processing. Therefore, changes in escapment of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

*Comparison of Annual Winter-run Chinook Salmon Escapement Using OBAN*

The Oncorhynchus Bayesian Analysis (OBAN) is a model that uses statistical relationships between historical patterns in winter-run Chinook salmon abundance and a number of other parameters that covary with abundance to predict future population abundance. The model determines the effects of water temperature, harvest, exports, striped bass abundance, and offshore upwelling using historical abundance data. The set of parameters, called covariates, that provided the best model fit was retained for the full model. The model then uses predicted future values of these parameters, primarily from CalSim II and temperature model outputs, to predict future patterns in Chinook salmon population abundance (escapement). Because OBAN uses output from the monthly time step CalSim II model, or other models downscaled from CalSim II, as input, it was determined that incremental changes in escapement estimates of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in escapement of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

##### 9.4.1.3.7 Changes in Sturgeon Year Class Strength

Changes in CVP and SWP operations can affect sturgeon species through changes in flows through the Delta that, in turn, affect the year class strength of both Green Sturgeon and White Sturgeon. Estimated Delta outflow from the CalSim II model was used to analyze the potential effects on sturgeon using the hypothesized relationship between Delta outflow and the age-0 Year Class Index (YCI) from the Bay Study in the presentation by Gingras et al. (2014). For this analysis, the mean Delta outflow during the March to July period for each year was calculated from the CalSim II output and used as an indicator of potential year class strength. Because the sturgeon analysis uses flow output from the monthly time step CalSim II model, it was determined that incremental changes in mean (March to July) Delta outflow of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in Delta outflow of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis.

Mean (March to July) Delta outflow was also used as an indicator of the likelihood of producing a strong year class of sturgeon by examining the number of years (over the 82-year CalSim II simulation) that mean (March-July) Delta outflow would exceed a threshold of 50,000 cfs. Changes in the number of years exceeding the threshold was considered to have a potential effect on sturgeon.

#### *9.4.1.4 Constructed Water Supply Facilities that Convey and Store CVP and SWP Water*

The distribution system for water exported by CVP and SWP includes hundreds of miles of canals and numerous reservoirs designed to help regulate the flow of water to the areas where the water is used. Many of these canals and reservoirs support fish that were entrained into the system or intentionally stocked for recreational purposes, and changes in export deliveries could influence the quality of the aquatic habitat in these constructed water bodies. These constructed water bodies do not support important populations of native fish species and the management of flows is under the control of the entities that receive the water. Because many of the reservoirs also store water from non-CVP and SWP water supplies; it is difficult to predict changes in the aquatic habitat related to changes in CVP and SWP water supplies. Therefore, the potential effects of operation of these facilities on fish and aquatic resources are not addressed further in this EIS.

#### *9.4.1.5 Analysis of Provision of Fish Passage*

As described previously in the Affected Environment section, Shasta, Folsom, and New Melones dams and their associated downstream re-regulating reservoirs permanently blocked salmonid access to upper watersheds and effectively removed many miles of suitable habitat. These barriers particularly influenced populations of winter-run and spring-run Chinook Salmon and steelhead because their life history strategies are adapted to accessing higher elevation river reaches and tributaries to successfully spawn and rear, as well as for oversummering. Improving passage would increase the amount of available habitat, including access to colder headwaters, which would be particularly important considering anticipated climate change scenarios. Improved fish passage is not included under the Second Basin of Comparison or Alternative 2.

#### *9.4.1.6 Analysis of Trap and Haul Program*

Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has been hypothesized as a major contributor to declines in the number of returning adults and may be a significant impediment to the recovery of threatened or endangered populations (NOAA 2009). Alternative 3 and Alternative 4 contain a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River, similar to the program in place on the Columbia River in Oregon. This action would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives, with the exception of Alternatives 3 and 4. Background information on the trap and haul program associated with Alternatives 3 and 4 is provided in Appendix 9O and was used in the qualitative assessment of the trap and haul program under Alternatives 3 and 4.

#### *9.4.1.7 Analysis of Predator Control Programs*

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include predator control actions designed to reduce predation on salmonids and Delta Smelt, primarily within the Delta. Predator control measures are included in Alternatives 3 and 4, including an increased bag limit and minimum size limit for Striped Bass and black bass. The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. In addition, a sport reward program for Sacramento Pikeminnow would be implemented to encourage fishing for and removal of this predatory species. These two actions would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives, with the exception of Alternatives 3 and 4.

#### *9.4.1.8 Analysis of Ocean Salmon Harvest Restrictions*

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include restrictions on the annual ocean Chinook Salmon harvest, which is intended to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population[5] standards. This would include working with the Pacific Fisheries Management Council (PFMC), CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years.

The salmon ocean fishery off the coast of California is regulated by the PFMC, which establishes the annual catch limit to optimize overall benefits, particularly with regard to food production, recreation, and ecosystem protection. An annual catch limit generally is based on achieving the maximum sustained yield from the fishery, but also takes into account the effects of uncertainty; management imprecision; the need to rebuild stocks; and other relevant economic, social, and ecological factors. Compliance with the ESA, other laws, and treaties also may affect the annual catch limit. Each year, the maximum allowable harvest (i.e., maximum number of fish caught) is determined based on the abundance of fish spawning in the previous year. Depending on the number of spawning fish, different formulas for calculating the maximum allowable harvest (i.e., control rules) are used. These rules calculate the maximum allowable harvest as a percentage of the number of spawning fish, and are designed to maximize the yield of fish from a stock while preventing overfishing. The annual catch limit may be set at or below the maximum allowable harvest.

Reduction of the annual catch limit could directly influence the number of adult salmon reaching their natal streams to spawn, which could affect the number of salmon annually produced in Central Valley streams and the Trinity River. Harvest restrictions would be implemented under Alternatives 3 and 4, but would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives.

#### *9.4.1.9 Approach to Analyzing the Effects of Alternatives on Fish*

The analysis of the effects of changes in operation of the CVP and SWP on fish and aquatic resources in this EIS is influenced by numerous factors related to the complexity of the ecosystem, changes within the system (e.g., climate change and species population trends), and the imprecision of operational controls and resolution in modeling tools. These factors are further complicated by the scientific uncertainty about some fundamental aspects of aquatic species life history and how these species respond to changes in the system, as well as sometimes competing points of view on the interpretation of biological and physical data within the scientific community. In light of these factors, the analysis takes an approach that presents available information and model outputs, synthesizes the results, and draws logical conclusions on likely effects of the various alternatives. Where relevant and appropriate, the analysis attempts to

[5] "A viable salmonid population (VSP)2 is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame" (McElhany et al. 2000, pg. 2).

identify the level of uncertainty and qualify effect conclusions where competing hypotheses may exist.

Many modeling tools have been developed to evaluate changes in CVP and SWP water management, and as a result, multiple sources of information are available to characterize conditions (e.g., water temperature, flows, reservoir storage). Most of these modeling tools explain or provide insight on one or two of the factors affecting the species, while some tools are more integrative (e.g., SALMOD) and capture multiple relationships among physical conditions and biological responses. Where integrative models were available, these were relied upon more than evaluation of the individual components. For species where these tools were not available, the analysis used a preponderance of evidence approach that drew conclusions based on trends indicated by the majority of the information. This approach assembled the full range of available information and model outputs and determined the direction (neutral, positive, or negative) of effect supported by the information.

For each focal species where sufficient information was available, the analysis includes an effects summary that presents the EIS authors' conclusions for that species and describes the rationale for the conclusion. It also presents a general indication of the level of uncertainty regarding the conclusion and presents qualifying information where disagreement in the scientific community may exist for more complete disclosure.

Because of the multiple model outputs, the body of the impact analysis contains a considerable amount of information, which is intended to summarize for the benefit of the reader, while leaving most of the detail in the appendices. The narrative contained in the body of the document and the model results in the appendices are intended to be used in concert in reviewing this EIS.

### 9.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to aquatic resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *9.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise

- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change aquatic resources, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 USFWS BO and 2009 NMFS BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that would affect aquatic resources, including:

- Habitat Restoration includes restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.
  - 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
  - 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Habitat.

  - 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
  - 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
  - 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
  - 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass.
- 2009 NMFS BO RPA Action I.1.3. Clear Creek Spawning Gravel Augmentation.
- 2009 NMFS BO RPA Action I.1.4. Spring Creek Temperature Control Curtain Replacement.
- 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead.
- 2009 NMFS BO RPA Action I.3.1. Operate Red Bluff Diversion Dam with Gates Out.
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program.
- 2009 NMFS BO RPA Action II.1. Lower American River Flow Management.

Implementation of these common actions are described in more detail in this section under the No Action Alternative and referred under the discussion of the Second Basis of Comparison.

#### *9.4.2.2 No Action Alternative*

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions. It also includes changes not related to the coordinated long-term operation of the CVP and SWP, specifically changes in CVP and SWP operations caused by climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary geographically, as described below.

As described in Chapter 5, Surface Water Resources and Water Supplies, it is anticipated that climate change would result in more short-duration, high-rainfall events and less snowpack in the winter and early spring months. By 2030, the reservoirs would be full more frequently by the end of April or May than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced storage in fall (end of September storage) would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs. Sea level rise also would result in reduced CVP and SWP reservoir storage because the CVP and SWP must continue to meet the salinity criteria to protect Delta water users and Delta aquatic resources, including the SWRCB D-1641 and other salinity criteria to protect Delta water users. To meet these criteria, the amount of water released from CVP and SWP reservoirs must be increased as compared to recent historical conditions.

#### 9.4.2.2.1 Trinity River Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

*Aquatic Habitat Conditions in Trinity and Lower Klamath Rivers*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for reduced Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the No Action Alternative as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

By 2030, implementation of 2009 NMFS BO RPA Action II.6, Preparation of Hatchery Genetic Management Plans for spring- and fall-run Chinook Salmon at the Trinity River Fish Hatchery, which is not currently being implemented, could reduce the adverse influence of recent hatchery operations on naturally produced fall-run and spring-run Chinook Salmon, and increase genetic diversity and diversity of run timing for these stocks.

*Effects Related to Water Transfers*

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

#### 9.4.2.2.2 Central Valley Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the No Action Alternative. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. Recent historical averages for reservoir storage and surface elevations in Shasta Lake, Lake Oroville, and Folsom Lake generally show increases in March and April, with a reduction in storage occurring in many years during May and June in response to releases to meet downstream demands. Water surface elevations in New Melones Reservoir generally decline throughout the spring period in many years, with reductions typically occurring from April through June.

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the No Action Alternative, the magnitude of changes in seasonal surface elevation and reservoir storage could be more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. A smaller snowpack could result in less water entering the reservoirs during the spring months and an increased frequency of reservoir elevation declines during the spring months. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

*Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities*

As described in Chapter 5, Surface Water Resources and Water Supplies, surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. In wetter years, fall flows may be increased relative to recent conditions to meet downstream targets for Fall X2, which would lead to reduced reservoir storage in the following months and less carryover storage in May of the following year.

As described in Chapter 6, Surface Water Quality, climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

Implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions under the No Action Alternative are anticipated to benefit aquatic species. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary from river to river, as described below.

*Aquatic Habitat Conditions in the Clear Creek from Whiskeytown Dam to Sacramento River*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The No Action Alternative includes a suite of six 2009 NMFS BO RPA actions, intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in Clear Creek by 2030. These include:

- 2009 NMFS BO RPA Action I.1. Spring Attraction Flows
- 2009 NMFS BO RPA Action I.2. Channel Maintenance Flows
- 2009 NMFS BO RPA Action I.3. Spawning Gravel Augmentation
- 2009 NMFS BO RPA Action I.4. Spring Creek Temperature Control Curtain
- 2009 NMFS BO RPA Action I.5. Thermal Stress Reduction
- 2009 NMFS BO RPA Action I.6. Adaptively Manage to Habitat Suitability/IFIM Study Results

Two of the actions involve additional flow releases to Clear Creek. 2009 NMFS BO RPA Action I.1, requires at least two pulse flows in May and June to attract adult spring-run Chinook Salmon holding in the Sacramento River. The pulse flows would be continued annually, and are expected to improve conditions for spring-run Chinook Salmon into the future. In addition, 2009 NMFS BO RPA Action I.1.2, requires the release of channel maintenance flows of a minimum of 3,250 cfs into Clear Creek seven times in a ten-year period. These channel maintenance flows are intended to provide the higher flows necessary to move spawning gravels downstream from injection sites (locations where gravel augmentation is implemented) for the purpose of increasing the amount of spawning habitat available to spring-run Chinook Salmon and steelhead. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the feasibility of releasing these flows is influenced by dam safety considerations and operational constraints, and the delivery of flows of this frequency may not be possible, thus the movement of gravel through mechanical means may be required to achieve this objective.

2009 NMFS BO RPA Action I.1.3 addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. This program is expected to continue under the No Action Alternative, with ongoing improvements to spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir and, to some extent, the magnitude of the release flows. As described in the Affected Environment, Reclamation has managed releases since 2002 to meet a daily average water temperature target of 56°F at the Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30 to support spring-run Chinook Salmon spawning. Beginning in 2004, an additional daily average temperature target of 60°F was implemented from June 1 to September 15 to protect over-summering juvenile steelhead and holding adult spring-run Chinook Salmon. 2009 NMFS BO RPA Action I.1.5 continues these temperature targets; however, recent real time operations have experienced difficulty in meeting the temperature objectives, and by 2030, it may not be possible to meet the temperature targets as often. The Spring Creek Temperature Control Curtain in Whiskeytown Lake repaired in 2011 (and also included in the 2009 NMFS BO RPA) improves this condition by retaining cold water that is released to reduce water temperatures during the summer for over-summering juvenile steelhead and holding adult spring-run Chinook Salmon and during the fall for spring- and winter-run Chinook Salmon spawning and incubation.

2009 NMFS BO RPA Action I.1.6 requires adaptive management of flows in Clear Creek based on results of habitat suitability/IFIM studies. If warranted by the studies and if sufficient water is available, this action could result in modified minimum flows in Clear Creek during the fall and winter to improve conditions for spawning and incubating salmonids. Whether flow requirements would be modified by 2030 and the extent of any changes are currently unknown.

*Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in the Sacramento River (and Battle Creek) by 2030. These include:

- 2009 NMFS BO RPA Action Suite I.2.1. Shasta Operations
  - 2009 NMFS BO RPA Action Suite I.2.1. Performance Measures

   - 2009 NMFS BO RPA Action I.2.2 (including I.2.2.A–I.2.2.C). November through February Keswick Release Schedule (Fall Actions)
   - 2009 NMFS BO RPA Action I.2.3 (including I.2.3.A–I.2.3.C). February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)
   - 2009 NMFS BO RPA Action I.2.4. May 15 Through October Keswick Release Schedule (Summer Action)
   - 2009 NMFS BO RPA Action I.2.5. Winter-Run Chinook Salmon Passage and Reintroduction Program at Shasta Dam – See "Conditions for Fish Passage"
   - 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead
- 2009 NMFS BO RPA Action Suite I.3. Red Bluff Diversion Dam (RBDD) Operations
- 2009 NMFS BO RPA Action I.4. Wilkins Slough Operations
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program

Action Suite I.2 (Shasta Operations) was aimed at maintaining suitable temperatures for egg incubation, fry emergence, and juvenile rearing in the Sacramento River for the survival and recovery of the winter-run Chinook Salmon ESU. Spring-run Chinook Salmon and steelhead are also affected by temperature management actions from Shasta Lake. This suite of actions is designed to ensure that Reclamation uses maximum discretion to reduce adverse impacts of the projects to Chinook Salmon and steelhead in the Sacramento River by maintaining sufficient carryover storage and optimizing use of the cold water pool. Because Reclamation already operates Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams, implementation of this suite of actions would have little effect on habitat conditions for winter-run Chinook Salmon and other fish species in the Sacramento River under the No Action Alternative.

A temperature control device has been in operation at Shasta Dam since 1998, with operations capable of maintaining a water temperature of 56°F downstream to Balls Ferry Bridge in most years through the summer spawning period for winter-run. Under the No Action Alternative, the ability to control water temperatures depends on a number of factors and management flexibility usually ends in October when the cold water pool in Shasta Lake is depleted. With climate change, cold water storage at the end of May in Shasta Lake is expected to be reduced under the No Action Alternative for all water year types. This would further reduce the already limited cold water pool in late summer. With the anticipated increase in demands for water by 2030 and less water being diverted from the Trinity River, it is expected that it would become increasingly difficult to meet water temperature targets at the various temperature compliance points.

It is likely that severe temperature-related effects will be unavoidable in some years under the No Action Alternative. Due to these unavoidable adverse effects, RPA Action Suite I.2 also specifies other actions that Reclamation must take, within its existing authority and discretion, to compensate for these periods of unavoidably high temperatures. These actions include restoration of habitat at Battle Creek (see below) which may support a second population of winter-run Chinook Salmon, and a fish passage program at Keswick and Shasta dams to partially restore winter-run Chinook Salmon to their historical cold water habitat.

2009 NMFS BO RPA Action Suite I.3 addresses mortality and delay of adult and juvenile migration of winter-run, spring-run, steelhead, and green sturgeon caused by the presence of the RBDD and the configuration of the operable gates. As described in the Affected Environment, the Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD, and is included in the 2009 NMFS BO as Action Suite I.3. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are completed and are anticipated to benefit fish species that migrate upstream of the RBDD location through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

Implementation of 2009 NMFS BO RPA Action I.4 is anticipated to enhance the ability to manage temperatures for anadromous fish downstream of Shasta Dam through adjusting Wilkins Slough flow criteria in a manner that best conserves the cold water pool for summer releases. In years other than critical dry years, the need for a variance from the 5,000 cfs navigation criterion will be considered during the process of developing the Keswick release schedules (Action I.2.2-4). Reclamation has stated that it is no longer necessary to maintain 5,000 cfs at Wilkins Slough for navigation (CVP/SWP operations BA, page 2-39), however, the 5,000 cfs flow criterion is now used to support long-time water diversions that have set their intake pumps just below this level. Under the No Action Alternative, operating to a minimal flow level at Wilkins Slough based on fish needs, rather than on outdated navigational requirements, could enhance the ability to use cold water releases to maintain cooler summer temperatures in the Sacramento River.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. This program is also addressed in the 2009 NMFS BO RPA Action I.5. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

As described in the Affected Environment, implementation of the Battle Creek Restoration Program is underway in accordance with implementation of the CVPIA. This action, also included in the 2009 NMFS BO RPA Action I.2.6, is being implemented to partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run Chinook Salmon to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program under the No Action Alternative would substantially improve passage conditions for adult Chinook Salmon and steelhead by 2030 and would result in newly accessible anadromous fish habitat and improved water quality for the Coleman National Fish Hatchery (Reclamation and SWRCB 2003). Implementation of the RPA helps ensures that the Battle Creek experimental winter-run Chinook Salmon re-introduction program will proceed in a timely fashion. The Battle Creek Restoration Program is critical in creating a second population of winter-run Chinook Salmon. A second population of winter-run Chinook Salmon would reduce the risk that lost resiliency and increased vulnerability to catastrophic events might result in extinction of the species.

*Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality, the NMFS and 2008 USFWS BO RPAs did not specifically recommend actions for Feather River operations. However, Reclamation and DWR operate the Shasta-Oroville-Folsom coordinated releases pursuant to 2009 NMFS BO RPA Actions 1.2.2C and 1.2.3B. The following two RPA actions for operations in the Sacramento River influence Feather River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

Under the No Action Alternative, Feather River flows in the high flow channel downstream of Thermalito Dam would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Lake Oroville releases and Delta export operations as described for the Affected Environment. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 and would change fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. The Plan will provide an overall strategy for managing the various environmental measures developed for implementation in the plan area. The following programs and plans will be included in the comprehensive Lower Feather River Habitat Improvement Plan:

1) Gravel Supplementation and Improvement Program
2) Channel Improvement Program
3) Structural Habitat Supplementation and Improvement Program
4) Fish Weir Program
5) Riparian and Floodplain Improvement Program including the evaluation of pulse/flood flows
6) Feather River Fish Hatchery Improvement Program
7) Comprehensive Water Quality Monitoring Program
8) Oroville Wildlife Area Management Plan
9) Instream Flow and Temperature Improvement for Anadromous Fish.

Implementation of these programs and plans under the terms of the Settlement Agreement as incorporated into the new license are anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River.

*Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River*

As described in the Affected Environment section, Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard flow recommendations developed by Reclamation, the Sacramento Area Water Forum, USFWS, NMFS, DFW, and other interested parties; SWRCB Decision 893 (D-893); and requirements of the 2009 NMFS BO RPA. The following two RPA actions for operations in the Sacramento River influence American River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the lower American River. These actions individually or in combination could influence conditions in the American River by 2030. These include:

- 2009 NMFS BO RPA Action II.2.1. Lower American River Flow Management
- 2009 NMFS BO RPA Action II.2. Lower American River Temperature Management
- 2009 NMFS BO RPA Action II.3. Structural Improvements
- 2009 NMFS BO RPA Action II.4. Minimize Flow Fluctuation Effects
- 2009 NMFS BO RPA Action II.5. Fish Passage at Nimbus and Folsom dams
- 2009 NMFS BO RPA Action II.6.1. Preparation of Hatchery Genetic Management Plan (HGMP) for Steelhead
- 2009 NMFS BO RPA Action II.6.2. Interim Actions Prior to Submittal of Draft HGMP for Steelhead.

Under the No Action Alternative, American River flows would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Folsom Dam releases and Delta exports. However, by 2030, increasing water demands and the influence of climate change could worsen conditions for fish in the lower American River, particularly for salmonids.

Reclamation releases water from Folsom Lake to implement the flow schedule specified in the American River Flow Management Standard. The flow schedule was developed and implemented prior to issuance of the 2009 NMFS BO (Action II.1) to establish required minimum flows for anadromous salmonids in the lower American River. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river's aquatic resources, particularly steelhead and fall-run.

Reclamation manages the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower American River. Water temperature is the physical factor with the greatest influence on salmonids in the American River. The inability to maintain suitable water temperatures for all life history stages of steelhead in the American River is a chronic issue because of operational (e.g., Folsom Lake operations to meet Delta water quality objectives and demands and deliveries to M&I users in Placer, El Dorado, and Sacramento County) and structural (e.g., limited reservoir water storage and cold water pool) factors. Under the No Action Alternative, increased water demand and climate change are expected to lead to further reductions in suitable habitat conditions and increased water temperatures.

2009 NMFS BO RPA Action II.3 requires Reclamation to evaluate physical and structural modifications that may improve temperature management capability in the lower American River. Structural improvements to be further evaluated and potentially implemented include: improvements to the Folsom Dam TCD, cold water transport through Lake Natoma, installation of a TCD at El Dorado Irrigation District's intake or its functional equivalent, and improved temperature management decision-support tools. If one or more of these actions are implemented by 2030, they could increase the likelihood that water temperatures would be suitable for steelhead more frequently.

2009 NMFS BO RPA Action II.4 addresses stranding and isolation of juvenile steelhead through implementation of flow ramping protocols. Implementation of this action, including the continued monitoring for stranding and isolation of salmonids in conjunction with flow fluctuations under the No Action Alternative, could help to better predict the potential for steelhead redd dewatering and isolation, fry stranding, and fry and juvenile isolation and to potentially avoid adverse effects to salmonids.

As described above, temperature-related effects are likely during some years under the No Action Alternative. Because of these unavoidable effects, RPA Action II.5 requires Reclamation to evaluate options for providing steelhead access their historic cold water habitat above Nimbus and Folsom dams and to provide access if feasible.

Under the No Action Alternative, 2009 NMFS BO RPA Action Suite II.6, which addresses project effects related to the Nimbus Fish Hatchery related to introgression of out-of-basin hatchery stock with wild steelhead populations in the Central Valley, would be implemented. Implementation of an HGMP prior to 2030 should minimize the effects of the ongoing steelhead hatchery program on the Central Valley steelhead DPS.

Implementation of the HGMP also would reduce operational effects on Killer Whale prey over the long term by improving the genetic diversity and diversity of run timing of Central Valley fall-run Chinook Salmon, decreasing the potential for localized prey depletions and increasing the likelihood that fall-run Chinook Salmon could withstand stochastic events, such as poor ocean conditions. By 2030, implementation of this action could begin to contribute to a more consistent food source for Killer Whales, even in years with overall poor Chinook Salmon productivity.

*Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River*

Under the No Action Alternative, operations at Friant Dam would remain similar to those described under the Affected Environment. Therefore, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

*Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP operations as described in Chapter 5, Surface Water Resources and Water Supplies. Flows in the lower Stanislaus River are primarily controlled by releases from New Melones Lake. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the Stanislaus River. These actions individually or in combination could influence conditions in the Stanislaus River by 2030. These include:

- 2009 NMFS BO RPA Action III.1.1. Establish Stanislaus Operations Group (SOG) for real-time operational decision-making
- 2009 NMFS BO RPA Action III.1.2. Provide cold water releases to maintain suitable steelhead temperatures
- 2009 NMFS BO RPA Action III.1.3. Operate the East Side Division dams to meet minimum flows
- 2009 NMFS BO RPA Action Suite III.2. Stanislaus River CV Steelhead Habitat Restoration
  - 2009 NMFS BO RPA Action III.2.1. Increase and improve quality of spawning habitat with addition of gravel
  - 2009 NMFS BO RPA Action III.2.2. Conduct floodplain restoration and inundation flows in winter or spring to inundate steelhead juvenile rearing habitat
  - 2009 NMFS BO RPA Action III.2.3. Restore freshwater migratory habitat for juvenile steelhead
  - 2009 NMFS BO RPA Action III.2.4. Evaluate Fish Passage at New Melones, Tulloch, and Goodwin dams

Under the No Action Alternative, Stanislaus River flows would be influenced by regulations to meet water quality and flow criteria. However, by 2030, conditions for fish, particularly salmonids, in the Stanislaus River fish are expected to worsen because of increased temperatures due to the influence of climate change.

In accordance with 2009 NMFS BO RPA Action III.1.1, Reclamation has convened a Stanislaus Operations Group (SOG) to provide a forum for real-time operational flexibility implementation of the actions defined in the 2009 NMFS BO RPA. This group includes representatives from Reclamation, NMFS, USFWS, DWR, CDFW, SWRCB, and outside expertise at the discretion of NMFS and Reclamation. The SOG provides direction and oversight to ensure that the East Side Division actions are implemented, monitored for effectiveness and evaluated.

Under the No Action Alternative, Reclamation will continue, where feasible, to manage the cold water supply within New Melones Reservoir as described in 2009 NMFS BO RPA Action III.1.2. The objective of these temperature criteria is to provide suitable temperatures for Central Valley steelhead rearing, spawning, egg incubation, smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams; thus, temperature management flexibility is limited to storage and flow management under certain conditions. Access to resources to offset operational temperature effects on steelhead in the Stanislaus River will continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the No Action Alternative, steelhead would continue to be vulnerable to elevated temperatures in dry and critical dry years, even if actions are taken to improve temperature management. The frequency of these occurrences is expected to increase with climate change-related temperature increases.

Under the No Action Alternative, Reclamation would continue to meet the minimum flow schedule, to the best of their ability, as described in 2009 NMFS BO RPA Action III.1.3. The objective of the minimum flow schedule is to maintain minimum base flows to provide habitat for all life history stages of steelhead and to incorporate habitat maintaining geomorphic flows in a flow pattern that would provide migratory cues to smolts and facilitate out-migrant smolt movement. The flow schedule specifies minimum flows and does not preclude higher releases for other operational criteria. However, due to limited availability of water under the CVP water rights, it would be difficult to fully implement this action. Therefore, habitat conditions for steelhead and other fish species in the Stanislaus River would be similar or reduced relative to recent conditions in the near term. The value of this habitat also may be adversely influenced by higher temperatures associated with climate change.

Ongoing implementation of 2009 NMFS BO RPA Action Suite III.2 through 2030 is anticipated to improve the physical habitat conditions for steelhead, although climate change may affect the types and cover rates of vegetation upslope of the river, and potentially increase the rate of fine sediment transport to the river and to spawning areas.

RPA Action III.2.4 requires Reclamation to evaluate options for providing steelhead access to their historic cold water habitat upstream of New Melones, Tulloch, and Goodwin dams and to provide access if feasible. As described above, temperature-related effects will be unavoidable in some years under the No Action Alternative. Lindley et al. (2007) identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for steelhead and salmon in the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that were historically unsuitable habitat because of high summertime temperatures. To the extent that preliminary fish passage efforts are underway by 2030, this could improve conditions for Stanislaus River salmonids.

*Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)*

As described in Chapter 5, Surface Water Resources and Water Supplies, climate change would increase the frequency of high flow events that would result in flows into the Yolo Bypass by 2030 as compared to recent historical conditions. Implementation of the operable gates at the Fremont Weir also would increase the frequency of flows into the Yolo Bypass.

Under the No Action Alternative, it is assumed that aquatic habitat conditions in the Yolo Bypass would improve by 2030 as a result of the following 2009 NMFS BO RPA actions:

- 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Rearing Habitat.
- 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
- 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
- 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
- 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass

Under the No Action Alternative, it is assumed that the elements of 2009 NMFS BO RPA Action Suite I.6.1 would be implemented in the Yolo Bypass, including up to 20,000 acres of shallow, low-velocity inundated floodplain. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species.

Passage at Fremont Weir would be facilitated by correcting a variety of passage issues within the bypass, including modification of agricultural structures in the northern Tule Canal that impede flow and cause fish passage delays. Modification of these structures under the No Action Alternative could substantially reduce fish passage delays through the Tule Canal. Similarly, replacement or modification of Lisbon Weir could allow unimpeded fish passage, reduced maintenance of the weir, and at the same time be managed to impound water for agriculture. In addition, the Knights Landing Ridge Cut could be modified to provide an exit path for upstream-migrating fish. These actions, along with the grading of downstream channels to improve connectivity to the Tule Canal when water levels fall as inundations recede and provide exit points for fish that would otherwise be stranded when inundations recede, are expected to improve conditions for salmonid rearing and fish passage by 2030.

Implementation of these ecosystem restoration actions and improvements under the No Action Alternative could increase growth and survival of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions may also reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

*Aquatic Habitat Conditions in the Delta*

Under the No Action Alternative, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies and Chapter 6, Surface Water Quality. Overall, long-term average CVP and SWP water supply deliveries in 2030 through the Delta would decline as compared to historical long-term average deliveries. Because entrainment of fish in the Delta export facilities is related to the amount of water exported, entrainment would decline relative to recent conditions as a result of reduced water supply delivery.

Under the No Action Alternative, climate change is anticipated to have more of an effect on Delta flows during wetter years than during drier years because CVP and SWP operations occur with more flexibility during wet years, within the constraints of flood control requirements, compared to drier years when the CVP and SWP operations may be more frequently constrained to maintain instream flows and other environmental objectives. Overall, it is anticipated that due to climate change, sea level rise, and increased water demands in the Sacramento Valley, there would be less CVP and SWP water available for export in the Delta and CVP and SWP exports would decline. The reduction in Delta exports would result in more positive OMR flows by 2030 as compared to recent historical conditions. In other words, it is expected that fish in the channels surrounding the CVP and SWP projects will be exposed to lower entrainment risks than under recent historical conditions as a result of changes in operation due to factors described above (i.e., climate change, sea level rise, and increased water demands in the Sacramento Valley) climate change by 2030.

The No Action Alternative includes a variety of RPA actions or action suites from both the USFWS and NMFS biological opinions intended to improve conditions in the Delta for Delta Smelt, Longfin Smelt, salmonids and sturgeon. These actions individually or in combination could influence aquatic habitat conditions in the Delta by 2030. These include:

- 2008 USFWS BO RPA Component 1 (Actions 1 and 2). Protection of the Adult Delta Smelt Life Stage.
- 2008 USFWS BO RPA Component 2 (Actions 3 and 5). Protection of Larval and Juvenile Delta Smelt.
- 2008 USFWS BO RPA Component 3 (Action 4). Improve Habitat for Delta Smelt Growth and Rearing (Fall X2).
- 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.

- 2009 NMFS BO RPA Action Suite IV.1. Modify DCC gate operations and evaluate methods to control access to Georgiana Slough and the Interior Delta to reduce diversion of listed fish from the Sacramento River into the southern or central Delta.
- 2009 NMFS BO RPA Action Suite IV.2. Control the net negative flows toward the export pumps in Old and Middle rivers to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento River into the southern or central Delta.
- 2009 NMFS BO RPA Action IV.3. Curtail exports when protected fish are observed near the export facilities to reduce mortality from entrainment and salvage.
- 2009 NMFS BO RPA Action Suite IV.4. Improve fish screening and salvage operations to reduce mortality from entrainment and salvage.

Component 1 of the 2008 USFWS BO RPA is designed to reduce entrainment of pre-spawning adult Delta Smelt during December to March by controlling OMR flows during vulnerable periods, including adaptive management of OMR flows based on input and guidance from the Smelt Working Group to further reduce entrainment. Action 1 is designed to protect upmigrating Delta Smelt and Action 2 is designed to protect adult Delta Smelt that have migrated upstream and are residing in the Delta prior to spawning. Overall, RPA Component 1 is expected to increase the suitability of spawning habitat for Delta Smelt by decreasing the amount of Delta habitat affected by export pumping prior to, and during, the critical spawning period.

Component 2 is intended to improve flow conditions in the Central and South Delta such that larval and juvenile Delta Smelt could successfully rear in the Central Delta and move downstream when appropriate. The spring HORB would be installed only if the USFWS determines Delta Smelt entrainment is not a concern.

Implementation of Component 3 of the 2008 USFWS BO RPA requires the provision of sufficient Delta outflow to maintain a monthly average X2 no greater than 74 km in Wet water year types and 81 km in Above Normal water years. The objective of this component is to improve fall habitat for Delta Smelt through increasing Delta outflow during fall. Increases in fall habitat quality and quantity are anticipated to improve conditions for Delta Smelt under the No Action Alternative. However, implementation of this action would result in reduced storage in upstream reservoirs which could adversely affect temperature management in the Sacramento, Feather, and American rivers.

Component 4 of the 2008 USFWS BO RPA is intended to improve conditions for Delta Smelt habitat to supplement the improvements resulting from the flow actions described above. DWR is required to implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. It is assumed under the No Action Alternative that this requirement would be met by the Suisun Marsh Restoration Program and would result in the restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough.

Implementation of the 2008 USFWS BO RPA would increase the likelihood that Delta Smelt habitat conditions and attributes for migration, spawning, recruitment, growth, and survival would be provided under the No Action Alternative. Implementation of actions under the 2008 USFWS BO RPA to restore tidally influenced habitat also is expected to increase salmonid and sturgeon rearing habitat and potentially food production for salmonids and Delta Smelt. Depending on the amount and type of restoration that would occur in brackish estuarine areas, restoration could increase rearing habitat for Sacramento Splittail, and alter conditions for predators and non-native fish species. Spawning habitat for roach, Hardhead, Sacramento Splittail, and Delta Smelt could be increased depending on whether restoration occurs in freshwater areas or in brackish estuarine areas. In addition, habitat restoration has the potential to alter habitat conditions for some invasive aquatic macrophyte species during some seasons, and in some locations, which could have indirect effects on predation.

Action Suite IV.1 of the 2009 NMFS BO RPA requires continued funding of monitoring programs at the RBDD, in spring-run Chinook Salmon tributaries to the Sacramento River, on the Sacramento River at Knights Landing and Sacramento, and sites within the Delta. In addition, salvage and loss of juvenile Chinook Salmon would be monitored at the Delta fish collection facilities operated by the CVP and SWP. A working group, composed of representatives from Reclamation, DWR, NMFS, USFWS, and CDFW, would develop and evaluate engineering solutions to reduce adverse impacts on listed fish and their critical habitat.

The DCC gate operations would be modified to reduce loss of emigrating salmonids and green sturgeon. The operating criteria provide for longer periods of gate closures during the outmigration season to reduce direct and indirect mortality of yearling spring-run and winter-run Chinook Salmon, and juvenile steelhead. Although route selection by Chinook Salmon and the mechanisms governing selection are complex (Perry et al. (2015), the closure of the DCC gates may increase the survival of salmonid emigrants through the Delta, and the early closures could reduce loss of fish with unique and valuable life history strategies in the spring-run Chinook Salmon and Central Valley steelhead populations.

Conditions under the No Action Alternative would be influenced by implementation of Action Suite IV.2 of the 2009 NMFS BO RPA. This action suite requires the maintenance of adequate flows in both the Sacramento River and San Joaquin River basins to increase survival of steelhead emigrating to the estuary from the San Joaquin River, and of Chinook Salmon, steelhead, and Green Sturgeon emigrating from the Sacramento River through the Delta to Chipps Island. This action suite includes actions to reduce the vulnerability of emigrating steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the export facilities by increasing the inflow to export ratio. Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook populations. In addition, there are actions to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows. Historical data suggest that high San Joaquin River flows in the spring result in higher survival of outmigrating Chinook Salmon smolts and greater returns of adults. The data also suggest that when the ratio between spring flows and exports increase, Chinook Salmon production increases. Increased flows within the San Joaquin River portion of the Delta could also enhance the survival of Sacramento River salmonids. Those fish from the Sacramento River that have been diverted through the interior Delta to the San Joaquin River could benefit by the increased net flow towards the ocean caused by the higher flows in the San Joaquin River from upstream and the reduced influence of the export pumps.

2009 NMFS BO RPA Action Suite IV.2 also includes flow management for the Old and Middle rivers that would be implemented in conjunction with the restrictions on exports under the 2008 USFWS BO RPA. Old and Middle river flow management is designed to ensure that emigrating steelhead from the San Joaquin Basin and the east-side tributaries remain in the mainstem of the San Joaquin River to the greatest extent possible and reduce their exposure to the adverse effects that are present in the channels leading south toward the export facilities. This is anticipated to increase the likelihood of survival of steelhead emigrating from the San Joaquin River. Reducing the risk of diversion into the central and southern Delta waterways also could increase survival of listed salmonids and Green Sturgeon entering the San Joaquin River via Georgiana Slough and the lower Mokelumne River. However, recent coded wire tagging and acoustic studies have shown survival to be reach specific for both Chinook Salmon and steelhead and that survival of hatchery-origin (Feather River) juvenile Chinook Salmon was higher through the south Delta via the Old River route than via the San Joaquin River (Buchanan et al. 2013, 2015). However, most fish in the Old River that survived to the end of the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013, SJRGA 2013). Zeug and Cavallo (2014) suggest that entrainment losses at the diversions may be small relative to overall migration mortality.

The 2009 NMFS BO RPA Action IV.3 requires operations of the Tracy and Skinner Fish Collection Facilities to be modified according to monitoring data from upstream of the Delta. In conjunction with the two alerts for closure of the DCC (Action IV.1.1), a third alert would be used to signal that export operations may need to be altered due to large numbers of juvenile Chinook Salmon migrating into the upper Delta region, increasing their risk of entrainment into the central and south Delta and then to the export pumps. When more fish are present, more fish are at risk of diversion and losses would be higher. The third alert is important for real-time operation of the export facilities because the collection and dissemination of field data to the resource agencies and coordination of response actions could take several days. This action is designed to work in concert with the Old and Middle River flow management in action suite IV.2. Under the No Action Alternative, implementation of this action is anticipated to reduce losses of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon by reducing exports when large numbers of juvenile Chinook Salmon are migrating into the upper Delta region.

Action Suite IV.4 of the 2009 NMFS BO RPA is designed to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon to achieve a 75 percent performance goal for whole facility salvage at both state and Federal facilities. Reclamation and DWR will (1) conduct studies to evaluate current operations and salvage criteria to reduce take associated with salvage, (2) develop new procedures and modifications to improve the current operations, and (3) implement changes to the physical infrastructure of the facilities where information indicates such changes need to be made. In addition, Reclamation would continue to fund and implement the CVPIA Tracy Fish Facility Program. Reclamation and DWR would fund quality control and quality assurance programs, genetic analysis, louver cleaning loss studies, release site studies and predation studies. Funding would also be provided for new studies to estimate Green Sturgeon screening efficiency at both facilities and survival through the trucking and handling process. Under the No Action Alternative, implementation of measures to fund fish screens, reduce pre-screen loss, improve screening efficiency, and improve reporting could reduce entrainment and salvage, and result in improved survival for juvenile Salmonids migrating downstream through the Delta, as well as for Sacramento Splittail, Delta Smelt, and other native fish species.

Abundance and habitat conditions for Delta Smelt and other fish species in the Delta under the No Action Alternative in 2030 are difficult to predict. Abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad under recent conditions are very low compared to pre-POD levels, as evidenced by the number of fish collected in sampling programs such as the FMWT surveys conducted by the IEP. Numbers of fish collected have continued to decline in recent years, even with implementation of the RPAs. Annual reviews conducted by the Delta Science Program Independent Review Panel (IRP) for the Long-Term Operations Biological Opinions have called for better metrics to measure the effects of the BO RPAs on the protected species (IRP 2011, 2013, 2014) to allow more informed decision-making, while acknowledging challenges, constraints, and the complexity of the issues.

Currently low levels of relative abundance do not bode well for the Delta Smelt or other fish species in the Delta in 2030. Challenges to fish species in the Delta are many, and would continue in the future under the No Action Alternative, including high water temperatures, reduced flows, habitat degradation, barriers, predation, low DO, contamination, entrainment, salvage, poaching, disease, competition, non-native species, and lack of available food. Use of observations on current conditions to predict future long-term changes for Delta fish is especially challenging when combined with other potentially adverse future changes foreseen for the Delta, e.g., altered hydrology due to drought, rising temperatures, and potential sea level rise (Sommer and Meija, 2013).

#### 9.4.2.2.3 Special Status Species and Critical Habitat

*Clear Creek*

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The Primary Constituent Element (PCEs) of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. As described above, it is anticipated minimum flows in Clear Creek would be increased during the fall and winter to improve conditions for spawning salmonids as a result of recently completed IFIM studies. Continuation of spring pulse flows (RPA Action I.1.1) and implementation of channel maintenance flows (RPA Action I.1.2), in conjunction with ongoing gravel augmentation in Clear Creek, is expected to result in improvements in the PCEs of critical habitat for spring-run Chinook Salmon and steelhead relative to recent conditions.

*Sacramento River*

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run and spring-run Chinook Salmon and steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of Green Sturgeon. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously.

Climate change is likely to reduce the conservation value of the spawning habitat PCE of critical habitat by increasing water temperatures, which would reduce the availability of suitable spawning habitat. Cold water in Shasta Lake is expected to be depleted sooner in the summer, impacting winter-run and spring-run Chinook Salmon spawning habitat. This reduction in an essential feature of the spawning habitat PCE could reduce the spatial structure, abundance, and productivity of salmonids. Similarly, as described above, climate change is likely to reduce availability of rearing habitat, and in turn, the value of the rearing habitat PCE of critical habitat, by increasing water temperatures.

The year-round opening of the gates at the RBDD in accordance with Action Suite I.3 of the 2009 NMFS BO RPA allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for Green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD location is expected to increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, predation on salmon, steelhead, and sturgeon would be reduced relative to conditions when the RBDD was operational.

*American River*

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and could adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

*Stanislaus River*

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

*Delta*

Critical habitat for both winter-run and spring-run Chinook Salmon is designated in the Sacramento River adjacent to the location of the DCC gates. The DCC is specifically not included in designated critical habitat for winter-run Chinook Salmon because the biological opinions issued by NMFS in 1992 and 1993 included measures on the operations of the gates that were designed to exclude winter-run Chinook Salmon from the channel and the waters of the Central Delta. However, for spring-run Chinook Salmon, designated critical habitat does include the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough, including the location of the gates. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways, but not the DCC waterway.

Operation of the DCC gates affects the PCEs for critical habitat designated for these species. Primarily, DCC gate operations interfere with the use of the Sacramento River as a migratory corridor for Chinook Salmon and steelhead juveniles during their downstream migration from spawning grounds upstream of the Delta to San Francisco Bay and the Pacific Ocean. The operation of the gates permits fish to enter habitat and waterways they would not normally access, with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Under the No Action Alternative, operation of the gates could have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor.

#### 9.4.2.2.4 Effects Related to Cross Delta Water Transfers

Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September in accordance with the 2008 USFWS BO and 2009 NMFS BO. The maximum amount of water to be transferred would be 600,000 acre-feet/year in critical dry years or in dry years following a dry or critical dry year. In all other water year types, the maximum amount of water would be 360,000 acre-feet/year.

#### 9.4.2.2.5 Conditions for Fish Passage

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes a suite of RPA actions intended to examine the reintroduction of salmonids into historical habitats upstream of currently impassable artificial barriers. The actions include consideration for passage of winter-run and spring-run Chinook Salmon, and steelhead above Shasta Dam on the Sacramento River, steelhead above Nimbus and Folsom dams on the American River, and steelhead above Goodwin, Tulloch, and New Melones dams on the Stanislaus River. The action suite outlines multiple planning and implementation steps to evaluate the efficacy of passage before long-term fish passage is provided. However, for the purposes of the describing the No Action Alternative, fish passage at each of these facilities (likely through interim means) is assumed to be functional by 2030.

As described in the Affected Environment, Reclamation is currently developing near-term and long-term fish passage solutions to provide access by anadromous salmonids to habitat upstream of Shasta Lake (2009 NMFS BO RPA Action I.2.5). The evaluation includes assessments of amount, suitability, and location of potential habitat, potential risks (e.g., predation by resident fish, disease transmission), as well as feasibility of providing upstream and downstream passage. There are approximately 60 mainstem miles and the McCloud River upstream of Shasta Lake. Reclamation (2014c) estimated approximately 9 river-miles of suitable winter-run Chinook Salmon spawning habitat in the upper Sacramento River below Box Canyon Dam, and approximately 12 river-miles of suitable spawning habitat for winter-run Chinook Salmon in the McCloud River below McCloud Dam. By 2030, access to this habitat could not only expand the amount of habitat available for winter-run Chinook Salmon relative to recent conditions, but provide access to areas of temperature refuge at a time when water temperatures in the river downstream of Keswick Dam are anticipated to increase. This could be particularly beneficial as winter-run Chinook Salmon are currently at high risk of extinction. Extinction factors include: winter-run Chinook Salmon is composed of only one population, which has been blocked from all of its historic spawning habitat; the potential for catastrophic risks associated with proximity to Mt. Lassen and the population's dependency on the cold water management of Shasta Lake; and the population has a "high" hatchery influence (Lindley et al. 2007). Combined with improvements on Battle Creek that are expected to support a second population component of winter-run Chinook Salmon, the provision for fish passage upstream of Shasta Dam may support a third population, which is consistent with the NMFS Recovery Plan for this species (NMFS 2014b).

Similarly, conditions for steelhead in the American River could be influenced by fish passage at Nimbus and Folsom dams afforded by implementation of 2009 NMFS BO RPA Action II.5. As described in the Affected Environment, water temperature conditions in the lower American River downstream of Nimbus Dam currently present challenges for steelhead, especially rearing juveniles. Under the No Action Alternative, anticipated increases in temperature related to climate change could increase the vulnerability of steelhead to serious effects of elevated temperatures in most years, particularly in dry and critical dry years, even if actions are taken to improve temperature management. The provision of passage to upstream reaches of the American River, including tributaries, would give steelhead access to former spawning and rearing habitat higher in the system where water temperatures are cooler and remain cooler during the summer months. Assuming this action results in fish passage by 2030, conditions for steelhead are expected to improve because of the increased amount of available habitat and the ability to access cooler water temperatures.

Relative to recent conditions, substantial improvements also would be expected for steelhead on the Stanislaus River under the No Action Alternative, if 2009 NMFS BO RPA Action II.2.4 is determined feasible and is implemented by 2030. As described in the Affected Environment, steelhead in the Stanislaus River are exposed to multiple stressors, including high water temperatures during adult immigration, embryo incubation, juvenile rearing, and smolt outmigration. In addition, flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt outmigration life stages. Access to former habitat in upstream areas under the No Action Alternative are anticipated to reduce many of the stressors associated with recent conditions and could provide improved resilience to climate change.

##### 9.4.2.2.6 Ocean Conditions

Operation of the CVP and SWP would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook Salmon (produced in the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales. The No Action Alternative would not directly affect critical habitat for Killer Whales. However, under the No Action Alternative, production of wild Chinook Salmon could increase with increased area and quality of habitat for Chinook Salmon, as discussed previously. Chinook Salmon from the Central Valley rivers and streams likely represent only a very small proportion of the diet of this Killer Whale population because most of their feeding is on Fraser River and Puget Sound stocks (Hanson et al. 2010). Therefore, any increase in the population of Chinook Salmon originating from the Central Valley under the No Action Alternative is not expected to substantially influence the Southern Resident Killer Whale population.

#### *9.4.2.3 Second Basis of Comparison*

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based upon:

- Coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs
- Changes in CVP and SWP operations due to climate change and sea level rise, and increased CVP and water rights water demand in portions of the Sacramento Valley
- Implementation of reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies, as described in Section 7.4.3.1, No Action Alternative
- Implementation of RPA actions that address programs and projects that were ongoing prior to issuance of the 2008 USFWS BO and 2009 NMFS BO, including restoration of Battle Creek for salmonids; replacement of the Red Bluff Diversion Dam; restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Overall, under the Second Basis of Comparison, long-term average CVP and SWP water supply deliveries by 2030 through the Delta would increase, and late summer and fall reservoir storage probably would decrease as compared to recent historical conditions without consideration for climate change. However, the Second Basis of Comparison also includes changes not related to the coordinated long-term operation of the CVP and SWP, including changes in CVP and SWP operations due to climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies, as described under the No Action Alternative. Therefore, primarily due to climate change, both CVP and SWP reservoir storage and long-term average CVP and SWP water supply deliveries would decrease by 2030 as compared to historical long-term average deliveries.

Under the Second Basis of Comparison it is assumed that fish and aquatic resources in 2030 would continue to be influenced by CVP and SWP operations. The resulting changes in ecological attributes and subsequent effects on aquatic resources would vary geographically, as described below.

#### 9.4.2.3.1 Trinity River Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

End of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

*Fish Habitat Conditions in Trinity and Lower Klamath Rivers*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for lower Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the Second Basis of Comparison as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

*Effects Related to Water Transfers*

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

#### 9.4.2.3.2 Central Valley Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the Second Basis of

Comparison. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. End of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the Second Basis of Comparison, the magnitude of changes in seasonal surface elevation and reservoir storage could be more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

*Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities*

Surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. Climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

*Aquatic Habitat Conditions in Clear Creek from Whiskeytown Dam to Sacramento River*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The Second Basis of Comparison assumes that one of the 2009 NMFS BO RPA actions intended to improve conditions for salmonids would be implemented, 2009 NMFS BO RPA Action I.3 Spawning Gravel Augmentation, which is currently being implemented as part of the CVPIA. This action addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. The gravel augmentation program is expected to continue under the Second Basis of Comparison, resulting in continued improvements to physical spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon by 2030.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir, ambient air temperatures, and solar radiation, and to some extent the magnitude of Whiskeytown Dam release flows. As described above for the No Action Alternative, Whiskeytown Dam has limited temperature control capabilities; however, the Spring Creek Temperature Control Curtain continues to be operated under the Second Basis of Comparison. With increasing ambient air temperature and changes in precipitation patterns as result of global warming, it may not be possible to meet the temperature targets as often in 2030 under the Second Basis of Comparison relative to recent conditions.

*Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish. Reclamation would continue to operate Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams. As described above for the No Action Alternative, it is likely that temperature-related effects in the Sacramento River under the Second Basis of Comparison also would be unavoidable in some years; however, restoration of habitat in Battle Creek (see below) may compensate for these periods of unavoidably high temperatures by providing passage and habitat conditions to support a second population of winter-run Chinook Salmon.

The Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are anticipated to improve conditions for fish species that spawn upstream of RBDD through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

As described above for the No Action Alternative, it is anticipated that worsening temperature conditions under the Second Basis of Comparison would occur in some years as a result of increased demands for water by 2030, climate change, and less water being diverted from the Trinity River. Continued implementation of the Battle Creek Restoration Program would partially compensate for unavoidable adverse effects by restoring winter-run and spring-run Chinook Salmon habitat to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program is expected to substantially improve passage conditions for adult Chinook Salmon and steelhead relative to recent conditions. The Battle Creek Restoration Program has a goal of improving habitat for a second population component of winter-run Chinook Salmon, which could reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.

*Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River*

Feather River flows in the high flow channel downstream of Thermalito Dam under the Second Basis of Comparison would be influenced by regulation to meet water temperature criteria and to coordinate Lake Oroville releases and Delta export operations. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 under the Second Basis of Comparison and could improve fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. Implementation of the habitat improvement plan and other actions under the terms of the Settlement Agreement is anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River under the Second Basis of Comparison.

*Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River*

Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard; and SWRCB Decision 893 (D-893). Under the Second Basis of Comparison, American River flows would be influenced by releases for regulation to meet water temperature criteria, and to coordinate timed Folsom Lake releases and Delta exports. It is anticipated that conditions for fish in the lower American River under the Second Basis of Comparison would worsen relative to recent past operations of the American River Division of the CVP because of continued operation of the American River Division through 2030 to meet increasing water demands. In addition, the influence of climate change could alter hydrologic conditions in the region and affect habitat conditions for fish in the American River.

Through 2030, Reclamation would implement the flow schedule specified in the American River Flow Management Standard. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river’s aquatic resources, particularly steelhead and fall-run Chinook Salmon.

*Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River*

Under the Second Basis of Comparison, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

*Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies. However, by 2030, conditions for fish in the Stanislaus River fish are expected to worsen relative to recent conditions because of continued operation to meet increasing water demands. In addition, the influence of climate change is expected to begin to alter hydrologic conditions in the region and affect habitat conditions for fish in the Stanislaus River.

Under the Second Basis of Comparison, management of the cold water supply within New Melones Reservoir would continue, as would cold water releases from the reservoir to provide suitable temperatures for steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams, so the only mechanism for temperature management is direct flow management. This has been achieved in the recent past through a combination of augmenting baseline water operations for meeting senior water right deliveries and D-1641 water quality standards with additional flows from: 1) the CDFW fish agreement, and 2) from b(2) or b(3) water acquisitions. Access to these resources to offset operational temperature effects on steelhead in the Stanislaus River would continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the Second Basis of Comparison, steelhead would likely continue to be vulnerable to the effects of elevated temperatures in dry and critical dry years. The frequency of these occurrences is expected to increase with climate change and increased water demands.

Reclamation would continue to operate releases from the East Side Division reservoirs to achieve the minimum flow schedule specified in the 1997 New Melones Interim Plan of Operations as described in Chapter 5, Surface Water Resources and Water Supplies. Because this flow schedule has been in place for a number of years, habitat conditions for steelhead and other fish species in the Stanislaus River are not anticipated to improve under the Second Basis of Comparison relative to recent conditions.

Dam operations would continue to suppress channel-forming flows that replenish spawning beds. The physical presence of the dams impedes normal sediment transportation processes. Climate change may affect the types and cover rates of vegetation upslope of the river, potentially increasing the rate of fine sediment transport to the river and to spawning areas Ongoing gravel augmentation through 2030 is anticipated to maintain or improve physical spawning habitat conditions for steelhead.

*Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)*

Similar to the No Action Alternative, it is assumed under the Second Basis of Comparison that restoration of up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass would occur by 2030. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species. Implementation of these ecosystem restoration actions and improvements could increase winter and spring growth and survival (relative to recent conditions) of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions are also expected to reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

*Aquatic Habitat Conditions in the Delta*

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based on coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs. Similar to the No Action Alternative, reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies would be implemented, in addition to restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Under the Second Basis of Comparison, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations. Climate change would result in increased stream flows in the winter and spring months during storm events due to precipitation primarily occurring as rain instead of snowfall. The increased stream flows also would increase Delta outflow. Delta outflow also would be increased in the spring and summer months as more water is released from the CVP and SWP reservoirs to maintain salinity criteria in the western Delta in response to sea level rise.

Under the Second Basis of Comparison in 2030, many years will have passed without seasonal limitations on OMR reverse (negative) flow rates, with the anticipated result that fish entrainment would occur at levels comparable to recent historical conditions. Future pumping operations would continue to expose fish to the salvage facilities and entrainment losses into the future. As described above for the No Action Alternative, recent coded wire tagging and acoustic studies have shown that survival of hatchery-origin juvenile Chinook Salmon was higher through the south Delta via the Old River route than via the San Joaquin River and that this may be due to increased survival during salvage at the facilities

(Buchanan et al. 2013, 2015; SJRGA 2013). Zeug and Cavallo (2014) suggest that entrainment losses at the diversions may be small relative to overall migration mortality.

Furthermore, operation of the permanent gates would lead to losses associated with predation at the physical structures and the local and far-field hydraulic conditions created by the barriers. Under the Second Basis of Comparison, significant reductions in the abundance of steelhead and fall-run Chinook Salmon originating in the San Joaquin River basin, (as well as the Calaveras River and Mokelumne River basins) are likely to continue.

As described above for the No Action Alternative, abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad are currently very low, and abundance and habitat conditions for fish in the Delta in future years are difficult to predict. It is not likely that operations of the CVP and SWP under the Second Basis of Comparison would result in improvement of habitat conditions in the Delta or increases in populations for these fish by 2030, and the recent trajectory of loss would likely continue.

#### 9.4.2.3.3 Special Status Species and Critical Habitat

*Clear Creek*

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The PCEs of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. Under the Second Basis of Comparison, there would be little change in the PCEs of critical habitat for spring-run Chinook Salmon and Central Valley steelhead relative to recent conditions. Ongoing gravel augmentation in Clear Creek will likely result in improvements to Chinook Salmon and steelhead physical spawning habitat in Clear Creek. However, due to climate change, the conservation value of critical habitat for these species will likely be reduced under the Second Basis of Comparison by 2030, particularly in drier years when cold water releases cannot be maintained from Whiskeytown Dam.

*Sacramento River*

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run Chinook Salmon, spring-run Chinook Salmon, and Central Valley steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of green sturgeon. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously.

As described above for the No Action Alternative, climate change is likely to reduce the conservation value of the spawning and rearing habitat PCEs of critical habitat by increasing water temperatures. The reduction in essential features of the spawning and rearing habitat PCEs could reduce the spatial structure, abundance, and productivity of salmonids.

The year-round opening of the gates at the RBDD allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD will increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, as described above, predation on salmon, steelhead, and sturgeon would be reduced relative to recent conditions when the RBDD was operational.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

*American River*

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

*Stanislaus River*

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

*Delta*

As described above for the No Action Alternative, designated critical habitat for both winter-run and spring-run Chinook Salmon lies adjacent to the location of the DCC gates and designated critical habitat for spring-run Chinook Salmon includes the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways; however, the DCC waterway was not included in designated critical habitat for this species.

Operation of the DCC gates under the Second Basis of Comparison will continue to affect the PCEs for critical habitat designated for spring-run Chinook Salmon and steelhead, primarily, the use of the Sacramento River as a migratory corridor. The operation of the gates permits fish to enter habitat and waterways they would not normally have access to with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Operation of the gates can have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor. Without the modifications to DCC gate operations to reduce loss of emigrating salmonids and green sturgeon described for the No Action Alternative, entrainment in the DCC will continue to be similar to recent historical conditions.

#### 9.4.2.3.4 Effects Related to Cross Delta Water Transfers

As described under the No Action Alternative, all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the Second Basis of Comparison, water transfers could occur throughout the year depending upon limitations of available conveyance capacity and regulatory requirements.

##### 9.4.2.3.5 Conditions for Fish Passage

Conditions for fish passage at Shasta, Folsom, and New Melones dams under the Second Basis of Comparison would be the same as described in the Affected Environment because passage of fish to river reaches above these dams would not be provided. Populations of anadromous fish under the Second Basis of Comparison would continue to be restricted to the river reaches downstream of these dams and subjected to increasing water temperatures associated primarily with climate change.

##### 9.4.2.3.6 Ocean Conditions

Conditions for the Southern Resident Killer Whale under the Second Basis of Comparison would differ from those for the No Action Alternative, but the effects on Killer Whales would be the same.

## 9.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

### *9.4.3.1 No Action Alternative Compared to the Second Basis of Comparison*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 9.4.3.1.1 Trinity River Region

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long term average monthly water temperatures in the Trinity River at Lewiston Dam under No Action Alternative generally would be similar to the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly temperatures under the Second Basis of Comparison generally would be similar to those predicted under the No Action Alternative in most water year types, except from November through January in above- and below-normal water years when water temperatures under the No Action Alternative could be up to 1.5°F warmer than under the Second Basis of Comparison. In November of critical years, water temperatures under the No Action Alternative could be as much as 2.4°F cooler than under the Second Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly water temperatures generally would be similar (less than 0.5°F difference) under the No Action Alternative and Second Basis of Comparison from July through September, except in September of wet years when temperatures would be slightly lower (0.6°F) and in August of critical years when temperatures could be slightly (0.7°F) higher under the No Action Alternative (Appendix 6B, Table B-1-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The substantially lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from Lewiston Dam, which may provide perspective on temperature conditions in the reach below. In October and November, average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both scenarios would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the No Action Alternative and the Second Basis of Comparison.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent) under the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

As described above for Coho Salmon, the temperature differences between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-1-4) would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both the No Action Alternative and the Second Basis of Comparison, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F (Appendix 9N), the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under the No Action Alternative as compared to the Second Basis of Comparison. In September, however, the threshold for spawning (56°F) would be exceeded 9 percent of the time under the No Action Alternative, which is 2 percent less frequently than under the Second Basis of Comparison (11 percent).

The differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor, although temperature conditions under the No Action Alternative could be less likely to affect spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly (2 percent) reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in September.

Overall, water temperature differences could adversely influence spring-run Chinook Salmon in the Trinity River under the Second Basis of Comparison; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures under the No Action Alternative as compared to the Second Basis of Comparison. In addition, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison. However, the potential magnitude of these benefits is uncertain. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River.

*Fall-Run Chinook Salmon*

The potential effects of operations on fall-run Chinook Salmon were evaluated based on water temperature differences and threshold comparisons as described above for Coho and spring-run Chinook Salmon. In addition, the Reclamation Salmon Mortality Model (Appendix 9C) was applied to examine the anticipated effects of water temperature on egg mortality.

The water temperature differences in the Trinity River at Lewiston Dam between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-1-4) would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon. The lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under either the No Action Alternative or the Second Basis of Comparison.

The water temperatures in the Trinity River downstream of Lewiston Dam are reflected in the analysis the Reclamation Salmon Mortality Model. For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical years under the No Action Alternative (Appendix 9C, Table B-1-1). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar.

In summary, the temperature threshold exceedance suggests that temperature conditions under the No Action Alternative could be slightly more likely to affect fall-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly (1 percent) increased frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

Although the combined analysis based on water temperature suggests that operations under the No Action Alternative could be slightly more adverse than under the Second Basis of Comparison, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality) between the No Action Alternative as compared to the Second Basis of Comparison. In addition, these potential adverse effects could be offset by implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative, which could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.

*Steelhead*

The temperature differences between the No Action Alternative and Second Basis of Comparison (Appendix 6B) would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. The substantially lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold for spawning and the months during which it applies for steelhead are the same as those for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the spawning threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. The differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor, although temperature conditions under the No Action Alternative could be more likely to affect steelhead spawning than under the Second Basis of Comparison because of the slightly (1 percent) increased frequency of exceedance of the 56°F threshold at Lewiston Dam in October.

Although the combined analysis based on water temperature suggests that operations under the No Action Alternative could be slightly more adverse than under the Second Basis of Comparison, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between the No Action Alternative as compared to the Second Basis of Comparison. Overall, given these small differences and the inherent uncertainty in the temperature model, the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the steelhead population in the Trinity River.

*Green Sturgeon*

As described in the Affected Environment and species accounts (Appendix 9B) Green Sturgeon spawn in the lower reaches of the Trinity River from April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions from April through June in the Trinity River at Lewiston Dam under the No Action Alternative would be similar to temperatures under the Second Basis of Comparison and would not exceed 58°F during this period (Appendix 6B, Table B-1-4). In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under the No Action Alternative and the Second Basis of Comparison, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes in Trinity Lake relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in lower reservoir storage in Trinity Lake. Storage in Trinity Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Using storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, bass nest survival in Trinity Lake is near 100 percent in March and April in response to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 1-2 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is lower than in May and is slightly (about 3 percent) higher under the No Action Alternative than the Second Basis of Comparison. For Spotted Bass, the likelihood of survival being greater than 40 percent is 100 percent in May and June under both the No Action Alternative and the Second Basis of Comparison.

Overall, the comparison of storage and the analysis of nesting suggest that effects of the No Action Alternative on reservoir fishes would be similar to those under the Second Basis of Comparison.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under the No Action Alternative would be similar to (within 0.5°F) water temperatures under the Second Basis of Comparison. Changes in CVP water supplies and operations under the No Action Alternative would result in lower reservoir storage in Trinity Lake and somewhat reduced Trinity River flows in December through February in wetter years as compared to the Second Basis of Comparison. The highest reductions in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative reduction in the lower Klamath River and Klamath River estuary.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under the No Action Alternative and the Second Basis of Comparison, it is likely that the No Action Alternative would have a similar potential to affect Pacific Lamprey in the Trinity River as the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

As described in the Affected Environment, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Yurok tribal fishers. It is unclear whether this species has been extirpated from the Klamath River. Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that the No Action Alternative would have a similar potential to influence Eulachon in the Klamath River as would the Second Basis of Comparison.

#### 9.4.3.1.2 Sacramento River System

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years (Appendix 6B, Table B-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, although average monthly temperatures would increase with average monthly temperature differences between the scenarios progressively decreasing, except in September (up to 2.8°F cooler at Bend Bridge) during wetter years under the No Action Alternative (Appendix 6B, Table B-8-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have similar effects on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat higher water temperatures in September and October of critical dry years under the No Action Alternative could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this water year type. Whereas, the reduced water temperatures during September and October under the No Action Alternative in wetter years could reduce the likelihood of adverse effects on egg incubation relative to the Second Basis of Comparison.

### *Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures from April to September under both the No Action Alternative and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation (Appendix 9N). Under the No Action Alternative, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded in 42 percent of the simulated years, about 10 percent less frequently under the No Action Alternative than the Second Basis of Comparison (52 percent).

Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both the No Action Alternative and Second Basis of Comparison as high as about 90 percent in some months. Under the No Action Alternative, temperature exceedances generally would be more frequent (by up to 8 percent) than under the Second Basis of Comparison, with the exception of September, when threshold exceedances under the No Action Alternative would be about 29 percent less frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison, particularly in September. Water temperature conditions under the No Action Alternative could be more likely to result in adverse effects on winter-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from April through August. However, the substantial reduction in the frequency of exceedance in September under the No Action Alternative may reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

### *Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average temperature induced egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under the No Action Alternative. In critical dry years the average egg mortality rate would be 5.4 percent greater under the No Action Alternative compared to the Second Basis of Comparison (Appendix 9C, Table B-4). Overall, egg mortality in the Sacramento River under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

As described above for the assessment methodology, Weighted Usable Area (WUA) is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from September through August under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar (less than 5 percent differences) under the No Action Alternative and Second Basis of Comparison in all water year types (Appendix 9D, Table B-4-16).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.349 for the No Action Alternative and 0.352 for the Second Basis of Comparison Alternative (Appendix 9J) indicating that Delta survival of winter-run Chinook Salmon would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under the No Action Alternative as compared to the Second Basis alternative (Appendix 9I). The median escapement under the No Action Alternative was higher in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that the No Action Alternative values would be greater than under the Second Basis of Comparison. Median delta survival was approximately 12 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

However, the probability intervals indicated that no difference between scenarios was a highly probable outcome (Appendix 9I).

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison across the 81 years (Appendix 9H). Under the No Action Alternative, median adult escapement was 3,935 and under the Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival trajectories for winter-run Chinook Salmon under the No Action Alternative and the Second Basis of Comparison Alternative across the 81 water years. Under the No Action Alternative, median egg survival was 0.990 and under the Second Basis of Comparison median egg survival was 0.987 (Appendix 9H).

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under the No Action Alternative was indistinguishable from the Second Basis of Comparison. On the San Joaquin River near the Mokelumne River confluence, the median percent of positive velocities was slightly higher in January and February but similar in March. In Old River downstream of the facilities, the median percent of positive velocities was substantially higher under the No Action Alternative during January, moderately higher in February and slightly higher in March. On Old River upstream of the facilities, median percent of positive velocities were moderately lower under No Action Alternative relative to Second Basis of Comparison in January but similar in February and March. On the San Joaquin River downstream of Head of Old River, the median percent of positive velocities was similar for both scenarios in January, February and March. See Appendix 9K for detailed results.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios during January, February, and March when winter-run Chinook Salmon smolts are most abundant in the Delta. At the Head of Old River, median entrainment probabilities were moderately lower under the No Action Alternative during January, slightly lower during February and similar in March. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in January and February, and similar in March. Overall, entrainment patterns at the Columbia Cut junction were similar to those observed at Turner Cut. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions. See Appendix 9L for detailed results.

*Changes in Salvage*

The median proportion salvaged of Sacramento River-origin Chinook salmon is predicted to be greater under Second Basis of Comparison relative to No Action Alternative in every month. Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February, and March. Predicted values in January and February indicated a moderately reduced proportion of fish salvaged under the No Action Alternative relative to the Second Basis of Comparison. See Appendix 9M for detailed results.

*Changes in Fish Passage on the Sacramento and American Rivers*

The No Action Alternative includes provision for passage of winter-run Chinook Salmon at Shasta Dam. Similar actions are underway at some locations in the Pacific Northwest, but none have been attempted for large storage and flood control reservoirs such as Shasta Lake. There is considerable uncertainty about whether such a program could be effective. For example, the size of the reservoir would require that adults be transported not just into the lake, but possibly to the river many miles upstream. Also because of the size of the reservoir, successful volitional passage of juveniles through the reservoir is unlikely. Thus, in order for juvenile salmonid emigrants to contribute to the population, they must be captured in the river (or at the entrance to the lake) and provided with safe transport downstream. A high level of capture efficiency for emigrating juveniles is essential for the program to be successful at generating a self-sustaining population.

If a fish passage program could establish self-sustaining populations of winter-run Chinook Salmon, spring-run Chinook Salmon, and steelhead, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded approximately 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently the on the productivity of habitat upstream of these impoundments. Given the technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at Shasta Dam would be likely to affect the status of Central Valley winter-run Chinook Salmon populations.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that production escapement under the No Action Alternative would be higher than under the Second Basis of Comparison, although there would be some chance (less than a 25 percent) that escapement under the Second Basis of Comparison could be greater than the No Action Alternative in some years.

The model results suggest that effects on winter-run Chinook Salmon would be similar under both the No Action Alternative and Second Basis of Comparison, with a small likelihood that winter-run Chinook Salmon escapement would be higher under the No Action Alternative. This distinction, however, likely would be greater because of the potential benefits of providing fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, benefits to winter-run Chinook Salmon may accrue under the No Action Alternative as a result of implementation of the 2009 NMFS BO RPA action suite (IV.4), which is intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under the No Action Alternative would be less likely to result in adverse effects on winter-run Chinook Salmon than would operation under the Second Basis of Comparison. However, in consideration of the potentially beneficial effects resulting from the RPA actions that are not included in the numerical models (see Appendix 5A, Section B), the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison. The No Action Alternative includes provisions for fish passage upstream of Shasta Dam to address long-term temperature increases associated with climate change. The Second Basis of Comparison does not include fish passage provisions. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under the No Action Alternative would be less than potential effects under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a fish passage strategy to address water temperatures that NMFS (2009) indicates is critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table B-5-4). A similar pattern in water temperatures generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 3.2°F cooler at Red Bluff) during wetter years under the No Action Alternative (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative and the Second Basis of Comparison.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under the No Action Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-4). Average monthly water temperatures during May under the No Action Alternative would be lower by up to 0.8°F compared to the Second Basis of Comparison. The lower water temperatures in May associated with the No Action Alternative reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for spring-run Chinook Salmon in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under the No Action Alternative and Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and the Second Basis of Comparison generally decreasing in most water year types. However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years (Appendix 6B, Table B-23-4).

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative as compared and the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances were predicted to occur at the greatest frequency in October (82 percent of the time under the No action Alternative); the water temperature threshold would be exceeded more frequently in November (8 percent under the No Action Alternative) and not exceeded at all from December through March under the No Action Alternative (Appendix 9N). As water temperatures warm in the spring, the thresholds were predicted to be exceeded in April by 15 percent under the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if the water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful in improving water temperatures.

*Clear Creek*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 to 15 percent of the time. Water temperatures under the No Action Alternative could exceed the threshold about 3 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October (Appendix 9N). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. Water temperatures under the No Action Alternative would exceed the spawning temperature threshold about 1 percent more frequently than under the

Second Basis of Comparison in October, November, and December, and about 2 percent less frequently in March.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 9 percent more frequently than under the Second Basis of Comparison in May. Temperature conditions in the Feather River under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon spawning and rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through December.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. In critical dry years the average egg mortality rate under the No Action Alternative is predicted to be 10.4 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-3). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. However, the results of the habitat suitability/IFIM studies associated with the 2009 NMFS BO Action I.1.6 could result in changes in releases from Whiskeytown Reservoir to Clear Creek. Any changes as a result of these studies would be implemented to improve habitat for fish.

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile spring-run production would be similar under the No Action Alternative and the Second Basis of Comparison, except in critical dry water years when production under the No Action Alternative could be 11 percent less than under the Second Basis of Comparison (Appendix 9D, Table B-3-16).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for the No Action Alternative and 0.286 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median percent of time that velocity was positive was similar in March, April, and May for both scenarios (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median percent of times with positive velocities was similar in March and slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River; the median percent of time that velocity was positive was similar in March, whereas values for the No Action Alternative were slightly to moderately lower relative to the Second Basis of Comparison in April and May. In Old River upstream of the facilities median percent of time with positive velocities was similar in March, slightly higher in April, and moderately higher in May under the No Action Alternative relative to the Second Basis of Comparison. In Old River downstream of the facilities, the median percent of time with positive velocity was slightly greater in March and increasingly greater in April and May under the No Action Alternative relative to the Second Basis of Comparison.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios during March, April, and May when spring-run are most abundant in the Delta (Appendix 9L). At the Head of Old River, median entrainment probabilities were much greater under the No Action Alternative during April and May, whereas probabilities were similar in March. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative and the Second Basis of Comparison were similar in March. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of median entrainment probabilities between the scenarios were similar. Patterns of entrainment probability at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged under the No Action Alternative. Predicted salvage was more similar in March, but still moderately lower under the No Action Alternative than under the Second Basis of Comparison.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison, although production under the No Action Alternative could be over 10 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly more frequently in the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, the No Action Alternative and Second Basis of

Comparison are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

The numerical model results suggest that, overall, effects on spring-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, and with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, spring-run Chinook Salmon may benefit under the No Action Alternative by implementation of the 2009 NMFS BO RPA action suite (IV.4), which is intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including spring-run Chinook Salmon.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under the No Action Alternative suggested by the results of the numerical models may be offset by the potential benefits of the RPA actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a fish passage strategy to address water temperatures that NMFS (2009) indicates is critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under the No Action Alternative would be less than those under the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased water temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*Clear Creek*

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences) in most months (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be up to 0.8°F lower than under the Second Basis of Comparison. Fall-run Chinook Salmon spawn and rear in the lower portion of Clear Creek, generally downstream of Igo. Average monthly temperatures at the confluence with the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison, except during May. Modeled average monthly water temperatures at the confluence during May could be 0.9°F to 1.3°F lower under the No Action Alternative than under the Second Basis of Comparison.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperatures in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types. However water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when temperatures under the No Action Alternative could be as much as 0.9°F higher in below normal years (Appendix 6B, Table B-12-4). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler (Appendix 6B, Table B-14-4).

Overall, the temperature differences in the American River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly higher water temperatures in June and August in some water year types under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American

River if they are present. The slightly lower water temperatures during September under the No Action Alternative would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later, in November, but conditions for holding would be improved. Implementation of water temperature management structural improvements (2009 NMFS BO RPA Action II.3) could contribute to better water temperature conditions for fish in the American River under the No Action Alternative than under the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period are generally below 56°F, except in October. Under the No Action Alternative, the 56°F threshold would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under the No Action Alternative, about 6 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to result in adverse effects on fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the average monthly temperatures at Igo would likely remain below the 60°F threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when water temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both the No Action Alternative and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. The threshold would be exceeded under both the No Action Alternative and Second Basis of Comparison about 75 percent of the time in April. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small, with the No Action Alternative generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period. Temperature conditions in the Feather River under the No Action Alternative could be more likely to result in adverse effects on fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison in all water year types (Appendix 9C, Table B-1).

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14.5 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison in all water year types (Appendix 9C, Table B-7).

*American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under the No Action Alternative. Overall, egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-6).

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, WUA modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in September and November under the No Action Alternative as compared to the Second Basis of Comparison. Fall-run spawning WUA would be similar in October and December under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-11-4). The long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative would be more than 20 percent lower, and around 6 percent lower in November compared to the Second Basis of Comparison. November is during the peak spawning period for fall-run Chinook Salmon in the Sacramento River. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat lower under the No Action Alternative relative to the Second Basis of Comparison.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under the No Action Alternative would be similar to the amount of fry rearing habitat available under the Second Basis of Comparison (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June under the No Action Alternative and the Second Basis of Comparison. (Appendix 9E, Table C-13-4).

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

*Feather River*

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in the Feather River downstream of the Thermalito Complex during September under the No Action Alternative as compared to the Second Basis of Comparison. Fall-run Chinook Salmon spawning WUA would be similar under the No Action Alternative and Second Basis of Comparison in October and November (the peak spawning months) and in December (after the peak spawning period) in this reach (Appendix 9E, Table C-24-4). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative would be relatively large (more than 15 percent). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9E, Table C-25-4).

*Changes in SALMOD Output – Sacramento River*

SALMOD results indicate that potential juvenile production would similar under the No Action Alternative and the Second Basis of Comparison, except in critical dry water years when production could be 7 percent lower under the No Action Alternative than under the Second Basis of Comparison (Appendix 9D, Table B-1-16).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.248 for the No Action Alternative and 0.245 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May, and June. At the junction of Georgiana Slough and the Sacramento River, the median percent of time with positive velocity was similar under both scenarios in the months of April, May and June (Appendix 9K). Near the Confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and similar in June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, whereas the values were similar in June.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios in most months, but was slightly lower under the No Action Alternative relative to the Second Basis of Comparison in the month of June (Appendix 9L). Median entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. The median entrainment probability was similar under both scenarios in the month of June. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between the two scenarios were similar. Patterns in entrainment probabilities at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged under the No Action Alternative relative to the Second Basis of Comparison. Predicted salvage was more similar in March but still lower under the No Action Alternative.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under the No Action Alternative than under the Second Basis of Comparison, and up to 7 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in the Feather River and Clear Creek under the No Action Alternative and could increase the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, with a small likelihood that fall-run Chinook Salmon production would be lower under the No Action Alternative.

Additional RPA actions in the 2009 NMFS BO could help improve conditions for fall-run Chinook Salmon under the No Action Alternative relative to the Second Basis of Comparison, such as structural improvements for water temperature management in the American River (NMFS RPA Action II.3), development of a hatchery management plan for the Nimbus Hatchery (NMFS RPA Action II.6.3) and actions (NMFS RPA Action Suite IV.4) intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids.

The implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is unlikely to benefit fall-run Chinook Salmon unless passage is provided to fall-run Chinook Salmon. It is unlikely that providing similar fish passage at Folsom Dam for steelhead would benefit fall-run Chinook Salmon for the same reason.

Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under the No Action Alternative as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effect of the No Action Alternative could be offset by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Thus, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative than under the Second Basis of Comparison.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing and water temperature differences between scenarios progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento

River. Spawning of late fall-run Chinook Salmon in the Sacramento River takes place from December to mid-April with incubation occurring over the same time period and extending into June. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under the No Action Alternative and the Second Basis of Comparison due to similar water temperatures during the January to May time period.

Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under the No Action Alternative and Second Basis of Comparison would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The lower water temperatures under the No Action Alternative in September of wetter years may reduce the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both the No Action Alternative and the Second Basis of Comparison. In April, model results indicate that water temperatures under the No Action Alternative could exceed the threshold about 2 percent more frequently than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be slightly more likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.5 to nearly 5 percent in all water year types under the No Action Alternative. Overall, egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-2).

*Changes in Weighted Usable Area*

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-14-4). Modeling results also indicate that there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available in the Sacramento River from April to June under the

No Action Alternative and Second Basis of Comparison (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run Chinook Salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under the No Action Alternative and Second Basis of Comparison. There could be decreases in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to 15 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in SALMOD Output – Sacramento River*

SALMOD results indicate that potential juvenile production would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9D, Table B-2-16).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly higher under the No Action Alternative relative to the Second Basis of Comparison for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.244 for the No Action Alternative and 0.199 for the Second Basis of Comparison.

*Changes in Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with winter-run Chinook Salmon. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run are assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook

Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under the No Action Alternative and the Second Basis of Comparison. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

These model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly less adverse under the No Action Alternative than under the Second Basis of Comparison. In addition, potential adverse effects may be lessened under the No Action Alternative by actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities (NMFS RPA Action Suite IV.4) and improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be lower under the No Action Alternative compared to the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to a 3.2°F difference at Red Bluff) during wetter years (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly higher water temperatures in September of drier years under the No Action Alternative may increase the likelihood of adverse effects on steelhead adults migrating upstream in the Sacramento River. The lower water temperatures in September of wetter years under the No Action Alternative may decrease the likelihood of adverse effects on steelhead migration compared to the Second Basis of Comparison.

*Clear Creek*

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences) in most months (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be up to 0.8°F lower than under the Second Basis of Comparison.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for steelhead, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits. Overall, thermal conditions for steelhead in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types. However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than

0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on adult steelhead migration as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly warmer water temperatures in June and August under the No Action Alternative may increase the likelihood of adverse effects on steelhead rearing in the American River compared to the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either the No Action Alternative or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded 30 to 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under the Second Basis of Comparison. Overall, thermal conditions for steelhead in the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either the No Action Alternative or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures throughout the year would not exceed 56°F at Igo. Overall, thermal conditions for steelhead in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold in January and February under both the No Action Alternative and the Second Basis of Comparison. However, the differences in the frequency of exceedance between the No Action Alternative and Second Basis of Comparison during March and April would be relatively small with water temperatures under the No Action Alternative exceeding the threshold about 2 percent less frequently in March (18 percent) and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 9 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect steelhead spawning and rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F spawning threshold in March and the increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both the No Action Alternative and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small and occur only in June (1 percent less frequent exceedance under the No Action Alternative), and in September, when average monthly water temperatures under the No Action Alternative would exceed 65°F about 7 percent less frequently than under the Second Basis of Comparison. Temperature conditions in the American River under the No Action Alternative could be less likely to result in adverse effects on steelhead rearing than under the Second Basis of Comparison because of the reduced frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-20-4).

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

*Feather River*

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-22-4).

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-26-4).

*Changes in Delta Hydrodynamics*

Sacramento River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run and fall-run Chinook Salmon above.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded slightly less frequently in the Feather River under the No Action Alternative, although water temperature thresholds for steelhead rearing would be exceeded more frequently during some months in the Feather River and American River under the No Action Alternative. The increased frequency of exceedance of rearing temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the steelhead population in the Feather and American rivers.

These numerical model results suggest that overall, effects on steelhead could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, particularly in the Feather and American rivers. However, implementation of a fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery (NMFS RPA Action Suite II.6) and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities (NMFS RPA Action Suite IV.4) could benefit steelhead under the No Action Alternative in comparison to the Second Basis of Comparison. Thus, it is concluded that the effects on steelhead would be less adverse under the No Action Alternative than under the Second Basis of Comparison.

*Green Sturgeon*

Potential effects on Green Sturgeon were evaluated based on anticipated water temperature conditions and exceedances of established temperature thresholds in the Sacramento and Feather rivers. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

*Changes in Water Temperature*

The effects of the No Action Alternative compared to the Second Basis of Comparison on Green Sturgeon were analyzed based on water temperature model outputs and comparisons of the frequency of water temperature threshold exceedances in the Sacramento and Feather rivers.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball’s Ferry Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Sacramento River.

### *Feather River*

Long-term average monthly water temperatures in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than the Second Basis of Comparison in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the water temperature differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types at the confluence with Sacramento River (Appendix 6B, Table B-23-1). However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River.

### *Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the exceedances for each of those rivers.

### *Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under the No Action Alternative occurring about 7 percent of the time in August and about 12 percent of the time in September. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 63°F threshold in August and September.

### *Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenario would occur in July and August. The frequency of exceedances would be high, with both the No Action Alternative and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Average monthly water temperatures under the No Action Alternative would exceed the threshold about 9 percent more frequently than under the Second Basis of Comparison during May and about 35 percent less frequently in September. Temperature conditions in the Feather River under the No Action Alternative could be more likely result in adverse effects on Green Sturgeon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Green Sturgeon*

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded more frequently during some months in the Feather River but would be exceeded substantially less frequently in September under the No Action Alternative.

The increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile Green Sturgeon relative to the Second Basis of Comparison. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of Green Sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under the No Action Alternative would exceed this threshold about 55 percent of the time (about 6 percent more frequently than under the Second Basis of Comparison). In June, average monthly water temperatures under the No Action Alternative would exceed the threshold about 86 percent of the time (about 13 percent more frequently than under the Second Basis of Comparison). Average monthly water temperatures during May and June under the No Action Alternative would as high as about 65°F which is below the 68°F threshold considered lethal for White Sturgeon eggs and may cause higher growth rates in juvenile white sturgeon. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on White Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of White Sturgeon.

Overall, the increased frequency of exceedance of temperature thresholds in June under the No Action Alternative could increase the potential for effects on White Sturgeon in the Sacramento River relative to the Second Basis of Comparison, however these effects are uncertain and may include reduced spawning and/or increased growth. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile White Sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

*Delta Smelt*

The potential effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on differences in proportional entrainment and the fall abiotic index as described below.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under the No Action Alternative would be similar to results under the Second Basis of Comparison.

A proportional entrainment regression model (based on Kimmerer 2008) was also used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June (Appendix 9G). Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be lower than projected entrainment under the Second Basis of Comparison by up to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical water year conditions, at 23.6 percent.

The predicted position of Fall X2 (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or

X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010).

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under the No Action Alternative would be similar to results under the Second Basis of Comparison in drier water year types. In wetter years, the X2 location would be further west under the No Action Alternative than under the Second Basis of Comparison, by 6.1 to 9.8 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in above normal and wet year types. Under the Second Basis of Comparison, the long-term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, the No Action Alternative likely would result in better conditions for Delta Smelt than would the Second Basis of Comparison, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

*Longfin Smelt*

The effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months under the Second Basis of Comparison, with the long-term average ranging from -3,700 to -7,400 cfs from December through June; whereas the OMR flows would generally be less negative during this time period under the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be positive under the No Action Alternative (Appendix 5A, Table C-17-4). The decrease in the magnitude of negative flows, with positive flows in April and May, under the No

Action Alternative as compared to the Second Basis of Comparison suggests that it could reduce the potential for entrainment of Delta Smelt at the export facilities.

Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147, under critical water year conditions, to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 during critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. These results suggest that the Longfin Smelt abundance index values would be higher in every water year type under the No Action Alternative as compared to the Second Basis of Comparison, with a long-term average index for the No Action Alternative that is almost 10 percent higher than the long-term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent higher under the No Action Alternative than under the Second Basis of Comparison, with the greatest difference (26.2 percent) predicted under dry conditions.

Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under the No Action Alternative likely would be less than under the Second Basis of Comparison.

*Sacramento Splittail*

Sacramento Splittail could benefit from the increase in inundated floodplain resulting from implementation of 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Rearing Habitat, which would restore 17,000 to 20,000 acres for the primary purpose of enhancing rearing habitat for juvenile salmonids. The efforts currently underway in the Yolo Bypass to comply with this action apply to all alternatives under consideration and it is assumed that a notch in the Fremont Weir (6,000 cfs capacity) will be constructed and that the inundation objectives will be met by 2030. It is not currently known if and how the notch would be operated and how flows entering the bypass would be managed to accommodate floodplain rearing.

While this action is common to all alternatives, changes in operations that influence the hydrology in the Sacramento River could affect the frequency and duration of flows available to provide inundation on the bypass. To generally evaluate the potential influence of these changes in hydrology, the flows entering the Yolo Bypass during December through April were examined to determine the differences among alternatives. It was assumed that the magnitude of flow (and flow change) roughly corresponds to the amount of inundated floodplain.

Under the No Action Alternative, flows entering the Yolo Bypass generally would be lower than under the Second Basis of Comparison from December through March, especially during wetter years (Appendix 5A, Table C-26-4). These decreases would occur during periods of relatively high flow in the bypass, and may only slightly decrease the potential area of inundation.

Overall, the slight flow decreases under the No Action Alternative could result in less spawning habitat for Sacramento Splittail than under the Second Basis of Comparison because of the decreased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between the No Action Alternative and Second Basis of Comparison.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

*Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

*Changes in Black Bass Nesting Success*

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations (Appendix 9F). For May and June, the likelihood of nest survival for Largemouth Bass in Shasta Lake being in the 40 to 100 percent range is similar under the No Action Alternative and the Second Basis of Comparison; however, nest survival of greater than 40 percent in June is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is generally high (near 100 percent) from March to May under both the No Action Alternative and the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is about 10 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under the No Action Alternative as compared to the Second Basis of Comparison; about 10 percent higher in May and 3 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (>90 percent) in May under both the No Action Alternative and the Second Basis of Comparison with the likelihood of greater than 40 percent survival similar under the No Action Alternative and the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially (about 20 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is around 5 percent higher under the No Action Alternative than under the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is about 5 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

*Summary of Effects on Reservoir Fishes*

Reservoir storage is anticipated to be reduced under the No Action Alternative relative to the Second Basis of Comparison and this reduction could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under the No Action Alternative would be similar under the Second Basis of Comparison from March through May and somewhat higher in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 2.8°F cooler) at Bend Bridge) during wetter years under the No Action Alternative. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel (downstream of the Thermalito Complex) generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years (Appendix 6B, Table B-20-4). Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between the No Action Alternative and Second Basis of Comparison would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years (Appendix 6B, Table B-23-4).

Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

The following describes temperature conditions in the Sacramento, Feather, and American rivers.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel (below the Thermalito Complex) generally were predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures would be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-4). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the Feather River.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the American River.

*Changes in Position of X2*

The No Action Alternative would result in a more westward X2 position as compared to the Second Basis of Comparison during April and May, with similar values in June (Appendix 5A, Section C Table C-16-4). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely increase the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

*Summary of Effects on Striped Bass, American Shad, and Hardhead*

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. Overall, the No Action Alternative likely would be similar for Hardhead and have a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival during larval and juvenile life stages, and more favorable location of Spring X2 on average.

#### 9.4.3.1.3 Stanislaus River/Lower San Joaquin River

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower in all water year types than the Second Basis of Comparison by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative and Second Basis of Comparison generally would be similar. An exception to this pattern occurs in April when average monthly water temperatures in all but wet water year types would be lower under the No Action Alternative by as much as about 1.2°F (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F in October and 2.0°F in April (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations with average June water temperatures reaching 2.4°F warmer under the No Action Alternative in wet years.

Based on the life history timing for fall-run Chinook Salmon, the lower temperatures in October under the No Action Alternative may reduce the likelihood of adverse to fall-run Chinook Salmon spawning and egg incubation as compared to the Second Basis of Comparison.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November approximately 30 percent of the time in the Stanislaus River at Goodwin Dam under the No Action Alternative (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the Second Basis of Comparison, although slightly less frequently in November. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both the No Action Alternative and the Second Basis of Comparison (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56°F in March (less than 10 percent of the time) and May (about 30 percent of the time) under the No Action Alternative which is about 10 percent more frequently in May than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 14 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality in the Stanislaus River would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-8).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the Confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and similar in June (Appendix 9K). In Old River downstream of the facilities, the median proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the proportion of positive velocities was slightly to moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, whereas the values were similar in June.

*Changes in Junction Entrainment*

Median entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. The median entrainment probability was similar under both scenarios in the month of June (Appendix 9L). At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two scenarios were similar. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Fish Passage on the Stanislaus River*

The No Action Alternative includes the provision of passage at New Melones Dam for steelhead. The challenges and difficulties associated with providing fish passage upstream of Shasta and Folsom dams were briefly summarized previously, and the same considerations apply to passage upstream of New Melones Dam.

If a fish passage program could establish self-sustaining populations of spring-run Chinook Salmon and steelhead upstream of New Melones, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently on the quantity, suitability, and accessibility of habitat upstream of New Melones. Given poor habitat data and the considerable technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at New Melones Dam are likely to affect the status of Central Valley spring-run Chinook Salmon and steelhead populations.

While the purpose of the fish passage action is not intended to benefit fall-run Chinook Salmon, it could provide benefit if passage is provided for fall-run Chinook Salmon.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. In the Stanislaus River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for fall-run Chinook Salmon spawning/egg incubation under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in November, but substantially less frequently in October under the No Action Alternative. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat more frequently under the No Action Alternative. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for spring-run Chinook Salmon and steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would provide some benefit to fall-run Chinook Salmon if passage for adult fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain. Moreover, RPA actions intended to increase the efficiency of the Tracy and

Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

The numerical model results for effects on fall-run Chinook Salmon under the No Action Alternative and Second Basis of Comparison do not definitively show distinct differences. Because the No Action Alternative has the potential for beneficial effects resulting from the RPA actions, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative relative to the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when water temperatures under the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower than the Second Basis of Comparison in all water year types by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative and Second Basis of Comparison generally would be similar, except in April when average monthly water temperatures would be lower under the No Action Alternative by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations with average June water temperatures reaching 2.4°F warmer under the No Action Alternative in wet years.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. Based on the life history timing for steelhead, the slightly higher temperatures in June and September of drier years under the No Action Alternative may increase the likelihood of adverse effects to steelhead rearing in the Stanislaus River; the lower temperatures in October under the No Action Alternative may reduce the likelihood of adverse effects on adult steelhead during their upstream migration.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either the No Action Alternative or Second Basis of Comparison during January or February. From March through May, however, exceedances would occur under both the No action Alternative and Second Basis of Comparison, with the threshold most frequently exceeded (nearly half the time) under the No Action Alternative in May (Appendix 9N). Average monthly water temperatures under the No Action Alternative would exceed the threshold 5 percent more frequently in March, 6 percent more frequently in May, and 17 percent less frequently in April than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both the No Action Alternative and Second Basis of Comparison in all months but November, and would exceed the threshold about 16 percent of the time in July under both the No Action Alternative and Second Basis of Comparison. The differences between the No Action Alternative and Second Basis of Comparison range from 1 percent less frequent exceedance in October to 4 percent more frequent exceedance in June under the No Action Alternative.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under the No Action Alternative would exceed 52°F in March, April, and May about 8 percent, 33 percent, and 63 percent of the time, respectively. Water temperatures under the No Action Alternative would result in exceedances occurring about 1 to 2 percent less frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under the No Action Alternative and the Second Basis of Comparison would not exceed the threshold during January through March. In April and May, exceedances of 2 percent and 18 percent would occur under the No Action Alternative, which represent a frequency of about 6 percent less than the Second Basis of Comparison in April and about an 8 percent higher frequency in May.

Overall, the differences in exceedance frequency between the No Action Alternative and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under the No Action Alternative would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the exceedance frequency would be about 17 percent less. Given the frequency of exceedance under both the No Action Alternative and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under the No Action Alternative suggest that there would be less potential to for adverse effects on steelhead under the No Action Alternative than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under the No Action Alternative suggest that there would be less potential to result in adverse effects on steelhead under the No Action Alternative than under the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for fall-run Chinook Salmon in the San Joaquin River basin above.

*Summary of Effects on Steelhead*

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for steelhead rearing under the No Action Alternative. Water temperatures could be somewhat less suitable during the adult upstream migration period under the No Action relative to the Second Basis of Comparison. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded less frequently in October, but more frequently in November under the No Action Alternative. The water temperature threshold for steelhead spawning would also be exceeded less frequently under the No Action Alternative. The water temperature threshold for steelhead rearing generally would be exceeded more frequently under the No

Action Alternative, while the temperature thresholds for smoltification would be exceeded less frequently in most months.

Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, however, the extent of benefit is uncertain. In addition, the potential effects of the No Action Alternative could be offset by the RPA actions intended to reduce predation risk on steelhead in the Stanislaus River, provide passage to upstream habitat, and to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. The actions to augment spawning gravel in the Stanislaus River under the No Action Alternative also could benefit steelhead.

The numerical model results for effects on steelhead under the No Action Alternative and Second Basis of Comparison do not definitively show distinct differences. However, in consideration of the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical models (see Appendix 5A, Section B), the No Action Alternative has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. The No Action Alternative includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on steelhead under the No Action Alternative would be clearly less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Table 5.16, due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage in New Melones could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, predicted survival in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent would be about 13 percent lower under the No Action Alternative than under the Second Basis of Comparison, but still would be relatively high (around 80 percent). For May, this pattern is reversed with the likelihood of high nest survival being similar under the No Action Alternative and the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is also higher (by about 8 percent) under the No Action Alternative as compared to the Second Basis of Comparison. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both the No Action Alternative and Second Basis of Comparison.

The somewhat lower likelihood of high nesting survival for Largemouth and Smallmouth Bass during April is not expected to adversely affect nesting success because the likelihood of successful nesting would be relatively high. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under the No Action Alternative generally would be similar to, although somewhat higher than, under the Second Basis of Comparison, except in April when average monthly water temperatures in all water year types would be lower under the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or water temperature increases could result in adverse effects on larval lamprey. Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

### *9.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because aquatic resource conditions under Alternative 1 are identical to aquatic resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 9.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 1 generally would be similar to the water temperatures that would occur under the No Action Alternative (Appendix 6B, Table B-1-1). Average monthly temperatures under Alternative 1 generally would be similar to those predicted under the No Action Alternative in most water year types, except from November through January in above- and below-normal water years when water temperatures under Alternative 1 could be up to 1.5°F cooler than under the No Action Alternative. In November of critical years water temperatures under Alternative 1 could be as much as 2.4°F warmer than under the No action Alternative (Appendix 6B, Table B-1-1). Average monthly water temperatures generally would be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative from July through September, except in September of wet years when temperatures would be slightly (0.7°F) lower under Alternative 1.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from the Lewiston Dam, which may provide perspective on temperature conditions in the reach below. In October and November, average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both scenarios would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the Alternative 1 and the No Action Alternative.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent) under Alternative 1. The higher water temperatures in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), Alternative 1 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The higher average monthly water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both Alternative 1 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F, the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under Alternative 1 as compared to the No Action Alternative. In September, however, the threshold for spawning (56°F) would be exceeded 11 percent of the time under Alternative 1 which is about 2 percent more frequently than under the No Action Alternative.

Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor, although temperature conditions under Alternative 1 could be slightly more likely to result in adverse effects on spring-run Chinook Salmon spawning than under the No Action Alternative because of the increased frequency of exceedance of the 56°F threshold at Lewiston Dam in September.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperatures under Alternative 1 could result in adverse effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences water temperatures under Alternative 1 as compared to the No Action Alternative.

Overall, Alternative 1 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 1. Thus, given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River.

*Fall-Run Chinook Salmon*

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. In addition, the Reclamation Salmon Mortality Model was used to assess egg mortality.

As described above for Coho Salmon, the temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Trinity River. The higher water temperatures (as much as 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both Alternative 1 and the No Action Alternative. Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 1 could be slightly less likely to result in adverse effects on fall-run

Chinook Salmon spawning than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical dry years under the No Action Alternative (Appendix 9C, Table B-1-5). Overall, egg mortality under Alternative 1 and the No Action Alternative would be similar in all water year types.

Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (and similar egg mortality) between Alternative 1 and the No Action Alternative. In addition, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 1.

Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with the Hatchery Management Plan, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

*Steelhead*

The analysis of effects associated with changes in operation on steelhead relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. The higher water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for steelhead are the same as those described for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. Water temperature conditions under Alternative 1 could be less likely to affect steelhead spawning than under the No Action Alternative because of the slightly (1 percent) reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. The biological significance of this difference, however, is uncertain.

Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between Alternative 1 and the No Action Alternative. Overall, given these small differences in water temperatures and the inherent uncertainty in the temperature model, Alternative 1 and the No Action Alternative are likely to have similar effects on steelhead in the Trinity River.

*Green Sturgeon*

The analysis of effects associated with changes in operation on Green Sturgeon relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 1 would be similar to the temperatures under the No Action Alternative and would not exceed 58°F during this period. In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 1 and the No Action Alternative, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could increase by up to about 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would not be reduced under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, nest survival in Trinity Lake is near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 2 percent) higher under Alternative 1 as compared to the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is somewhat lower than in May and is slightly lower (about 2 percent) under Alternative 1 as compared to the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under Alternative 1 and the No Action Alternative.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 1 on reservoir fishes would be similar to those under the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 1 generally would be similar to (less than 0.5°F differences) to those under the No Action Alternative. Given the similarities in water temperatures, it is likely that the effects on Pacific Lamprey would be similar under Alternative 1 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

It is unclear whether this species has been extirpated from the Klamath River. Given that the highest increases in flow under Alternative 1 would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 1 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar to (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years in some water year types(up to 0.3°F) (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures differences between the scenarios progressively decreasing, except in September (up to 2.8°F warmer at Bend Bridge) during wetter years under Alternative 1 (Appendix 6B, Table B-8-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have similar effects on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat lower water temperatures in September and October of critical dry years under the No Action Alternative could reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. However, the increased water temperatures during this time period under Alternative 1 in wetter years could increase the likelihood of adverse effects on egg incubation relative to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures from April to September under both Alternative 1 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation (Appendix 9N). Under Alternative 1, the temperature threshold generally would be exceeded less frequently than under the No Action Alternative (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded in 52 percent of the simulated years about 10 percent more frequently under Alternative 1 than the No Action Alternative (42 percent). Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 1 and the No Action as Alternative as high as about 90 percent in some months. Under Alternative 1, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when threshold exceedances under Alternative 1 would be about 29 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative, particularly in September. Temperature conditions under Alternative 1 would reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August. However, the substantial increase in the frequency of exceedance in September under Alternative 1 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 1. In critical dry years the average egg mortality rate would be 5.4 percent lower under Alternative 1 than under the No Action Alternative (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

As described above for the assessment methodology, Weighted Usable Area (WUA) is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under Alternative 1 and the No Action Alternative (Appendix 9E).

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 1 and the No Action Alternative (Appendix 9E).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from September through August under Alternative 1 and the No Action Alternative (Appendix 9E).

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar to the No Action Alternative (Appendix 9D, Table B-4-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.352 for Alternative 1 and 0.349 for the No Action Alternative.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 1 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 1 was lower in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 1 values would be lower than under the No Action Alternative. Median delta survival was approximately 12 percent lower under Alternative 1 as compared to the No Action Alternative. However, the probability intervals indicated that no difference between scenarios was a likely outcome.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median adult escapement was 4,042 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 1 was indistinguishable from the No Action Alternative (Appendix 9K).

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during January, February and March when winter-run Chinook Salmon smolts are most abundant in the Delta (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February and March. Predicted values in January and February indicated a moderate increase in the proportion of fish salvaged under Alternative 1 relative to the No Action Alternative.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 1 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 1 would be lower than under the No Action Alternative, although there would be some chance (less than a 25 percent) that escapement under the Alternative 1 could be greater than the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 1 than under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset or reversed by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would be more likely to result in adverse effects on winter-run Chinook Salmon than would the No Action Alternative. In addition, the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical models (see Appendix 5A, Section B) suggest that the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Alternative 1. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 1 would be greater than those under the No Action Alternative, principally because Alternative 1 does not include fish passage to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences between scenarios progressively decreasing, except in September (up to 3.2°F warmer at Red Bluff) during wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 could be higher by up to 0.8°F than under the No Action Alternative. Overall, thermal conditions for spring-run Chinook Salmon in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures from July to September under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (79 percent of the time under Alternative 1); under Alternative 1 the water temperature threshold would be exceeded less frequently in November (7 percent of the time under Alternative 1) and not exceeded at all from December through March (Appendix 9N). As water temperatures warm in the spring, the thresholds would be exceeded in April by 15 percent under Alternative 1. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

*Clear Creek*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time (Appendix 9N). Water temperatures under Alternative 1 could exceed the threshold about 3 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October (Appendix 9N). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

*Feather River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. However, water temperatures under Alternative 1 would exceed the spawning temperature threshold about 1 percent less frequently than under the No Action Alternative in October, November, and December, and about 2 percent more frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. In critical dry years the average egg mortality rate under Alternative 1is predicted to be 10.4 percent lower than under the No Action Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that potential spring-run juvenile production would be similar under Alternative 1 and the No Action Alternative except that production under Alternative 1 could be 12 percent higher than under the No Action Alternative in critical dry years (Appendix 9D, Table B-3-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 1 and 0.296 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median percent of time that velocity was positive was similar in March, April, and May for both scenarios. In Old River upstream of the facilities, the median percent of time with positive velocity was similar in March, slightly lower in April, and moderately lower in May under Alternative 1 relative to the No Action Alternative (Appendix 9K). In Old River downstream of the facilities the median percent of time with positive velocity was slightly lower in March and increasingly lower in April and May under Alternative 1 relative to No Action Alternative.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during March, April and May when spring run are most abundant in the Delta (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March April and May. Predicted values in April and May indicated a substantially larger fraction of fish salvaged under Alternative 1. Predicted salvage was more similar in March but still higher under Alternative 1 than under the No Action Alternative.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 1 and the No Action Alternative, although production under Alternative 1 could be over 10 percent greater than under the No Action Alterative in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 1 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat more suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly less frequently under Alternative 1 than under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly less frequently in the Feather River under Alternative 1. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 1 could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, Alternative 1 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly less adverse under Alternative 1 than the No Action Alternative. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of spring-run Chinook Salmon under the No Action Alternative.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 1 would be greater than under the No Action Alternative, principally because Alternative 1 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball’s Ferry Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the o Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon under Alternative 1, although the reduced water temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar (less than 0.5°F) from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 would be higher by up to 0.8°F than under the No Action Alternative. Average monthly temperatures at the confluence with the Sacramento River would exhibit a similar pattern, although temperatures in the creek would be slightly higher in general.

Under Alternative 1, temperature conditions at Igo would be similar to temperature conditions under the No Action Alternative. However, these temperature outputs represent conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning and rearing. Water temperatures where most fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 1 and the No Action Alternative. Overall, thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperatures differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*American River*

Long-term average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years (Appendix 6B, Table B-12-1). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer (Appendix 6B, Table B-14-1).

Overall, the temperature differences in the American River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly lower water temperatures in June and August in some water year types under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they are present. The slightly higher water temperatures during September under Alternative 1 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally fall below 56°F, except in October. Under Alternative 1, the 56°F threshold would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with the 56°F threshold exceeded slightly less frequently under Alternative 1 compared to the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the average monthly temperatures at Igo would likely remain below the 60°F rearing threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 1 and the No Action Alternative (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when this temperature threshold would be exceeded frequently (Appendix 6B, Table B-22-4). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 1 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 1 and the No Action Alternative about

85 percent of the time in April. The differences between Alternative 1 and the No Action Alternative, however, would be relatively small, with water temperatures under Alternative 1 generally exceeding the spawning temperature threshold about 1-2 percent less frequently than under the No Action Alternative during the October through April period. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would similar under Alternative 1 and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 17 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would similar under Alternative 1 and the No Action Alternative in all water year types (Appendix 9C, Table B-7).

*American River*

For fall-run Chinook Salmon in the American River, the predicted long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 1. The predicted egg mortality rate would similar under Alternative 1 and the No Action Alternative (Appendix 9C, Table B-6).

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September and November under Alternative 1 as compared to the No Action Alternative. Fall-run spawning WUA would be similar in October and December, under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-11-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than

20 percent) and around 6 percent higher in November. November is during the peak spawning period for fall-run Chinook Salmon in the Sacramento River. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat higher under Alternative 1 relative to the No Action Alternative.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under Alternative 1 would be similar to the amount of fry rearing habitat available under the No Action Alternative (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-13-4).

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September under Alternative 1 as compared to the No Action Alternative; fall-run Chinook Salmon spawning WUA would be similar in October and November (the peak spawning months) and in December (after the peak spawning period) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than 15 percent). Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 1 as compared to the No Action Alternative (Appendix 9E, Table C-25-4).

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs would be approximately 16 percent lower under Alternative 1, primarily due to reduced summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be increased by 8 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 11 percent lower under Alternative 1 (Appendix 9D, Table B-1-4). Flow (habitat)-related fry mortality would be similar under Alternative 1 and the No Action Alternative. Temperature-related juvenile mortality would be approximately 21 percent lower under Alternative 1, while flow (habitat)-related mortality would be similar under Alternative 1 and the No Action Alternative. Overall, potential fall-run juvenile production would be similar under Alternative 1 and the No Action Alternative, but up to 12 percent greater than under the No Action Alternative in critical dry years (Appendix 9D, Table B-1-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for fall-run between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.245 for Alternative 1 and 0.248 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, median percent of time with positive velocity was similar under both Alternative 1 and No Action Alternative in the months of April, May and June (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly lower under Alternative 1 relative to No Action Alternative in April and May and similar in June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action Alternative but became more similar in June (Appendix 9K). In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately lower for Alternative 1 relative to No Action Alternative in April and May, respectively and slightly higher in June (Appendix 9K). On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately higher under Alternative 1 relative to No Action Alternative in April and May, respectively, whereas the values were similar in June (Appendix 9K).

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and the No Action Alternative in most months but was slightly higher under Alternative 1 in the month of June (Appendix 9L). Median entrainment probabilities at the Head of Old River were much lower under Alternative 1 relative to the No Action Alternative during April and May. The median entrainment probability was similar under both alternatives in the month of June. At the Turner Cut junction, median entrainment probabilities under Alternative 1 were slightly higher than under the No Action Alternative in June. During April and May, median entrainment probabilities were more divergent with moderately higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between the two alternatives were similar. Patterns in entrainment probabilities at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 1 relative to No Action Alternative. Predicted salvage was more similar in March but still higher under Alternative 1.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under Alternative 1 than under the No Action Alternative, and up to 12 percent greater than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 1 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 1 than the No Action Alternative, with a small likelihood that fall-run Chinook Salmon production would be higher under Alternative 1 due to increased production potential in critical dry years. This potential distinction between the two scenarios, however, may be partially balanced by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential benefit, however, would only apply if passage is provided for adult fall-run Chinook Salmon that allows access to additional habitat. In addition, RPA actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

The results of the numerical models suggest that Alternative 1 is less likely to result in adverse effects on fall-run Chinook Salmon than the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios in June at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 1 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 1 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The higher water temperatures under Alternative 1 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In April, model results indicate that water temperatures under Alternative 1 would exceed the threshold about 2 percent less frequently than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be slightly less likely to result in adverse effects on late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2 to nearly 5 percent in all water year types under Alternative 1. Overall, egg mortality would be similar under Alternative 1and the No Action Alternative (Appendix 9C, Table B-2).

*Changes in Weighted Usable Area*

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-14-4). Modeling results also indicate that there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available from April to June under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under Alternative 1 and the No Action Alternative. There could be an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to 15 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under Alternative 1 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar under Alternative 1 and the No Action Alternative (Appendix 9D, Table B-2-1).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly lower under Alternative 1 relative to the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 1 and 0.244 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

The late fall run Chinook migration period overlaps with winter-run. See the section on hydrodynamic analysis for winter run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 1 and the No Action Alternative. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month. Actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of late fall-run Chinook Salmon.

Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that Alternative 1 and the No Action Alternative would have similar effects on fall-run Chinook Salmon.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's

Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences between scenarios progressively decreasing, except in September (up to a 3.2°F warmer at Red Bluff) during wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly lower water temperatures in September and October of drier years under Alternative 1 may reduce the likelihood of adverse effects on steelhead adults migrating upstream in the Sacramento River. The higher water temperatures in September of wetter years under Alternative 1 may increase the likelihood of adverse effects on steelhead migration compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 are generally predicted to be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 could be higher by up to 0.8°F than under the No Action Alternative in all water year types. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between Alternative 1 and the No Action Alternative exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. Water temperatures under Alternative 1 are predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with Sacramento River from July to September in wetter years than under the No Action Alternative.

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on adult steelhead migration as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the decreased temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly cooler water temperatures in June and August under Alternative 1 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

Steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 1 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this water temperature would be exceeded 30 to 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under Alternative 1. Overall, thermal conditions for steelhead in the Sacramento River would be similar under Alternative 1 and the No Action Alternative.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under Alternative 1 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold from December through February under Alternative 1. However, the differences in the frequency of exceedance between Alternative 1 and No Action Alternative during March and April would be relatively small with water temperatures under Alternative 1 exceeding the threshold about 2 percent more frequently in March (20 percent) and the same exceedance frequency (75 percent) as the No Action Alternative in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F spawning threshold in March and the increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 1 and No Action Alternative, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences in exceedance frequency between Alternative 1 and No Action Alternative, however, would be relatively small and only occur in June (1 percent more frequent exceedance under Alternative 1), and in September, when average monthly water temperatures under Alternative 1 would exceed 65°F about 7 percent more frequently than under the No Action Alternative. Temperature conditions in the American River under Alternative 1 could be more likely to result in adverse effects on steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-20-4).

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-22-4).

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 1 and the No Action Alternative.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 1 and the No Action Alternative. The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities.

The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 1. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River and could reduce the potential for adverse effects on the steelhead population in the Feather River.

The numerical model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 1 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to Alternative 1. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 1 would be greater than those under the No Action Alternative.

*Green Sturgeon*

The effects on Green Sturgeon were analyzed by comparing changes in water temperature and the frequency of temperature threshold exceedance between Alternative 1 and the No Action Alternative. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

*Changes in Water Temperature*

The effects of Alternative 1 compared to the No Action Alternative on Green Sturgeon were analyzed based on water temperature model outputs and comparisons of the frequency of water temperature threshold exceedances in the Sacramento and Feather rivers.

*Sacramento River*

As described previously, long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action

Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon. Increased temperatures in September are likely not to be lethal, but may increase growth of juvenile green sturgeon if food was not limiting.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years.

Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in

August and September, with exceedances under Alternative 1 occurring about 6 percent of the time in August and about 10 percent of the time in September. This is 1 to 2 percent less frequent than under the No Action Alternative. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with water temperatures under both Alternative 1 and No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly water temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 1 would exceed the threshold during May about 9 percent less frequently than the No Action Alternative and about 35 percent more frequently in September. Temperature conditions in the Feather River under Alternative 1 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 1 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 12 percent lower under Alternative 1 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Green Sturgeon*

The temperature model outputs for the Sacramento and Feather rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 1 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River, but would be exceeded more frequently in September under Alternative 1 and could reduce the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon relative to the No Action Alternative. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 1 and No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 1 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than under the No Action Alternative). In June, the average monthly water temperature under Alternative 1 would exceed the threshold about 74 percent of the time (about 13 percent less frequently than under the No Action Alternative). Average monthly water temperatures during May and June under Alternative 1 would as high as about 64°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to result in adverse effects on White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 12 percent lower under Alternative 1 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative.

*Delta Smelt*

The potential for effects on Delta Smelt resulting from Alternative 1 as compared to the No Action Alternative were analyzed using changes in proportional entrainment and fall abiotic habitat index values.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 1 would be 9 percent (long term average percent entrainment). Percent entrainment of adult Delta Smelt under Alternative 1 would be similar to results under the No Action Alternative.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be 15.5 percent, long-term average, and highest entrainment of 23.6 percent under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be higher than results under the No Action Alternative, by up to 9.4 percent. Under the No Action Alternative, the long term average percent entrainment would be 8.6 percent, and highest entrainment would occur under Critical water year conditions, at 19.3 percent.

The predicted location of Fall X2 position (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile delta smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010). The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared.

Alternative 1 does not include the operations related to the 2008 USFWS BO RPA Component 3 (Action 4), Fall X2 requirement while the No Action Alternative includes it. Therefore, the average September through December X2 position under Alternative 1 would be eastward by over 6 km compared to the No

Action Alternative during the wetter years. In the drier years September through December average X2 position is similar under both scenarios.

Overall, Alternative 1 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

*Longfin Smelt*

The effects of the Alternative 1 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

The OMR flows would generally be negative in all months under Alternative 1, with the long-term average ranging from -3,700 to -7,400 cfs from December through June (Appendix 5A). The OMR flows generally would be more negative during this time period under Alternative 1 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 1 and positive under the No Action Alternative (Appendix 5A, Table C-17-4). The increase in the magnitude of negative flows, with negative flows in April and May, under Alternative 1 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 1, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 1 than they would be under the No Action Alternative, with a long-term average index for Alternative 1 that is almost 10 percent lower than the long-term average index for the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent lower under Alternative 1 than they would be under the No Action Alternative, with the greatest difference (26.2 percent) predicted under dry conditions. Based on the Longfin Smelt abundance indices, Alternative 1 likely would have adverse effects on Longfin Smelt, as compared to the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under Alternative 1 likely would be greater than under the No Action Alternative.

*Sacramento Splittail*

Under Alternative 1, flows entering the Yolo Bypass generally would be higher than under the No Action Alternative from December through March, especially during wetter years (Appendix 5A, Table C-26-1). These increases would occur during periods of relatively high flow in the bypass, and could slightly increase the area of inundation. Thus, Alternative 1 could result in a slight increase in spawning habitat for Sacramento Splittail as a result of the increased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 1 and the No Action Alternative.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

*Changes in Available Habitat (Storage)*

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 1 as compared to the No Action Alternative, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest increases in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake and New Melones could be increased by up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could increase under Alternative 1 as compared to the No Action Alternative.

*Changes in Black Bass Nesting Success*

As shown in Appendix 9F, black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May and June, the likelihood of nest survival for Largemouth

Bass in Shasta Lake being in the 40 to 100 percent range is similar under Alternative 1 and the No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of high nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) from March to May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of nest survival being greater than 40 percent is about 10 percent less under Alternative 1 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is somewhat (4 to 10 percent) lower under Alternative 1 than under the No Action Alternative. However, in June, nest survival of greater than 40 percent is likely only in about 35 percent of the years evaluated under Alternative 1. The likelihood of high nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 1 and the No Action Alternative with the likelihood of greater than 40 percent survival being similar under Alternative 1 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 1 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is about 5 percent lower under Alternative 1 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is around 5 percent lower under Alternative 1 as compared to the No Action Alternative.

*Summary of Effects on Reservoir Fishes*

The analysis of the effects of Alternative 1 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 1 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 1 and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 2.8°F warmer) at Bend Bridge) during wetter years under Alternative 1. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 generally could be up to 1.3°F higher than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types However, water temperatures from July to September under Alternative 1 could be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with Sacramento River in wetter years

Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods under Alternative 1 and the No Action Alternative.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when water temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Based on the similar water temperatures during their spawning and incubation period under Alternative 1, it is likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar water temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly water temperatures increasing in a downstream direction and temperature differences between scenarios progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during the wetter years under Alternative 1 relative to the No Action Alternative. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in the wetter years. Although temperatures in the river would become progressively lower in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-1). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the Feather River.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when differences under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the American River.

*Changes in Position of X2*

Alternative 1 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-1). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

#### *Summary of Effects on Striped Bass, American Shad, and Hardhead*

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 1, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative. Overall, however, Alternative 1 likely would have slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average.

### *Stanislaus River/Lower San Joaquin River*

#### *Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

##### *Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-1-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than under the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 and the No Action Alternative generally would be similar. An exception to this pattern occurs in April when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F (Appendix 6B, Table B-18-1).

This water temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F in October and 2.0 F in April (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations with average June water temperatures being 2.4°F cooler under Alternative 1 in wet years.

Based on the life history timing for fall-run Chinook Salmon, the higher water temperatures in October under Alternative 1 may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning and egg incubation as compared to the No action Alternative.

*Changes in Exceedance of Water Temperature Thresholds Appendix*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November about 30 and 25 percent of the time, respectively at Goodwin Dam under Alternative 1 (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the No Action Alternative, although slightly more frequently in November. Water temperatures for rearing generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both Alternative 1 and the No action Alternative (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both Alternative 1 and the No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October. This, would be about 28 percent more frequently than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 20 percent of the time) under Alternative 1, which is about 10 percent less frequently than under the No Action Alternative in May (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 1. Overall, egg mortality in the Stanislaus River would be similar under Alternative 1 and the No Action Alternative (Appendix 9C, Table B-1).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly lower under Alternative 1 relative to the No Action Alternative in April and May and similar in June (Appendix 9K). In Old River downstream of the facilities, the median proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action

Alternative but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately lower for Alternative 1 relative to No Action Alternative in April and May, respectively and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately higher under Alternative 1 relative to No Action Alternative in April and May, respectively, whereas values were similar in June.

*Changes in Junction Entrainment*

Median entrainment probabilities at the Head of Old River were much lower under Alternative 1 relative to the No Action Alternative during April and May. The median entrainment probability was similar under both alternatives in the month of June (Appendix 9L). At the Turner Cut junction, median entrainment probabilities under Alternative 1 were slightly higher than under the No Action Alternative in June. During April and May, entrainment probabilities were more divergent with moderately higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Summary of Effects on Fall-Run Chinook Salmon*

In the Stanislaus River, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for fall-run Chinook Salmon spawning/egg incubation under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in November, but substantially more frequently in October under Alternative 1. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat less frequently under Alternative 1. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, could provide some benefit to fall-run Chinook Salmon if passage for adult fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon under the No Action Alternative relative to Alternative 1 is uncertain. The potential benefits of actions under the No Action Alternative intended to increase the efficiency of the Tracy and

Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon relative to Alternative 1.

The results of the numerical models suggest that Alternative 1 is less likely to result in adverse effects on fall-run Chinook Salmon than the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when water temperatures under Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-17-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 and the No Action Alternative generally would be similar (less than 0.5°F differences), except in April when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-1).

This water temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and the No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations with average June water temperatures being 2.4°F cooler under Alternative 1 in wet years.

Overall, the water temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. Based on the life history timing for steelhead, the slightly lower temperatures in June and September of drier years under Alternative 1 may decrease the likelihood of adverse effects to steelhead rearing in the Stanislaus River; the higher temperatures in October under Alternative 1 may increase the likelihood of adverse effects on adult steelhead during their upstream migration.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 1 and No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October which is about 28 percent more frequently than under the No Action Alternative (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 1 or No Action Alternative during January or February. From March through May, however, exceedances would occur under both Alternative 1 and the No Action Alternative in each month, with the threshold most frequently exceeded (43 percent) under Alternative 1 in May (Appendix 9N). Water temperatures under Alternative 1 would exceed the threshold 5 percent less frequently in March, 6 percent less frequently in May, and 17 percent more frequently in April than under the No Action Alternative.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 1 and No Action Alternative in all months but November, and would exceed the threshold by 16 percent of the time in July under both Alternative 1 and the No Action Alternative. The differences between Alternative 1 and the No Action Alternative range from 1 percent less frequent exceedance in October to 4 percent more frequent exceedance in June under the No Action Alternative.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 1 would exceed 52°F in March, April, and May about 9 percent, 31 percent, and 66 percent of the time, respectively. Water temperatures under

Alternative 1 would result in exceedances occurring about 1 to 2 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 1 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 8 percent and 10 percent would occur under Alternative 1, which represent a frequency of about 6 percent more than the No Action Alternative in April and about an 8 percent lower frequency in May.

Overall, the differences in exceedance frequency between Alternative 1 and the No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 1 would exceed the threshold for adult steelhead migration about 28 percent more frequently and in April during the spawning period when the exceedance frequency would be about 17 percent more. Given the frequency of exceedance under both Alternative 1 and No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences in October and April under Alternative 1 suggest that there would be more potential to result in adverse effects on steelhead under Alternative 1 than under the No Action Alternative. Even during months when the differences would be relatively small, the slightly higher frequency of exceedances under Alternative 1 suggest that there would be more potential to result in adverse effects on steelhead under Alternative 1 than under the No Action Alternative.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

*Summary of Effects on Steelhead*

The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for steelhead rearing under Alternative 1. Water temperatures could be somewhat more suitable during the adult upstream migration period under Alternative 1 than the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded substantially more frequently on October, but somewhat more frequently in November under Alternative 1. The water temperature threshold for steelhead spawning would also be exceeded substantially more frequently in May, but somewhat less frequently in other months under Alternative 1. The water temperature threshold for steelhead rearing generally would be exceeded less frequently under Alternative 1 while the temperature thresholds for smoltification would be exceeded more frequently in most months.

The differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages under Alternative 1 could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to Central Valley steelhead in the Stanislaus River. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. Thus, it is concluded that the potential for adverse effects on steelhead under Alternative 1 would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in higher storage levels in New Melones Reservoir under Alternative 1 as compared to the No Action Alternative, as summarized in Table 5.16, due to lower instream releases to support fish flows under Alternative 1.

Storage in New Melones could be increased by up to around 10 percent in some months of some water year types under Alternative 1 compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Assuming that storage volume is an indicator of how much habitat is available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes could be increased under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, Largemouth Bass and Smallmouth Bass nest survival is anticipated to always be above 40 percent under both Alternative 1 and the No Action Alternative in March. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (nearly 80 percent), although about 13 percent higher under Alternative 1 as compared to the No Action Alternative. For May, nest survival is anticipated to be similar under Alternative 1 and the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones Reservoir is about 8 percent lower under Alternative 1 as compared to the No Action Alternative. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 1 and No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under Alternative 1 generally would be similar to, although somewhat lower than, under the No Action Alternative. In April and October, average monthly water temperatures in all water year types would be higher under Alternative 1 and in September, water temperatures would be lower under Alternative 1 compared to the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

*San Francisco Bay Area Region*

*Killer Whale*

Southern Resident killer whales (Southern Residents) are thought to rely heavily upon salmon as their main source of prey (about 96 percent of their diet) throughout the areas and times for which reliable data on prey consumption are available (Ford and Ellis 2006). Studies have indicated that Chinook Salmon generally constitute a large percentage of the Southern Resident salmon diet, with some indications that Chinook Salmon are strongly preferred at certain times in comparison to other salmonids (Ford and Ellis 2006; Hanson et al. 2007). Results have also suggested that Chinook Salmon from ESUs from California to British Columbia are being consumed by Southern Residents (Hanson et al. 2007).

Best available data on the abundance and composition of Central Valley Chinook Salmon indicates that approximately 75 percent of all Central Valley-origin Chinook Salmon available for consumption by Southern Residents are produced by Central Valley fall-run Chinook Salmon hatcheries (Palmer-Zwhalen and Kormos 2012; Table 9). Most Central Valley hatchery fall-run Chinook Salmon production is released directly into San Francisco Bay, and thus bypass potential impacts from water project operations. Even where there might be a nexus with water project operations, the purpose of Central Valley fall-run Chinook Salmon hatchery programs is to produce large numbers of fish independent of freshwater conditions. Since fall-run Chinook Salmon hatcheries came on-line more than forty years ago, the only period of exceptionally low returns was principally attributed to unusual ocean conditions (Lindley et al. 2007).

Ocean commercial and recreational fisheries annually harvest hundreds of thousands of Chinook salmon. The Northwest Region of NMFS (NMFS 2009c) used a model that estimates prey reduction associated with the salmon fishery and which considers the metabolic requirements of Southern Residents and the remaining levels of prey availability. Their analysis concluded that the salmon fishery was not likely to result in jeopardy for Southern Residents. Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected by any of the alternatives.

#### 9.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison.

#### ***9.4.3.3 Alternative 2***

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, as described in Chapter 3, Description of Alternatives. Alternative 2 would not include implementation of fish passage actions under the 2009 NMFS BO. As described in Chapter 4, Approach to Environmental Analysis, Alternative 2 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 9.4.3.3.1 Alternative 2 Compared to the No Action Alternative

*Trinity River Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, fish and aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 would be the same as under the No Action Alternative.

*Central Valley Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, physical conditions that affect aquatic resources under Alternative 2 would be the same as under the No Action Alternative. However, salmonid survival could be less under Alternative 2 due to the lack of fish passage actions to move fish to portions of the Sacramento, American, and Stanislaus rivers that would provide cooler temperatures for spawning and rearing under the No Action Alternative. In addition, Alternative 2 would not include various actions that would occur under the No Action Alternative intended to benefit salmonids and sturgeon, such as structural improvements for temperature control on the American River; gravel augmentation, floodplain restoration and inundation flows, and freshwater migratory habitat restoration in the Stanislaus River; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. Thus, it is concluded that the potential for adverse effects on salmonids and sturgeon under Alternative 2 would be greater than under the No Action Alternative.

*San Francisco Bay Area Region*

*Killer Whale*

It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

##### 9.4.3.3.2 Alternative 2 Compared to the Second Basis of Comparison

*Trinity River Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in aquatic resources at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 10.4.4.1, No Action Alternative Compared to the Second Basis of Comparison.

*Central Valley Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in physical conditions that affect aquatic resources in the Central Valley Region under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described for the No Action Alternative Compared to the Second Basis of Comparison. Actions to provide fish passage to portions of the Sacramento, American, and Stanislaus rivers upstream of their dams would not be undertaken under Alternative 2 or the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

### *9.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified OMR flow criteria and New Melones Reservoir operations. Alternative 3 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Sacramento Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Sacramento Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - “Barge” all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of out-migrating juvenile salmonids

- Work with Pacific Fisheries Management Council, CDFW, and NMFS to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced.

As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 9.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 3 generally would be similar to the temperatures that would occur under the No Action Alternative (Appendix 6B, Table B-1-2). An exception occurs during November when long-term average water temperatures are increased by 3.3°F under Alternative 3 relative to the No Action Alternative in critical years. In addition, water temperatures under Alternative 3 could be as much as 1.5°F cooler than under the No Action Alternative in December of below normal years. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The higher water temperatures in November of critical years and lower temperatures in December of below normal years under Alternative 3 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for Lewiston Dam, which may provide perspective on temperature conditions in the reach below. Under Alternative 3, the spawning temperature threshold would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time. The threshold would not be exceeded in December under either scenario (Appendix 9N).

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the differences in long-term average monthly water temperatures between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The substantially higher (3.3°F) water temperatures in November of critical dry years and lower (by 1.5°F) in December of below normal years under Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

In July, water temperatures in the Trinity River at Lewiston Dam would not exceed the 60°F threshold for spring-run Chinook Salmon holding under Alternative 3, although this threshold would be exceeded 1 percent of the time under the No Action Alternative. Under both Alternative 3 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would exceed 60°F two percent of the time in August. In September, the threshold for spawning (56°F) would be exceeded under both scenarios about 9 percent of the time. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. However, temperature conditions under Alternative 3 could be slightly less likely to affect spring-run Chinook Salmon holding than under the No Action Alternative because of the reduced frequency of exceedance of the 60°F threshold at Lewiston Dam in July.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperature and flow changes could have slight beneficial effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.

*Fall-Run Chinook Salmon*

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. The Reclamation Salmon Survival Model also was applied to assess changes in egg mortality.

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Trinity River. The higher water temperatures (as much as 3.3°F) in November of critical years (and lower temperatures in December) under Alternative 3 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 3, the 56°F threshold for fall-run Chinook Salmon spawning would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November and December, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time in November, with no exceedances in December. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 3 could be slightly less likely to affect fall-run Chinook Salmon spawning than under the No Action Alternative because of the slightly reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period (November-December) for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (over 10 percent) occurring in critical dry years under Alternative 3 (Appendix 9C, Table B-5). Overall, egg mortality under Alternative 3 and the No Action Alternative would be similar in all water year types.

Although the water temperature and flow changes suggest a lower potential for adverse effects on fall-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (and similar egg mortality) under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on fall-run Chinook Salmon in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.

*Steelhead*

The analysis of effects associated with changes in operation on steelhead was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. In critical dry years, increased water temperatures in November under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead, although water temperatures are relatively low at this time of year.

The temperature threshold and months during which it applies for steelhead are the same as those for Coho Salmon. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River. While average monthly temperatures would be similar overall, the slight reduction in the frequency of threshold exceedance provided by Alternative 3 during warm periods in October and November suggest that temperature conditions under Alternative 3 could be slightly less likely to affect steelhead than under the No Action Alternative.

Although water temperatures under Alternative 3 suggest a slightly lower potential for adverse effects on steelhead in the Trinity River, the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative would likely have similar effects on steelhead in the Trinity River as compared to the No Action Alternative.

*Green Sturgeon*

Changes in operations that influence temperature and flow conditions in the Trinity River downstream of Lewiston Dam could influence Green Sturgeon. The following describes those changes and their potential effects.

As described in the Affected Environment, Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 3 are similar and do not exceed 58°F during this period. Water temperatures in the downstream reaches where Green Sturgeon spawn would be higher, although temperature conditions likely would be controlled by other factors (e.g., ambient air temperatures and tributary inflows) rather than water operations at Trinity and Lewiston dams. Therefore, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 3 and the No Action Alternative, it is likely that temperature conditions for Green Sturgeon in the Trinity River and lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could be increased up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Aquatic habitat in Trinity Lake may not be limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased somewhat under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Bass nest survival in Trinity Lake is predicted to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth and Smallmouth Bass in Trinity Lake being in the 40 to 100 percent range would be similar under Alternative 3 and the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth and Smallmouth Bass would be somewhat lower than in May and would be similar under Alternative 3 and the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under Alternative 3 and the No Action Alternative.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 3 on reservoir fishes would be similar to those under the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 3 would be similar to (within 0.5°F) (Appendix 6B). The highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and Klamath River estuary (Appendix 5A).

Overall, it is likely that effects on Pacific Lamprey would be similar under both Alternative 3 and the No Action Alternative. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

It is uncertain whether Eulachon has been extirpated from the Klamath River. Given that the highest increases in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative increase in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River (Appendix 6B) would be unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 3 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 generally would be similar to (less than 0.5°F difference) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 2°F between Keswick Dam and Bend Bridge) (Appendix 6B, Table B-8-2). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 2.6°F warmer under Alternative 3, while the differences in drier years could reach 1.0°F cooler in September of drier years.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on winter-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 could reduce the likelihood of adverse effects on winter-run Chinook Salmon fry rearing in or outmigrating from the Sacramento River. There would be little difference in potential effects on spawning of winter-run Chinook Salmon due to the similar water temperatures during the April to June time period under Alternative 3 as compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 49 percent and 42 percent, respectively, in some months. Under Alternative 3, the temperature threshold generally would be exceeded less frequently than it would under the No Action Alternative (by about 2 percent to 4 percent) in June through August, with the temperature threshold in September exceeded about 6 percent more frequently under Alternative 3 than the No Action Alternative. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 3 and the No Action Alternative as high as nearly 90 percent in some months. Under Alternative 3, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when exceedances under Alternative 3 would be about 26 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative, particularly in September. While temperature conditions under Alternative 3 could be less likely to affect winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August, the substantial increase in the frequency of exceedance in September under Alternative 3 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using Reclamation's salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 25 percent) occurring in critical dry years under Alternative 3. In critical dry years the average egg mortality rate would be 6 percent less than under the No Action Alternative (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in the Sacramento River under Alternative 3 and the No Action Alternative would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from April through August under Alternative 3 as compared to the No Action

Alternative (Appendix 9E, Weighted Usable Area Analysis). Modeling results also indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 3. Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from July to May under Alternative 3 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 as compared to the No Action Alternative (Appendix 9D, Table B-4-6).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.354 for Alternative 3 and 0.349 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 3 was indistinguishable from the No Action Alternative (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities would be indistinguishable between these two alternatives. In Old River downstream of the facilities, the median proportion of positive velocities would be similar under Alternative 3 and the No Action Alternative in January, February, and March. In Old River upstream of the facilities, the median proportion of positive velocities also would be similar under Alternative 3 and the No Action Alternative in these months. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities would be similar under both alternatives in January, February and March.

*Changes in Junction Entrainment*

For all junctions examined, entrainment probabilities for both scenarios would be similar under Alternative 3 and the No Action Alternative from January through March (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 relative to No Action Alternative during the three months when winter-run Chinook Salmon are most abundant in the Delta (January, February, March; (Appendix 9M).

#### *Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 3 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 3 was higher in only 5 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 3 values would be lower than under the No Action Alternative. Median delta survival was consistently lower (by approximately 7 percent) under Alternative 3 as compared to the No Action Alternative. However, the probability intervals indicated that no difference between scenarios was a likely outcome. Thus delta survival was not responsible for the temporal patterns in relative escapement. Since the ocean conditions were equivalent across, scenarios, the differences under Alternative 3 were likely due to differences in survival in the life stages upstream of the delta (i.e., due to differences in temperature and flow at Bend Bridge).

#### *Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative across the 81 years (Appendix 9H). Under Alternative 3 median adult escapement was 4,025 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time trajectories for winter-run Chinook Salmon between Alternative 3 and No Action Alternative across the 81 water years. Under Alternative 3 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990.

#### *Changes in Predator Management*

The fish predator assemblage of the Delta is dominated by invasive predators, with the exception of the Sacramento Pikeminnow (Brown and Michniuk 2007; Nobriga and Feyrer 2007, National Research Council 2010; Cavallo et al. 2012, NRC 2012, Brown 2013). With the exception of Striped Bass, there is little population-level information for fish predators including Largemouth Bass and Sacramento Pikeminnow and there is even less information for Smallmouth Bass and White and Channel Catfish (Grossman et al. 2013). It is important to note that, in addition to predation by native and non-native fishes, there has been extensive modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation such as *Egeria densa*, and other effects of human population growth within the Delta, which also undoubtedly influence the survival of salmonids in the Delta (Brown and Michniuk 2007; National Research Council 2010, 2012).

Bowen et al. (2009 and 2010) describe salmonid behavior in the vicinity of the Head of Old River Barrier and predation from the release point upstream at Durham Ferry. Predation in this short reach seemed to be increased during the lower flows in 2009 and during later release in 2010. While this two year study observed a variable and negative relationship between flow and survival past a Head of Old River Barrier, there remains uncertainty in this due to the actual barrier structures implemented and how they affected predator habitat in this reach.

Although it is well documented that Striped Bass can feed heavily on juvenile salmon and steelhead in the rivers, as they migrate seaward, many of the salmon eaten are likely to be hatchery-reared fish; juveniles from natural spawning may be more wary and encounter lower predation rates. It is thought that predation on hatchery-reared juveniles may buffer wild fish from such predation (Moyle and Bennett 2010). Much of the predation on juvenile salmon seems to take in place in conjunction with artificial structures and release practices. These include releases of fish from hatcheries and those trucked to the estuary from the export facilities in the south Delta (DWR 2010).

In general, Striped Bass are opportunistic predators that tend to forage on whatever prey are most abundant, from benthic invertebrates to their own young to juvenile salmon and American Shad (Stevens 1966, Moyle 2002, Nobriga and Feyrer 2008). Striped Bass are unlikely to be a major predator of Delta Smelt because Delta Smelt are semi-transparent (making them hard to see in turbid water) and do not school, unlike more favored prey such as Threadfin Shad, juvenile Striped Bass, and Mississippi Silverside. Delta Smelt were a minor item in Striped Bass diets when they were highly abundant in the early 1960s (Stevens 1966), as well as in recent years at record low abundance (Nobriga and Feyrer 2008).

Predator control measures are included in Alternative 3, including an increased bag limit (10/day) with a minimum size limit of 12 inches on Striped Bass and black bass. In addition, a sport reward program for Sacramento Pikeminnow ($2/fish > 8 inches) would be implemented to encourage fishing for and removal of this native predatory fish.

A number of studies have been conducted on predation effects in the Delta, and a recent (2013) workshop was held to assess the status of information and potentially establish conclusions regarding the importance of fish predation on salmonid populations in the Delta (Grossman et al. 2013). The workshop concluded that:

> "Available data and analyses have generated valuable information regarding aspects of the predation process in the Delta but do not provide unambiguous and comprehensive estimates of fish predation rates on juvenile salmon or steelhead nor on population-level effects for these species in the Delta."

And:

> "Juvenile salmon are clearly consumed by fish predators and several studies indicate that the population of predators is large enough to effectively consume all juvenile salmon production. However, given extensive flow modification, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and overall reduction in historical salmon population size, it is

> not clear what proportion of juvenile mortality can be directly attributed to fish predation. Fish predation may serve as the proximate mechanism of mortality in a large proportion of the population but the ultimate causes of mortality and declines in productivity are less clear."

The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass species, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. It is reasonable to assume that removing or relaxing restrictions on the harvest of these predatory species would lead to a substantial reduction in their number. However, whether or not this reduction would lead to a substantial benefit or population-level effect on salmonid populations is unknown (Moyle and Bennett 2010). For the proposed (under Alternative 3) predator reduction program to be effective, it must be true that predation by Striped Bass and black bass regulates populations of salmon, steelhead, and smelt, with predation by other species (other fish, birds, marine mammals, etc.) playing a minor role. The program may not be effective, or the effectiveness would be reduced if other predators exhibit compensatory increases in predation if Striped Bass and black bass are removed.

As noted above, the modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation, and other effects of human population growth within the Delta play a role in the survival of salmonids in the Delta and contribute to the uncertainty that any predator reduction program will have the desired results. It is unknown whether reducing Striped bass and black bass populations can measurably compensate for the large changes to the estuary and watershed, which also contribute to reduced populations of salmon, steelhead and smelt.

In addition to the proposed bag and size limits, Alternative 3 includes a proposal to implement a sport reward program for Sacramento Pikeminnow to encourage fishing for and removal of predatory Sacramento Pikeminnow. It is unknown whether a Sacramento Pikeminnow bounty would be feasible under California regulations. Currently, the Sacramento Pikeminnow is regulated under CCR Title 14, section 5.95 (no limit or season), sections 2.25 and 2.30 (bow and arrow and spear fishing) and section 1.87 (no wastage of fish). Therefore, any fishing practice, derby or bounty program in which the Sacramento Pikeminnow is wasted would be in violation of the regulations. In addition, Sacramento Pikeminnow is listed as a "game fish" in commission regulations (CCR Title 14, section 230) and a permit is required before any prizes can be offered to take them.

Regardless of whether a Sacramento Pikeminnow reward system is feasible to implement, the effectiveness of such a program is not assured. This same approach to predator reduction is ongoing in the Columbia River through the Northern Pikeminnow (*Ptychocheilus oregonensis*) Sport-Reward Program sponsored by Bonneville Power Administration that began in 1991. The program seeks to maintain 10 to 20 percent exploitation rate on Northern Pikeminnow throughout the Columbia River by paying anglers $4 to $8 to harvest fish >

228 mm (>9 inches) in total length. In 2012, a total of 158,159 fish were harvested in the sport-reward fishery. Vouchers for 156,837 untagged fish were submitted for payment totaling rewards of $1,016,672. System-wide pikeminnow exploitation efforts suggest that the desired 10 to 20 percent exploitation rate has been achieved for a number of years (Porter 2012). The program has removed over 2.2 million fish from 1998-2009 and is believed to have reduced predation on juvenile salmonids; however, predation estimates have varied widely and positive effects on salmonid populations have been difficult to detect (Carey et al. 2012).

Control of undesired and invasive fishes is a common fishery management strategy (Kolar et al. 2010). However, changes in predator abundance produced via removal, augmentation, or invasion can produce unintended consequences (Polis and Strong 1996). It is possible that other species on which Striped Bass prey, such as Mississippi Silverside, would increase in abundance, causing harm by competing with and preying on desired species, particularly Delta Smelt. Mississippi Silversides are important in the diets of 1 to 3 year old Striped Bass; predation by Striped Bass could be regulating the silverside population. Reducing Striped Bass predation pressure on Mississippi Silversides may increase their numbers, which could have negative effects on Delta Smelt through predation on eggs and larvae (Bennett and Moyle 2006).

The predator reduction program under Alternative 3 is intended to improve the survival of listed species (e.g., salmonids and Delta Smelt) by reducing predation on these species. As described above, the program may be difficult to implement, may not be effective, and may cause unintended harm to other native Delta fish species. Consequently, the outcome of the predator management program is highly uncertain. Compared to the No Action Alternative, which does not include a predator reduction program, Alternative 3 may or may not provide a benefit to salmonids and may result in an adverse effect on Delta smelt.

*Changes in Ocean Salmon Harvest*

Alternative 3 includes an action to change ocean salmon harvest for the purpose of increasing escapement of adult winter-run Chinook Salmon as well as other runs. The following outlines the benefits and challenges associated with such a program.

Central Valley origin Chinook Salmon of all races are harvested in commercial and recreational fisheries off the coast of California. Central Valley origin fall-run Chinook Salmon are the primary target of this harvest. Harvested Chinook Salmon between Point Conception and Bodega Bay were found to be composed of 89-95 percent Central Valley fall-run Chinook Salmon (Winans et al. 2001). More recent studies have shown most Central Valley fall-run Chinook Salmon are produced by hatcheries, and are not of natural origin. Barnett-Johnson et al. (2007) analyzed otolith microstructure from harvested Chinook Salmon and estimated 90 percent were of hatchery origin. Palmer-Zwhalen and Kormos (2012; Table 9) reported data indicating spawning-escapement for Central Valley fall-run Chinook Salmon was composed of 75 percent hatchery origin fish.

Despite the relatively high abundance of hatchery-produced fall-run Chinook Salmon, ocean fisheries are often constrained to protect ESA-listed Chinook Salmon stocks (including Sacramento winter-run and spring-run Chinook Salmon, and Coastal Chinook Salmon), which constitute less than 10 percent of available Chinook Salmon (Winans et al. 2001). This “mixed-stock” fishery is managed by using stock-specific differences in ocean distribution, age at maturity, size-at-date, and/or timing of river entry to help minimize harvest of sensitive stocks. However, such management strategies are only partially effective.

For example, spring-run Chinook Salmon return to freshwater in the spring and thus avoid most ocean harvest during the year in which they mature. However, spring-run Chinook Salmon that mature at age 4 (or older) are subjected to a full season of harvest at “impact levels” comparable to those directed at Central Valley fall-run Chinook Salmon. Harvest managers define “impact rate” as the proportion of a particular stock that will suffer mortality associated with the ocean fishery. Fall-run Chinook Salmon often experience impact rates between 40 and 70 percent.

Thus, the impact of ocean harvest varies substantially by stock, but all stocks are impacted by harvest directed at the most abundant Chinook Salmon population (typically hatchery origin fall-run Chinook Salmon). Several analyses are available that provide a basis for assessing how harvest management identified in Alternative 3 would affect Central Valley Chinook Salmon populations. Though there are political and societal considerations for changes in ocean harvest management, there are no technical or scientific constraints. We have the tools, the knowledge and the ability to manage Chinook ocean harvest in whatever way is needed. As such, Alternative 3 is, from a technical and scientific level, entirely feasible.

Alternative 3 calls for ocean harvest to be managed with the standard of causing no appreciable reduction in viability criteria for natural origin Chinook Salmon. This alternative is addressed separately for Central Valley spring-run, winter-run, and fall-run Chinook Salmon.

*Spring-Run Chinook Salmon.*

Fifteen years have elapsed since NMFS last updated its spring-run Chinook Salmon ocean harvest Biological Opinion (NMFS 2000). The 2000 BO did not report an estimated “impact rate” for the ocean harvest impact on spring-run Chinook Salmon. The BO reached a non-jeopardy opinion for the impacts of ocean harvest primarily by referring to the growth in Central Valley spring-run Chinook Salmon population which was occurring at that time. Though NMFS (2010) did not provide a quantitative analysis of spring-run Chinook Salmon harvest, Grover et al. (2004) estimated that two thirds of spring-run Chinook Salmon matured at age 4, indicating that a large fraction of the spring-run Chinook Salmon population is annually subject to high impact rates (40 to 70 percent), which would greatly influence population productivity and abundance. Harvest of age-3 spring-run Chinook Salmon is likely to be comparable to that experienced by winter-run Chinook Salmon (which also mature and return to fresh water, missing most of the ocean fishing season).

Though a comparable analysis for spring-run Chinook Salmon is not available, Winship et al. (2013) applied a simulation model that showed a 25 percent impact rate (much less than that likely experienced by age 4 spring-run Chinook Salmon) on winter-run Chinook Salmon substantially decreased population abundance and population resiliency relative to alternatives with less harvest.

Harvest pressure of this intensity can also alter diversity in age at-maturity, a critical factor for population viability (NMFS 2010). The ocean fishery is thought to select against fish that mature later because fish that would do so are vulnerable to harvest for more years (Ricker 1981; Hankin and Healey 1986; Sierra and Lackey 2015), and age at maturity has moderate heritability (Hankin et al. 1993). As such, reduced ocean harvest would contribute substantially to age at-maturity diversity (certainly demographically, if not genetically) and thereby enhance population viability. A downward shift in size and age at maturity also affect fitness by reducing fecundity and reproductive rates (Calduch-Verdiell et al. 2014). Larger females generally have larger and more numerous eggs (Wertheimer et al. 2004), both of which provide reproductive advantages. Larger eggs produce larger juveniles, which tend to have higher survival rates (Quinn 2005) and are more resistance to temperature extremes. Since size and age-at-maturity are heritable, selection for earlier adult maturity leads to a feedback loop in which younger and smaller adults produce offspring that mature earlier at smaller sizes. Change in body size may also influence spawning habitat use where larger fish occupy areas with coarser substrate that smaller fish may not be able to use. Thus, advantages of diversity in age at-maturity could be especially important in degraded and thermally stressful habitats typical of Central Valley tributaries.

*Winter-Run Chinook Salmon*

NMFS updated their winter-run Chinook Salmon ocean harvest BO in 2010 (NMFS 2010) and concluded:

> *The effect of harvest and indirect mortality associated with the salmon ocean fishery reduces the reproductive capability of this population, and subsequently the entire ESU, by 10-25 percent per brood, when ocean fisheries occur at a level similar to what has been observed for most of the last decade south of Point Arena, California.*
>
> *There is concern about the relatively high impact rate for age-4 fish and the consequences of this relative to the genetic diversity of winter-run. If age at maturity is strongly related to a genetic component, the removal of older fish at a high rate before they can return to spawn, however few of these individuals in the population there might be, could theoretically reduce the potential for that trait to pass on to successive generation. The change in an average life history trait over time, such as age at maturity, has been suggested as evidence for fisheries induced evolution in some situations (Law 2000; Kuparinen and Merilä 2007; Hard et al. 2008).*

NMFS has since implemented changes in ocean harvest regulations intended to reduce impacts, but the effectiveness of those programs is unclear. Winship et al. (2013) applied a simulation model and showed that all current winter-run Chinook Salmon harvest alternatives substantially decreased population abundance and population extinction risk relative to closing recreational and commercial fisheries south of Point Arena. While closing these fisheries may not be a realistic management alternative, Winship et al. (2013) did not consider intermediate harvest management strategies such as a mark-selective fishery (Pyper et al. 2012) or quota based fishing seasons. Currently, about 90 percent of winter-run Chinook Salmon mature at age-3. As identified in the winter-run Chinook Salmon harvest BO (NMFS 2010), diversity in age at maturity is an important viability criterion likely to be adversely impacted by current harvest management; winter-run Chinook Salmon currently maturing at age-4 are subjected to impact rates comparable to those targeting fall-run Chinook Salmon (40 to 70 percent). Given information presented in the spring-run Chinook Salmon section, it seems likely that in the absence of this harvest, winter-run Chinook Salmon would have a larger fraction of their population maturing at age-4 or possibly older. Age-4 and older winter-run Chinook Salmon would enhance demographic population viability, but also benefit the population by more effectively spawning in coarse substrates, and producing more, larger, and more thermally tolerant eggs.

*Fall-Run Chinook Salmon.*

As indicated previously, fall-run Chinook Salmon produced by Central Valley hatcheries are the most abundant stock harvested off the coast of California. The current management of Central Valley fall-run Chinook Salmon makes no distinction between natural and hatchery fish, and, as such, harvest of natural origin fall-run Chinook Salmon appears to occur at a much higher rate than population productivity can sustain. The recently convened California HSRG concluded:

> *"Fishery harvests that are sustained at high levels by targeting abundant hatchery-origin fish may over-exploit naturally reproducing salmonids and may also induce selection on maturation schedule and other traits… fishery exploitation rates must be in alignment with the productivity of naturally reproducing salmon stocks for the recommendations in this report to be successful at conserving natural salmonid populations" (p. 19)*

> *"The California HSRG also believes that an aggregate escapement target for [the Central Valley natural stocks] that includes returns to hatcheries lacks biological support. The target could theoretically be met if all fish returned to hatcheries and none returned to natural spawning areas, or if all fish in natural spawning areas were of hatchery origin" (p. 21).*

Quantitative analyses of current ocean harvest impacts to natural origin fall-run Chinook Salmon are not currently available. However, impact rates combined with relatively low abundances of natural origin fall-run Chinook Salmon indicate adverse impacts to population viability are likely severe. Changes in harvest strategies which could more effectively target hatchery origin fall Chinook while better protecting natural origin fish would yield substantial benefits. Pyper et al. (2012) analyzed one alternative, a mark-selective fishery, and found that natural origin spawning escapement would increase from 24 to 48 percent.

Managing ocean salmon harvest as described in Alternative 3 would contribute to the abundance, productivity and diversity viability criteria for natural origin spring-run, winter-run, and fall-run Chinook Salmon.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 3 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 would be lower than under the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 3 than under the No Action Alternative. This potential distinction between the two scenarios, however, may be increased due to the benefits of implementation of fish passage under the No Action Alternative. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of winter-run Chinook Salmon.

The ocean harvest restriction component of Alternative 3 could increase winter-run Chinook Salmon numbers by reducing ocean harvest and the predator control measures under Alternative 3 could reduce predation on juvenile winter-run Chinook Salmon and thereby increase survival.

Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon relative to the No Action Alternative over the short term if successful; however, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative if fish passage is successful. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 3 would be greater than those under the No Action Alternative, principally because Alternative 3 does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years would be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to the differences at upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 would reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation in the Sacramento River as compared to the No Action Alternative. There would be little difference in potential effects on spring-run Chinook Salmon holding in other summer months due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run

Chinook Salmon into the creek. Overall, water temperature conditions for spring-run Chinook Salmon in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River low flow channel under Alternative 3 generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative, except in November and December (differences as much as 1.6°F lower in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the water temperature under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years (Appendix 6B, Table B-23-2).

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The somewhat lower water temperatures in November and December under Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon egg incubation and fry rearing in the Feather River. There would be little difference in potential for adverse effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during

December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under Alternative 3 would exceed the water temperature threshold of 56°F established for spawning in September and October about 12 percent to 11 percent of the time, respectively. Water temperatures under Alternative 3 could exceed the threshold about 4 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

*Feather River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance would be highest (about 97 percent) in October, a month in which average monthly water could get as high as about 68°F under Alternative 3. However, water temperatures under Alternative 3 would exceed the temperature threshold about 1 percent less frequently than the No Action Alternative from October to December, and 1 percent more frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 5 percent less frequently than under the No Action Alternative in May, with the same likelihood of exceedance in June. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect spring-run Chinook

Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

*Changes in Egg Mortality*

The temperature differences described above are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (around 80 percent) occurring in critical dry years under Action Alternative 3. In critical dry years the average egg mortality rate would be 6.6 percent less under Alternative 3 than under the No Action Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg mortality in the Sacramento River under Alternative 3 and the No Action Alternative would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 and the No Action Alternative (Appendix 9D, Table B-3-6).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 3 and 0.296 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity would be positive was similar in March, April, and May under both alternatives (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar in March and slightly to moderately, lower under Alternative 3 relative to the No Action Alternative in April and May, respectively. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River (Appendix 9K). In Old River upstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May under Alternative 3 relative to the No Action Alternative and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities would be similar in March and substantially lower in April and May under Alternative 3 relative to the No Action Alternative.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough would be similar under both alternatives during March, April and May, when spring-run Chinook Salmon are most abundant in the Delta (Appendix 9L). At the Head of Old River, median entrainment probabilities would be slightly greater under Alternative 3 during April and May, whereas probabilities would be similar in March. At the Turner Cut junction, median entrainment probabilities under Alternative 3 and the No Action Alternative would be similar in March. During April and May, entrainment probabilities would be more divergent with slightly higher values for Alternative 3 relative to the No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives would be similar with moderately higher values for median entrainment in April and May under Alternative 3. Patterns at the Middle River and Old River junctions would be similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 and the No Action Alternative in every month except during April, May, and June (Appendix 9M). Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially larger fraction of fish salvaged under Alternative 3 relative to the No Action Alternative. Predicted median salvage was similar in March under Alternative 3 and the No Action Alternative.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 3 and the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under Alternative 3 than under the No Action Alternative in Clear Creek and the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 3 could increase the potential for adverse effects on spring-run Chinook Salmon in the Feather River. Given the similarity of the results, Alternative 3 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 3 than under the No Action Alternative. The potential differences between the two scenarios, however, may be even larger due to the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of spring-run Chinook Salmon under the No Action Alternative.

The ocean harvest restriction component of Alternative 3 could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival.

Although the operational components associated with Alternative 3 could have greater adverse effects on spring-run Chinook Salmon than the No Action Alternative, the non-operational components associated with Alternative 3 could benefit spring-run Chinook Salmon relative to the No Action Alternative over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative if fish passage is successful. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 3 clearly would be greater than those under the No Action Alternative, principally because Alternative 3 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 4.4°F warmer under Alternative 3 at Knight's Landing, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the water temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 would reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon in the Sacramento River as compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). Alternative 32). As described above for spring-run Chinook Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements.

Under Alternative 3, temperature conditions at Igo would be similar to water temperatures under the No Action Alternative. However, these temperature outputs are at a location upstream of most fall-run Chinook Salmon spawning and rearing in Clear Creek. Temperatures where fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 3 and the No Action Alternative. Overall, effects on fall-run Chinook Salmon in Clear Creek due to temperature differences between Alternative 3 and the No Action Alternative would be relatively minor.

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative generally would be, except in November and December (differences as much as 1.6°F lower in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when water temperatures under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The somewhat lower water temperatures in November and December under Alternative 3 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon in these water year types.

*American River*

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0. 5°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). This pattern generally would persist downstream to Watt Avenue and the mouth although the temperature differences between scenarios would increase in June and September (Appendix 6B, Tables b-13-2 and B-13-2 and B-14-2). In June water temperatures could be up to 0.7°F lower under Alternative 3 than under the No Action Alternative in some water year types. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences in the American River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The lower water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they were present. Higher water temperatures during September under Alternative 3 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally remain below 56°F, except in October. Under Alternative 3, 56°F would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative.

At the confluence with the Sacramento River, average monthly water temperatures would be warmer, with 56°F exceeded about 15 percent of the time under Alternative 3 and slightly more frequently under the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold in all months Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 3 and the No Action Alternative (Appendix 6B Figures). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and rearing during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 3 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both alternatives about 85 percent of the time in April. However, water temperatures under Alternative 3 could exceed temperature thresholds about 1-4 percent less frequently than under the No Action Alternative. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

The analysis of fall-run Chinook Salmon included the application of the Reclamation Salmon Survival Model. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers based on the model output.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would similar under Alternative 3and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 6 percent), with higher mortality rates (around 14.6 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-7).

*American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 3. Overall, egg mortality would be 0similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-6).

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from September and November under Alternative 3 as compared to the No Action Alternative; fall-run spawning WUA would be similar in October and December (Appendix 9E, Table C-11-2). The increase in long-term average spawning WUA in September under Alternative 3 (prior to the peak spawning period) would be relatively large (around 20 percent), with a smaller increase in November (around 15 percent) which comprises the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9E, Table C-10-2). Overall, spawning habitat availability could be increased under Alternative 3 relative to the No Action Alternative.

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from December to March under Alternative 3 (Appendix 9E, Table C-12-2). Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June (Appendix 9E, Table C-13-2).

*Clear Creek*

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September under Alternative 3 as compared to the No Action Alternative. The increase in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (around 30 percent), with similar amounts of spawning WUA for fall-run Chinook Salmon predicted during other months. Overall, spawning habitat availability would be somewhat similar under Alternative 3 relative to the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October to December under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-25-2).

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 and the No Action Alternative, but up to 5 percent greater under Alternative 3 in critical dry years.

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities would be similar in April, May and June under Alternative 3 and the No Action Alternative (Appendix 9K). Near the confluence of the San Joaquin River and the

Mokelumne River, the median proportion of positive velocities would be slightly lower under Alternative 3 relative to the No Action Alternative in April and May and similar in June. On Old River downstream of the facilities, the median proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would be only moderately lower in June. In Old River upstream of the facilities, the median proportion of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in June. In April and May, values for Alternative 3 would be slightly higher under Alternative 3 relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be similar under Alternative 3 relative to the No Action Alternative in April, May, and June.

*Changes in Junction Entrainment*

The median entrainment at Georgiana Slough under Alternative 3 would be slightly greater in June relative to the No Action Alternative (Appendix 9L). In April and May, median entrainment would be almost identical under both alternatives. At the Head of Old River junction, entrainment under Alternative 3 would be slightly higher in April, May, and June relative to the No Action Alternative. Median entrainment into Turner Cut would be slightly greater under Alternative 3 during April, and May and similar in June. At the Columbia Cut junction, entrainment would be moderately higher under Alternative 3 during April and May, whereas entrainment would be slightly higher in June. Entrainment probabilities at the Middle River junction from April through June would be moderately greater under Alternative 3 relative to the No Action Alternative. A similar pattern would be observed at the Old River junction.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 and No Action Alternative in every month except April, May, and June (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 3 relative to the No Action Alternative and a moderately increased fraction salvaged in June under Alternative 3.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under Alternative 3 and the No Action Alternative, but up to 5 percent greater under Alternative 3 than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be slightly reduced fall-run Chinook Salmon egg mortality in the Feather River under Alternative 3 compared to the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 3 than the No Action Alternative. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential benefit, however, would only apply if passage is provided for fall-run Chinook Salmon that allows access to additional habitat. In addition, RPA actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon. The ocean harvest restriction component of Alternative 3 could increase fall-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile fall-run Chinook Salmon and thereby increase survival.

Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon under Alternative 3 as compared to the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be offset by the potentially beneficial effects resulting from the

RPA actions evaluated qualitatively for the No Action Alternative. Adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 4.4°F warmer under Alternative 3 at Knight's Landing, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 3 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 3 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The slightly higher water temperatures under Alternative 3 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon rearing in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under

Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 1.8 to nearly 5 percent in all water year types under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative (Appendix 9C, Table B-2) in all water year types.

*Changes in Weighted Usable Area*

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-14-4).

Modeling results indicate that, in general, there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 3 and the No Action Alternative (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under Alternative 3 and the No Action Alternative. There could an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to nearly 10 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be the same under Alternative 3 and the No Action Alternative (Appendix 9D, Table B-2-6).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, Delta survival was predicted to be slightly lower for Alternative 3 versus the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 3 and 0.244 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 3 and the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 relative to the No Action Alternative. Actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of late fall-run Chinook Salmon.

Overall, the results of the numerical models suggest that potential effects on late fall-run Chinook Salmon would be similar for Alternative 3 and the No Action Alternative. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Because fish passage under the No Action Alternative is not expected to directly benefit late fall-run Chinook Salmon, the non-operational actions intended to benefit salmonids under both alternatives are expected to balance. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the water temperature differences between Alternative 3 and the No Action Alternative would be relatively (less than 0.5°F) minor and likely would have little effect on steelhead in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 could reduce the likelihood of adverse effects on migrating adult steelhead during drier years as compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative. As described above for spring-run Chinook

Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative except in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar among months at the confluence with the Sacramento River, except in September when water temperatures under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The somewhat lower water temperatures in in November and December under Alternative 3 also could reduce the likelihood of adverse effects on steelhead adults migrating upstream and juveniles migrating downstream in the Feather River as compared to the No Action Alternative.

*American River*

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0.5°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). This pattern generally would persist downstream to Watt Avenue and the mouth, although the temperature differences between scenarios would increase in June and September (Appendix 6B, Tables B-13-2 and B-13-2 and B-14-2). In June water temperatures could be up to 0.7°F lower under Alternative 3 than under the No Action Alternative in some water year types. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The cooler water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts, steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 3 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded 30 to 40 percent of the time under both Alternative 3 and the No Action Alternative. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under Alternative 3. Overall, thermal conditions for steelhead in the Sacramento River would be more likely to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative because of the increased frequency of exceedance of 56°F in September.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 49°F during the spawning period (December to April) under Alternative 3 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River at Robinson Riffle would on occasion exceed the water temperature threshold of 56°F established for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold from December through February under Alternative 3. However, the differences in the frequency of exceedance between Alternative 3 and No Action Alternative during March and April would be relatively small with water temperatures under Alternative 3 exceeding the threshold about 1 percent more frequently in March (19 percent) and the same exceedance frequency (75 percent) as the No Action Alternative in April.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 5 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the spawning and rearing thresholds.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 3 and the No Action Alternative, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between Alternative 3 and No Action Alternative, however, would be relatively small (differences within 2 percent), except in September, when water temperatures under Alternative 3 would exceed 65°F about 7 percent more frequently than under the No Action Alternative. Temperature conditions in the American River under Alternative 3 could be more likely to affect steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-20-2).

*Clear Creek*

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River below Thermalito available from December through April under Alternative 3 and the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 3 and the No Action Alternative.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the No Action Alternative. The analysis of the effects of Alternative 3 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead could be slightly less adverse for some life stages in various rivers under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River. However, the water temperature threshold for steelhead rearing in the American River would be exceeded more frequently under Alternative 3 than under the No Action Alternative. The reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on the steelhead population in the Feather River while the increased frequency of exceedance could increase the likelihood of adverse effects on steelhead rearing in the American River.

These model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 3 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento and American river could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to Alternative 3. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 3 would be greater than those under the No Action Alternative.

*Green Sturgeon*

The effects on Green Sturgeon were analyzed by comparing changes in water temperature and the frequency of temperature threshold exceedance between Alternative 3 and the No Action Alternative. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

*Changes in Water Temperature*

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F). The similar water temperatures during most months suggest that temperature-related effects on

Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative except in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the water temperature under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F). The similar water temperatures during most months suggest that temperature-related effects on Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative. The somewhat higher water temperatures in September under Alternative 3 could affect spawning by Green Sturgeon in the Feather River.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under Alternative 3 occurring about 6 percent of the time in August relative the No Action Alternative (7 percent), and about 9 percent of the time in September relative to 12 percent under the No Action Alternative. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either condition would occur in July and August. The frequency of exceedances would be high, with both Alternative 3 and the No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 3 would exceed the threshold for May about 7 percent less frequently than the No Action Alternative and about 33 percent more frequently in September. Temperature conditions in the Feather River under Alternative 3 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 3 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 9 percent lower under the Alternative 3 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Green Sturgeon*

The analysis of the effects of Alternative 3 and the No Action Alternative for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River but would be exceeded substantially more frequently in September under Alternative 3 and could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action

Alternative. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento and Feather rivers.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F during March through June. Both Alternative 3 and the No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 3 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than the No Action Alternative). In June, the temperature under Alternative 3 would exceed the threshold about 74 percent of the time (about 13 percent less frequently than the No Action Alternative). Average monthly water temperatures during May and June under Alternative 3 would as high as about 65°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to result in adverse effects on White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of Alternative 3 and the No Action Alternative for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3 in the Sacramento River. The reduced frequency of exceedance of water temperature thresholds under Alternative 3 could reduce the potential for adverse effects on White Sturgeon in the Sacramento River relative to the No Action Alternative.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 9 percent lower under Alternative 3 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse under Alternative 3. The analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative.

*Delta Smelt*

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 3 would be 7.3 to 8.5 percent, depending on the water year type, with a long term average percent entrainment of 7.9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the No Action Alternative.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be 5.6 to 20.5 percent, depending on the water year type, with a long term average percent entrainment of 12.7 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be similar to results under the No Action Alternative, except in above- and below-normal years when entrainment would be higher under Alternative 3 by 5 to 6 percent.

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to results under the No Action Alternative in drier water year types. In wetter years, the X2 location would be further east under Alternative 3 than under the No Action Alternative, by 6.0 to 9.7 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in Above Normal and Wet years. Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, Alternative 3 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

*Longfin Smelt*

The effects of the Alternative 3 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months, except April and May where OMR flows would be positive, under the No Action Alternative and the long-term average negative flow ranges from -2,700 to -6,200 cfs from December through June. Because there would be no restrictions on export pumping from December 1 to June 15 due to OMR flow criteria under Alternative 3, OMR flows would generally be more negative during this time period under Alternative 3 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 3 instead of positive as under the No Action Alternative. The increase in the magnitude of negative flows, particularly the negative flows in April and May, under Alternative 3 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7951 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 3 than under the No Action Alternative, with a long-term average index for Alternative 3 that is 7.6 percent lower than the long-term average index under the No Action Alternative. The greatest decrease in the Longfin Smelt abundance index occurs in above normal years where the index value is 12.3 percent less under Alternative 3 than under the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be 4.6 to 9.9 percent lower under Alternative 3 than under the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects on the Longfin Smelt population under Alternative 3 likely would be greater than under the No Action Alternative. Given the current condition of the Longfin Smelt population, even small differences between alternatives may be important.

*Sacramento Splittail*

Under Alternative 3, flows entering the Yolo Bypass generally would be somewhat higher than under the No Action Alternative from December through March, especially during wetter years (Appendix 5A, Table C-26-2), providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the No Action Alternative.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 3 as compared to the No Action Alternative (Appendix 9F).

The greatest increases in Shasta Lake storage could be as high as 15 percent. Storage in Lake Oroville could be increased by up to 30 percent in some months under Alternative 3 as compared to the No Action Alternative. Storage in Folsom Lake could be increased up to around 20 percent in some months of some water year types and could be reduced by up to 10 percent in July, August, and September. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Although aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, storage volume, as an indicator of how much habitat is available to fish species inhabiting these reservoirs, suggests that the amount of habitat for reservoir fishes could be higher under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth and Smallmouth Bass in Shasta Lake being in the 40 to 100 percent range is similar under Alternative 3 and the No Action Alternative. For June, the likelihood of nest survival being greater than 40 percent for Largemouth and Smallmouth Bass is the same under Alternative 3 and the No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is about 10 percent less under Alternative 3 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is somewhat (4 to 10 percent) lower under Alternative 3 as compared to the No Action Alternative. However, June nest survival of greater than 40 percent is likely only in about 30 percent of the years evaluated under Alternative 3. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 3 and the No Action Alternative with the likelihood of greater than 40 percent survival being similar under Alternative 3 as compared to the No Action Alternative. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 3 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is anticipated to be near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range would be about 5 percent lower under Alternative 3 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is around 7 percent lower under Alternative 3 as compared to the No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative.

*Summary of Effects on Reservoir Fishes*

The analysis of the effects of Alternative 3 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 3 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 3 and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Overall, the results of the habitat and nest survival analysis suggest that conditions in the reservoirs likely to support self-sustaining populations of black bass would be similar under Alternative 3 and the No Action Alternative.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Average monthly water temperatures under Alternative 3 and the No Action Alternative would generally be similar. Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the somewhat increased flows and similar temperatures under Alternative 3 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey in the Sacramento, Feather, and American rivers under Alternative 3 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Average monthly water temperatures under Alternative 3 and the No Action Alternative would generally be similar. Striped Bass, American Shad, and Hardhead can generally tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative.

Alternative 3 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-2). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad. In addition, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

Overall, Alternative 3 likely would have similar effects on Hardhead, but slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except from May through October of drier years when average monthly water temperatures could be up to 2.9°F cooler (September) under Alternative 3 as compared to the No Action Alternative (Appendix 6B, Table B-17-2).

Downstream at Orange Blossom Bridge, average monthly water temperatures would be similar (less than 0.5°F differences) under Alternative 3 and the No Action Alternative, except in October when water temperatures under Alternative 3 could be higher than water temperatures under the No Action Alternative by up to 1.5°F in some water year types. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years. In September of drier years, water temperatures under Alternative 3 could be cooler (by up to 2.1°F in critical years) than under the No Action Alternative (Appendix 6B, Table B-18-2).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures and magnitude of temperature differences under Alternative 3 compared to the No Action Alternative would progressively increase in a downstream direction except for in September when temperature differences would diminish at this location (Appendix 6B, Table B-19-2).

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Stanislaus River. Based on the life history timing for fall-run Chinook Salmon, the lower water temperatures in September and October below Goodwin Dam under Alternative 3 likely would have little effect on fall-run Chinook Salmon spawning as the majority of spawning occurs later, in November. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the Stanislaus River, if they are present, as compared to the No action Alternative.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-2). Similar exceedances would occur under the No Action Alternative, although average monthly water temperatures under Alternative 3 would remain lower than under the No Action Alternative during the periods when the threshold is exceeded. Water temperatures under Alternative 3 also would exceed the threshold about 5 percent less frequently in November than under the No Action Alternative. Water temperatures for rearing generally would be below 56°F, except in May and June when average monthly water temperatures would reach about 60°F under the No Action Alternative (Appendix 6B, Figures B-17-8 and B-17-9).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October. This would be about 31 percent more frequently than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-1 and B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 3 would occasionally encounter average monthly water temperatures that exceed 56°F at Orange Blossom Bridge under both Alternative 3 and the No Action Alternative (Appendix 6B, Table B-18-2).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 6 percent, with higher mortality rates (in excess of 13 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin Chinook Salmon smolts are most abundant in the Delta from April through June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be slightly lower under Alternative 3 relative to the No Action Alternative in April and May, and similar in June (Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would be only moderately lower in June. In Old River upstream of the facilities, the median proportion of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in June. In April and May, values for Alternative 3 would be slightly higher under Alternative 3 relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be similar under Alternative 3 relative to the No action Alternative in April, May and June.

*Changes in Junction Entrainment*

At the Head of Old River junction, entrainment under Alternative 3 would be slightly higher in April, May, and June (Appendix 9L). Median entrainment into Turner Cut would be slightly greater under Alternative 3 during April and May, and similar in June. At the Columbia Cut junction, entrainment would be moderately higher under Alternative 3 during April and May, whereas entrainment would be slightly higher in June. Entrainment probabilities at the Middle River junction from April through June would be moderately greater under Alternative 3 relative to the No action Alternative. A similar pattern would be observed at the Old River junction.

*Changes in Juvenile Salmonid Passage through the Delta (Trap and Haul)*

Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has been hypothesized as a major contributor to declines in the number of returning adults and may be a significant impediment to the recovery of threatened or endangered populations (NOAA 2009). Under Alternative 3, fish would be trapped in the San Joaquin River between the mouth of the Stanislaus River and the Head of Old River to capture juveniles migrating from natal rearing habitat in the San Joaquin River, Merced River, Tuolumne River and Stanislaus River. Captured fish would be transported by barge through the Delta and released at locations within San Francisco Bay. Although trucks are currently used to transport hatchery reared salmonids and salvaged fishes (including salmonids), barging results in greater survival benefits (Ward et al. 1997) and may reduce straying of returning adults.

In response to low survival in the Columbia River hydro system, a transportation program was initiated where migrating salmonids (Chinook salmon and steelhead) are captured at dams and transported by barge to the lowest dam in the system before being released (Williams et al. 2004). The effectiveness of the Columbia River transportation program has been questioned because although survival of transported Chinook (≈98 percent; McMichael et al. 2011) is greater than in-river migrants (≈50 percent; Faulkner et al. 2010), SAR rates have not been proportional to the increase in hydro system survival. The most recent evidence suggests that that differences in ocean entry timing that occur due to the rapid rate of barge transport and the long distances transported are likely responsible for the lower post-hydro system survival of transported fish (Muir et al 2006; Rechisky et al 2012). To assess the potential benefits and risks of a transportation program for salmonids in the San Joaquin River, an analysis of CWT recovery rates for Chinook Salmon reared at the Feather River Hatchery and the Mokelumne River Hatchery was performed (Appendix 9O). Based on this analysis, Alternative 3 is expected to improve the survival of juvenile fall-run Chinook Salmon and steelhead smolts originating from the San Joaquin River basin in comparison to the No Action Alternative. Previous work on the Columbia River suggests that benefits may be greater than demonstrated in Appendix 9O if juveniles were transported by barge instead of truck (Ward et al. 1997). The program would also improve the survival of spring-run Chinook Salmon if these fish become established as part of the San Joaquin River Restoration Program, or as part of the New Melones fish passage project. As indicated in Chapter 3, Description of Alternatives, this action will include measures to quantify the benefit.

While a trap and haul program may increase survival, it also may result in unintended consequences or population impacts. For example, a study of returning adult Chinook Salmon and steelhead on the Columbia River following transport as juveniles found that the proportion of adults successfully homing was significantly lower and that the unaccounted loss and permanent straying into non-natal rivers was higher for barged fish of both species (Keefer et al. 2008). Increased straying could have consequences for populations in their natal streams, but also could adversely influence populations in other streams if those fish breed with other wild populations. The conditions and transport distances in the Delta differ from those studied on the Columbia River system, thus the overall influence on straying is uncertain.

However, as indicated in Appendix 9O, straying rates of transported fish are anticipated to be greater than fish allowed to migrate within the river system. An important consideration for this analysis of straying is that all releases into the bay were transported by truck to bypass the Delta. Barge transport where water is recirculated may reduce straying by allowing fish to “sample” water along the migration route. Additionally, the location of collection on the San Joaquin River would be downstream of natal rearing locations allowing fish to experience portions of the migration route during rearing. In addition, trapping and hauling is inconsistent with CDFW’s goal of achieving volitional fish passage.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the No Action Alternative in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is not reflected in the overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for fall-run in the Stanislaus River.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for spring-run Chinook Salmon and steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would provide some benefit to fall-run Chinook Salmon if passage for fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon under the No Action

Alternative relative to Alternative 3 is uncertain. The potential benefits of actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon relative to Alternative 3.

Overall, Alternative 3 likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the No Action Alternative. Alternative 3 could also provide beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 and fish passage under the No Action Alternative would benefit fall-run Chinook Salmon.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except from May through October of drier years when average monthly water temperatures could be up to 2.9°F cooler (September) under Alternative 3than under the No Action Alternative.

Downstream at Orange Blossom Bridge, average monthly water temperatures would be similar (less than 0.5°F differences) under Alternative 3 and the No Action Alternative, except in October when water temperatures under Alternative 3 could be higher than water temperatures under the No Action Alternative by up to 1.5°F in some water year types. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years. In September of drier years, water temperatures under Alternative 3 could be cooler (by up to 2.1°F in critical years) than under the No Action Alternative.

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures and magnitude of temperature differences under Alternative 3 compared to the No Action Alternative would progressively increase in a downstream direction except for in September when temperature differences would diminish at this location (Appendix 6B, Table B-19-2).

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on steelhead rearing in the Stanislaus River as compared to the No action Alternative. The lower water temperatures in September of drier years under Alternative 3 may decrease the likelihood of adverse effects to steelhead rearing in the Stanislaus River during this month.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October and about 57 percent of the time under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative.

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold could be exceeded about 1 percent of the time under Alternative 3 in February. In March through May, exceedances would occur under both alternatives in each month, with the threshold most frequently exceeded (nearly half the time) in May. Compared to the No Action Alternative, water temperatures under Alternative 3 would exceed the threshold 3 percent more frequently in March, 1 percent more frequently in April, and 4 percent more frequently in May. From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 3 and No Action Alternative in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and No Action Alternative, however, would be variable depending on the month, with Alternative 3 exceeding the threshold up to about 6 percent less frequently than under the No Action Alternative in June and from August through October. Under Alternative 3, water temperatures would exceed the rearing temperature threshold up to 4 percent more frequently in April, May, and July.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 3 would exceed 52°F in March, April, and May about 12 percent, 30 percent, and 63 percent of the time, respectively and 2 percent of the time in January and February. By comparison to the No Action Alternative, Alternative 3 would result in exceedances occurring about 2 to 4 percent more frequently during the January through March period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 3 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 3 percent and 17 percent would occur under

Alternative 3, which would be nearly the same as under the No Action Alternative.

Overall, the differences in exceedance frequency between Alternative 3 and the No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 3 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 17 percent less. Given the frequency of exceedance under both Alternative 3 and the No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 3 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 3 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

*Summary of Effects on Steelhead*

Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months. The differences in temperature exceedance (both positive and negative) between Alternative 3 and the No Action Alternative would be relatively small, with no clear benefit associated with either alternative. However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, it may have slightly less impact than the No Action Alternative. Alternative 3 also could provide additional beneficial effects to juvenile steelhead as a result of trap and haul passage through the Delta. It remains uncertain, however, if predator management actions under Alternative 3 would benefit steelhead.

Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to Central Valley steelhead in the Stanislaus River. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative. Thus, it is concluded that the potential for adverse effects on steelhead under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Under Alternative 3, storage in New Melones could be increased up to around 20 percent in some months of some water year types (Appendix 5A). Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is 100 percent under Alternative 3 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is substantially (about 10 percent) higher under Alternative 3 than under the No Action Alternative. For May, the pattern is similar with the likelihood of high nest survival being about 6 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is similar under Alternative 3 and the No Action Alternative. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 3 and the No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures under Alternative 3 generally would be similar to water temperatures under the No Action Alternative except in September when they could be cooler and October when they could be warmer than under the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase. Water temperatures from May to July may also be warmer under Alternative 3 compared to the No Action Alternative (Appendix 6B, Table B-19-2).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or water temperature increases could result in adverse effects on larval lamprey. Given the slightly lower flows and increased water temperatures during portions of their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be somewhat greater under Alternative 3 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Thus, thermal conditions for these species are expected to be similar under Alternative 3 and the No Action Alternative. However, implementation of a predator control program under Alternative 3 could result in adverse effects on Striped Bass.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, the CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 3 would be similar to the operational assumptions under the Second Basis of Comparison except for changes to water demand assumptions, OMR flow criteria, and operations of New Melones Reservoir to meet SWRCB D-1641 flow requirements on the San Joaquin River at Vernalis. As a consequence, conditions for fish and aquatic resources would be relatively unchanged in most of the system under Alternative 3. The following briefly summarizes these minor changes, but focuses on portions of the CVP and SWP where changes would occur under Alternative 3 relative to the Second Basis of Comparison.

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 3 would be similar (less than 0.5°F) to long-term average water temperatures under the Second Basis of Comparison in all months. The greatest differences would occur in critical years when average monthly temperatures would be 0.6°F lower in September and October and 0.8°F higher in November under Alternative 3 (Appendix 6B, Table B-1-5). The differences in the frequency with which Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with water temperatures under Alternative 3 exceeding thresholds about 0-2 percent less frequently than under the Second Basis of Comparison.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the water temperature model (average monthly outputs), it is concluded that Alternative 3 and the Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

As described above for Coho Salmon, water temperatures would generally be similar (less than 0.5°F difference) under Alternative 3 and the Second Basis of Comparison. Similarly, the differences in the frequency with which water temperatures under Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with Alternative 3 exceeding water temperature thresholds about 1 to 2 percent less frequently than the Second Basis of Comparison.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River.

*Fall-Run Chinook Salmon*

As described above for Coho Salmon, water temperatures under Alternative 3 and the Second Basis of Comparison generally would be similar (Appendix 6B, Table B-1-5. This is reflected in the egg mortality results, which indicate similar levels of mortality, under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table 5-5).

Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and Second Basis of Comparison are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.

*Steelhead*

Differences in water temperature conditions for steelhead in the Trinity River between Alternative 3 and the Second Basis of Comparison would be minor as described above for salmon. These results suggest that conditions for steelhead in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Green Sturgeon*

Green Sturgeon would be subjected to the same water temperature conditions described above for salmonids. The similarity in temperatures between Alternative 3 and the Second Basis of Comparison suggest that conditions for Green Sturgeon in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Reservoir Fishes*

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage under Alternative 3 as compared to the Second Basis of Comparison and these relatively small differences would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 3 and the Second Basis of Comparison. Overall, effects on reservoir fishes in Trinity Lake would be similar under both Alternative 3 and the Second Basis of Comparison.

*Pacific Lamprey and Eulachon*

As described above for Coho Salmon, there would be only minor differences in water temperatures between Alternative 3 and the Second Basis of Comparison. This suggests that water temperature conditions for Pacific Lamprey and Eulachon in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 and the Second Basis would be similar (Appendix 6B, Table B-5-5). There would be slight differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison with the frequency of exceedance being up to 4 percent less under Alternative 3 at Balls Ferry and up to 4 percent more at Bend Bridge. Egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that the amount of spawning habitat would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-17-5). Results were similar for fry rearing, (Appendix 9E, Table C-18-5). Results for juvenile rearing also were similar under both Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-19-5).

*Changes in SALMOD Output*

SALMOD results indicate that potential production of winter-run Chinook Salmon under Alternative 3 would be essentially the same as under the Second Basis of Comparison. (Appendix 9D, Table B-4-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.354 for Alternative 3 and 0.352 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 3 was indistinguishable from the Second Basis of Comparison (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities would be slightly higher under Alternative 3 than under the Second Basis of Comparison. In Old River downstream of the facilities, the median proportion of positive velocities would be similar under Alternative 3 and the Second Basis of Comparison in March, but would be moderately to slightly higher January and February, respectively under Alternative 3. In Old River upstream of the facilities, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 and the Second Basis of Comparison in these months. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities would be similar under both alternative in January, February and March.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison (Appendix 9L). At the Head of Old River junction, median entrainment probability would be slightly lower under Alternative 3 in January and February and similar in March. At Turner Cut, median entrainment probabilities would be slightly lower under Alternative 3 relative to the Second Basis of Comparison in January and February; however, median entrainment probability would be similar in March. The median entrainment probability under Alternative 3 at Columbia Cut, Middle River, and Old River would be slightly lower from January to March relative to the Second Basis of Comparison.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook salmon is predicted to be substantially lower under Alternative 3 relative to the Second Basis of Comparison in January (Appendix 9M). In February salvage would be only moderately lower and slightly lower in March.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Differences in escapement between Alternative 3 and the Second Basis scenarios were moderately small (Appendix 9I). Escapement was generally greater under Alternative 3 relative to Second Basis of Comparison, and it was consistently greater over the 1986 to 1988 simulation period (dark gray and light gray areas above the dashed line). In most other years the difference in escapement estimates included 0 (i.e., dashed line located in the dark gray, central 0.50 probability region) (see Appendix 9I). The median delta survival was slightly higher under Alternative 3 relative to the Second Basis scenario (6 percent), although the probability of no difference between alternatives was generally high throughout the simulation time period.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 years (Appendix 9H). Median adult escapement under Alternative 3 was 4,025 and under the Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 water years. Median egg survival was 0.987 for both scenarios.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 3 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 could be higher than under the Second Basis of Comparison.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be higher under Alternative 3 than under the Second Basis of Comparison. The ocean harvest restrictions under Alternative 3 could provide additional benefit, although the effects of the predator management program are uncertain. Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. Thus, it is concluded that the potential for adverse effects on winter-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

*Spring-run Chinook Salmon*

Operations under Alternative 3 generally would be similar to those for the Second Basis of Comparison. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River under Alternative 3 and the Second Basis of Comparison would be similar (Appendix 6B). Differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison also would be minor (differences of about 1 percent), as would egg mortality, which would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-3).

In Clear Creek, average monthly water temperature at Igo under Alternative 3 relative to the Second Basis of Comparison would be similar (Appendix 6B, Table B-3-5). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be minor (differences of 1 percent).

In the Feather River, average monthly water temperature at the low flow channel under Alternative 3 relative to the Second Basis of Comparison also would be similar (differences less than 0.5°F), with a slight reduction in temperature (0.7°F) in August of below normal years (Appendix 6B, Table B-20-5). Water temperatures at the downstream location also would be similar, with temperatures under Alternative 3 at Robinson Riffle and Gridley up to 2°F percent cooler in July and August of some water year types (Appendix 6B, Table B-21-5). Changes in the frequency of temperature thresholds would be minor (differences of 1 percent or less), except in May when the temperature threshold for rearing would be exceeded about 4 percent more frequently than under the Second Basis of Comparison.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. Flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the Alternative 3 as compared to the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that potential production of spring-run Chinook Salmon would be essentially the same under Alternative 3 relative to the Second Basis of Comparison, but could be up to 8 percent less than under the Second Basis of Comparison in critical dry years (Appendix 9D, Table B-3-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.286 for both scenarios.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity would be positive was similar for both Alternative 3 and the Second Basis of Comparison in March, April and May (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion with positive velocity was similar during these months under Alternative 3 and the Second Basis of Comparison. In the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was similar between scenarios in March, whereas values were slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively. In Old River upstream of the facilities, the median proportion with positive velocities was similar between scenarios in March and moderately higher in April and May under Alternative 3 relative to the Second Basis of Comparison. In Old River downstream of the facilities, the median proportion with positive velocities was similar between scenarios in March and slightly higher in April and May under Alternative 3 relative to the Second Basis of Comparison.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison during March April and May (Appendix 9L). At the Head of Old River junction, entrainment would be similar under Alternative 3 and the Second Basis of Comparison in March, whereas entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison in April and May. At Turner Cut, entrainment would be similar under Alternative 3 relative to the Second Basis of Comparison in March and slightly to moderately lower in April and May, respectively under Alternative 3. Entrainment at Columbia Cut, Middle River, and Old River would yield similar patterns as those observed at Turner Cut.

*Changes in Salvage*

Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Salvage of Sacramento River-origin Chinook salmon is predicted to be similar under Alternative 3 and the Second Basis of Comparison in March, April, and May (Appendix 9M).

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 3 and the Second Basis of Comparison, although production under Alternative 3 could be up to 8 percent less than under the Second Basis of Comparison in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be similar under Alternative 3 and the Second Basis of Comparison.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally cannot be fully characterized in Clear Creek and the Feather River. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation in Clear Creek and the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3 than under the Second Basis of Comparison. The water temperature threshold for rearing spring-run Chinook Salmon in the Feather River would also be exceeded less frequently in some months and more frequently in others under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under

Alternative 3, the extent of temperature-related effects on spring-run Chinook Salmon in Clear Creek and the Feather River is uncertain.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 3 than the Second Basis of Comparison, with a small likelihood that spring-run Chinook Salmon production would be lower under the Second Basis of Comparison. Although the operational components associated with Alternative 3 could have greater adverse effects on spring-run Chinook Salmon than the Second Basis of Comparison, the non-operational components associated with Alternative 3 could benefit spring-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. The ocean harvest restriction component of Alternative 3 could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival. The effects of the trap and haul and predator management programs under Alternative 3 are uncertain. Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Water temperature conditions in the Sacramento River, Clear Creek, and Feather River under Alternative 3 and the Second Basis of Comparison would be same as those described above for spring-run Chinook Salmon. Temperature conditions in the Sacramento River, Clear Creek, Feather River, and American River would generally be similar (differences less than 0.5°F) under Alternative 3 and the Second Basis of Comparison (Appendix 6B).

The frequency of exceeding established temperature thresholds in the Sacramento and Feather rivers for fall-run Chinook Salmon would be the same or nearly so (differences of up to 2 percent) for both Alternative 3 and the Second Basis of Comparison. Similarly, in the American River (Appendix 9C, Table B-6), differences in the frequency of temperature threshold exceedance would be minor (up to about 1 percent).

The results from Reclamation’s salmon mortality model reflect the similarities in temperature described above. For fall-run Chinook Salmon in the Sacramento River, egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1). Differences in the Feather and American rivers would also be similar under Alternative 3 and the Second Basis of Comparison.

*Changes in Weighted Usable Area*

Modeling results indicate that, in general, there would be similar amounts (less than 5 percent differences) of fall-run Chinook Salmon spawning habitat available in the Sacramento, Feather, and American rivers under Alternative 3 as compared to the Second Basis of Comparison; fall-run fry and juvenile rearing WUA would also be similar under Alternative 3 and the Second Basis of Comparison in the Sacramento River. Overall, spawning and rearing habitat availability for fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that production for fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9D, Table B-1-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 8-year time period for fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities would be similar in April, May, and June under Alternative 3 and the Second Basis of Comparison (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar to or slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run Chinook Salmon are most abundant. On Old River downstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May, and similar in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities would be moderately higher under Alternative 3 in April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison. In June, entrainment would be similar under each scenario. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River. At these junctions, median entrainment under Alternative 3 would be slightly to moderately lower in April and May, and almost indistinguishable in June.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 3 relative to the Second Basis of Comparison in every month except April, May, and June (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a similar fraction of fish salvaged under Alternative 3 and the Second Basis of Comparison and a slightly reduce fraction salvaged in June under Alternative 3.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in all water year types under Alternative 3 and the Second Basis of Comparison.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be similar under Alternative 3 and the Second Basis of Comparison.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 3 and the Second Basis of Comparison.

Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of Alternative 3 could be offset by the potentially beneficial effects of the predator control program and ocean harvest restrictions. Thus, it is concluded that the potential for adverse effects on fall-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

*Late Fall-Run Chinook Salmon*

*Changes in Water Temperature*

Temperature conditions in the Sacramento River downstream of Keswick Dam for late fall-run Chinook Salmon under Alternative 3 and the Second Basis of Comparison generally would be similar, as described above for fall-run Chinook Salmon. The results from Reclamation’s salmon mortality model reflect the similarities in temperature described above. For late fall-run Chinook Salmon in the Sacramento River, egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1).

*Changes in Weighted Usable Area*

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 3 as compared to the Second Basis of Comparison (Appendix 9E, Table C-14-5). There also would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-15-5). Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available all year long under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-16-5).

*Changes in SALMOD Output*

Results from the SALMOD model indicate that potential production under Alternative 3 would be similar under Alternative 3 and the Second Basis of Comparison in all water year types (Appendix 9D, Table B-2-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for late fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.199 for both scenarios.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

##### *Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

##### *Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on the late fall-run Chinook Salmon.

##### *Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD suggested that late fall-run Chinook Salmon production would be similar under Alternative 3 and the Second Basis of Comparison.

Although, potential losses of juvenile salmon at the export facilities could be higher under Alternative 3, as suggested by the analysis of salvage, it is likely that effects on the late fall-run Chinook Salmon population would be similar under Alternative 3 and the Second Basis of Comparison.

Overall, the results of the numerical models suggest the potential for less adverse effects on late fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.

#### *Steelhead*

##### *Changes in Water Temperature*

Water temperature conditions in the Sacramento River, Clear Creek, Feather River and American River under Alternative 3 and the Second Basis of Comparison would be same as those described above for fall-run Chinook Salmon. Temperature conditions in the Sacramento River, Clear Creek, Feather River, and American River would generally be similar (differences less than 0.5°F) under Alternative 3 and the Second Basis of Comparison (Appendix 6B).

The frequency of exceeding temperature thresholds in the Sacramento, Feather, and American rivers for steelhead would be the same or nearly so (differences of up to 2 percent) for both Alternative 3 and the Second Basis of Comparison Exceedances.

*Changes in Weighted Usable Area*

Modeling results indicate that, in general, there would be similar amounts (less than 5 percent differences) of steelhead spawning habitat available in Clear Creek, and the Sacramento, Feather, and American rivers under Alternative 3 as compared to the Second Basis of Comparison.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the Second Basis of Comparison. The analysis of the effects of Alternative 3 and the Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. However, the water temperature threshold for steelhead rearing in the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3. The water temperature threshold for steelhead rearing in the American River would also be exceeded more frequently in most months under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under Alternative 3, the extent of temperature-related effects on steelhead in the Feather and American rivers is uncertain.

Overall, the results of the numerical models suggest a slightly greater potential to result in adverse effects on steelhead under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.

*Sturgeon (green and white)*

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

The analysis of the effects of Alternative 3 and Second Basis of Comparison for sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on sturgeon in the Sacramento and Feather rivers generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for sturgeon spawning, incubation, and rearing would be exceeded slightly less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for sturgeon spawning, incubation, and rearing also would be exceeded slightly less frequently in the Feather River.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to similar under the Alternative 3 and the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Sturgeon*

The slightly reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that Alternative 3 provides similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon relative to the Second Basis of Comparison. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

*Delta Smelt*

*Changes in Proportional Entrainment*

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 3 would be 7.3 to 8.5 percent, depending on the water year type, with a long term average percent entrainment of 7.9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be 5.6 to 20.5 percent, depending on the water year type, with a long term average percent entrainment of 12.7 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison.

*Changes in Fall Abiotic Habitat Index*

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that under the Second Basis of Comparison, the X2 position would range from 85.6 km to 92.3 km, depending on the water year type, with a long term average X2 position of 88.1 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to predictions under the Second Basis of Comparison (only 0.1 to 0.3 km difference). Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

*Summary of Effects on Delta Smelt*

Overall, Alternative 3 likely would have similar effects on Delta Smelt, as compared to the Second Basis of Comparison with regard to estimated entrainment and predicted location of Fall X2. However, given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

*Longfin Smelt*

The effects of the Alternative 3 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would be negative in all months under both Alternative 3 and the Second Basis of Comparison. Flows under Alternative 3 generally would be less negative than under the Second Basis of

Comparison, except in June, July, and August, when OMR flows under Alternative 3 would be more negative by greater 25 percent in some months and year types. The increase in the magnitude of negative flows in June, July, and August under Alternative 3 could increase the likelihood of entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values range from 1,094 under critical water year conditions to a high of 15,638 under wet water year conditions, with a long-term average value of 7,345 (see Appendix 9G). Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be similar in wetter years and higher in drier water year types under Alternative 3 than they would be under the Second Basis of Comparison, with a long-term average index for Alternative 3 that is 1similar to the long-term average index under the Second Basis of Comparison. The greatest increase in the Longfin Smelt abundance index occurs in critical years where it is 15.5 percent greater under Alternative 3 than under the Second Basis of Comparison. For below normal, and dry water years, the Longfin Smelt abundance index values would be 9.7 and 13.8 percent higher, respectively, under Alternative 3 than under the Second Basis of Comparison. Based on the Longfin Smelt abundance indices, Alternative 3 likely would have a lower potential for adverse effects on Longfin Smelt, as compared to the Second Basis of Comparison. Given the current condition of the Longfin Smelt population, even these small differences between alternatives may be important.

*Sacramento Splittail*

Under Alternative 3, flows entering the Yolo Bypass generally would similar to flows under the Second Basis of Comparison from December through March (Appendix 5A, Table C-26-5). Any differences likely would be insufficient to reduce potential Sacramento Splittail spawning habitat in the bypass. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the Second Basis of Comparison.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Alternative 3 as compared to the Second Basis of Comparison generally would result in similar (differences less than 5 percent) storage levels in CVP and SWP reservoirs during the March through June period (Appendix 5A).

In general, black bass nesting success also would be similar under Alternative 3 and the Second Basis of Comparison. Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May, the likelihood of high (>40 percent) nesting success would be similar in most of the reservoirs under Alternative 3 as compared to the Second Basis of Comparison. This pattern is reversed in June, with the likelihood of high nesting success being somewhat (5 to 7 percent) lower under Alternative 3 (Appendix 9F). Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the Second Basis of Comparison.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on these other species in the Sacramento, Feather, and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. Alternative 3 would result in a similar X2 position as compared to the Second Basis of Comparison during April, May, and June (Appendix 5A, Section C Table C-16-5). This similarity in the position of X2 would likely result in a similar survival index and habitat index as measured by salinity for Striped Bass and a similar abundance and habitat index for American Shad. Alternative 3 likely would have a similar potential for adverse effects on lampreys, American Shad, and Hardhead as the Second Basis of Comparison. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. Overall, Alternative 3 likely would have slightly greater potential for adverse effects on Striped Bass as compared to the Second Basis of Comparison, primarily due to the potential for adverse effects of changing the bag and size limits for Striped Bass under the predator control program.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in

September, October, and November of drier years (Appendix 6B, Table B-17-5). Downstream at Orange Blossom Bridge, average monthly water temperatures under Alternative 3 and the Second Basis of Comparison would generally be similar except from August through November of drier years when water temperatures could be up to up to 1.6°F cooler under Alternative 3 and in June when the average monthly water temperature could be 2.8°F warmer and up to 4.3°F warmer in wet years under Alternative 3 as compared to the Second Basis of Comparison (Appendix 6B, Table B-18-5). This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature differences under Alternative 3 (Appendix 6B, Table B-19-5) would be larger in June and water temperatures could be up to 1.6°F cooler in April under Alternative 3 as compared to the Second Basis of Comparison. Lower fall water temperatures in drier years would reduce the likelihood of adverse effects on spawning fall-run Chinook Salmon.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar exceedances would occur under the Second Basis of Comparison. Water temperatures for rearing generally would be below 56°F, except in May.

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the Second Basis of Comparison during October and November, but the 56°F threshold would be exceeded 2 percent more frequently in October and 4 percent less frequently in November percent.

During January through May, rearing fall-run Chinook Salmon under Alternative 3 and the Second Basis of Comparison would be subjected to average monthly water temperatures that exceed 56°F, with water temperatures under Alternative 3 exceeding the threshold in April about 4 percent less frequently and about 7 percent more frequently in May than under the Second Basis of Comparison (Appendix 6B, Figure B-18-5).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, egg mortality rates would be similar under both scenarios (Appendix 9C, Table B-8).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar to or slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run would be most abundant

(Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May, and similar in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities would be moderately higher under Alternative 3 in April and May, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison (Appendix 9L). In June, entrainment would be similar under each scenario. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River. At these junctions, median entrainment under Alternative 3 would be slightly to moderately lower in April and May, and almost indistinguishable in June.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates somewhat similar temperatures and a similar likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the similar overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for fall-run in the Stanislaus River.

Overall, Alternative 3 likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the Second Basis of Comparison. Alternative 3 could also provide beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 would benefit fall-run Chinook Salmon.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in September, October, and November of drier years. Downstream at Orange

Blossom Bridge, average monthly water temperatures under Alternative 3 and the Second Basis of Comparison would generally be similar except from August through November of drier years when water temperatures could be up to up to 1.6°F cooler under Alternative 3 and in June when the average monthly water temperature could be 2.8°F warmer and up to 4.3°F warmer in drier years under Alternative 3 as compared to the Second Basis of Comparison. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature differences under Alternative 3 would be larger in June and water temperatures could be up to 1.6°F cooler in April under Alternative 3 as compared to the Second Basis of Comparison.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the Second Basis of Comparison during October and November, with the threshold being exceeded 2 percent more frequently in October and 4 percent less frequently in November percent. In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. Under Alternative 3, this threshold would be exceeded under Alternative 3 about 8 percent and 10 percent more frequently in March and May, respectively, than under the Second Basis of Comparison. However, the threshold would be exceeded 16 percent less frequently under Alternative 3 in April.

During June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both Alternative 3 and the Second Basis of Comparison in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and the Second Basis of Comparison, however, would be variable depending on the month, with water temperatures under Alternative 3 exceeding the threshold 2 percent to 4 percent more frequently than under the Second Basis of Comparison in June and July and up to 4 percent less frequently from August to October.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry from January through May under both Alternative 3 and the Second Basis of Comparison. Differences in the likelihood of threshold exceedance between scenarios would be small (up to 3 percent) with the threshold being more likely to be exceeded in March and less likely to be exceeded in April and May. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F). Under Alternative 3, water temperatures would exceed the 57°F threshold about 4 percent less frequently in April and about 7 percent more frequently than under the Second Basis of Comparison in May.

##### *Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period could have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin, above.

##### *Summary of Effects on Steelhead*

Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would likely be similar. The differences in temperature exceedance would be variable (both positive and negative) between Alternative 3 and the Second Basis of Comparison, with no clear benefit associated with either alternative. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Thus, it is concluded that the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.

#### *White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

#### *Reservoir Fishes*

##### *Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, storage levels in New Melones Reservoir would be higher under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Table 5.38, due to higher allocations of water supplies to CVP water service contractors, less fisheries flows, no water quality releases under SWRCB D-1641, and no Bay-Delta flow releases under SWRCB D-1641.

Storage in New Melones could be increased up to around 20 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the Second Basis of Comparison.

*Changes in Black Bass Nesting Success*

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is similar under Alternative 3 and the Second Basis of Comparison. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is about 5 percent lower under Alternative 3 as compared to the Second Basis of Comparison. For May, the pattern is reversed with the likelihood of high nest survival being about 7 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about 38 percent greater under Alternative 3 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 3 and the Second Basis of Comparison. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the Second Basis of Comparison.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in New Melones under Alternative 3 would be similar to or higher than under the Second Basis of Comparison. This suggests that conditions in New Melones could be more likely to support self-sustaining populations of black bass under Alternative 3 than under the Second Basis of Comparison.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass. As described above, water temperatures would generally be similar under Alternative 3 and the Second Basis of Comparison. In general, lampreys, Striped Bass and Hardhead can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect these species in the Stanislaus and San Joaquin rivers would be similar under Alternative 3 and the Second Basis of Comparison. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### *9.4.3.5 Alternative 4*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1, as described in Chapter 3, Description of Alternatives. Alternative 4 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - “Barge” all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of outmigrating juvenile salmonids
- Work with Pacific Fisheries Management Council, CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years

As described in Chapter 4, Approach to Environmental Analysis, Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 9.4.3.5.1 Alternative 4 Compared to the No Action Alternative

*Trinity River Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in aquatic resources at Trinity Lake and along the Trinity

River and lower Klamath River under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.4.2.1, Alternative 1 Compared to the No Action Alternative.

*Central Valley Region and Stanislaus River*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 9.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the No Action Alternative due to implementation of changes in Striped Bass bag limits for predator control and changes in PMFC/NMFS harvest limits. However, these benefits would not likely exceed those described for the No Action Alternative, particularly in consideration of the provision of fish passage upstream of Shasta and Folsom dams to address long-term temperature challenges on listed salmonids caused by climate change.

Conditions for Striped Bass under Alternative 4 could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

*San Francisco Bay Area Region*

*Killer Whale*

As described above the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

*Trinity River Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 4 be the same as under the Second Basis of Comparison.

*Central Valley Region and Stanislaus River*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta due to operations under

Alternative 4 would be the same as described for the Second Basis of Comparison.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the Second Basis of Comparison due to implementation of the Trap and Haul Program, changes in bag limits, and changes in PMFC/NMFS harvest limits. Conditions related to year class strength of juvenile sturgeon would be the same under the Alternative 4 relative to the Second Basis of Comparison due to similar reductions in mean (March to July) Delta outflow. Conditions for Striped Bass under Alternative 4 would be the same as those described above for the comparison to the No Action Alternative.

However, it should be noted that the changes in ocean harvest limits under Alternative 4 could be inconsistent with NMFS' fisheries management framework for reducing the impact of ocean salmon fishery on winter-run Chinook Salmon for the Pacific Coast Salmon Fishery Management Plan (National Marine Fisheries Service 2012). The framework consists of two components. The first component specifies that the previous standards for winter-run Chinook Salmon regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate limit. The second component is based on the population status of winter-run Chinook Salmon where, during periods of relatively low abundance, the proposed structure of fishing management measures each year for winter-run Chinook Salmon south of Point Arena must be equal to or less than the maximum allowable impact rate (MAIR) specified annually. The fishery control rule and tiered approach for managing impacts to winter-run Chinook Salmon in the ocean salmon fishery include: (1) if the geometric mean of the most recent 3 years of spawning return estimates is less than 500, the MAIR is zero percent; and (2) if the geometric mean of the most recent 3 years of spawning return estimates is between 500 and 4,000, the MAIR is between 10 percent and 20 percent, increasing linearly.

If Alternative 4 were selected, Reclamation would be required to re-consult with NMFS regarding all aspects of the alternative that could result in the take of listed salmonids before implementation, including the provisions of the proposed changes in harvest limits.

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### *9.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified OMR flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

Alternative 5 also includes the Delta Cross Channel Temporary Closure Multi-year Study. As noted in the Finding of No Significant Impact (FONSI) document from Reclamation (Reclamation, 2012), this study proposes closing the DCC for up to 10 days during the first half of October from 2012 through 2016. The FONSI also notes that the DCC closure would not cause any adverse effects to the native aquatic and fisheries. Therefore, the effects of this study are not considered any further in the impact analyses for Alternative 5 below.

#### 9.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Because of the considerable similarities between Alternative 5 and the No Action Alternative, the analysis below combines species within some regions where to reduce repetition.

*Trinity River Region*

*Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon*

Average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 would be similar to water temperatures under the No Action Alternative (less than 0.5°F differences) in all months (Appendix 6B, Table B-1-3). Similarly, the differences in the frequency with which Alternative 5 and the No Action Alternative would exceed established temperature thresholds also would be small (up to 1 or 2 percent) (Appendix 9N). These temperature results are reflected in the egg mortality results for fall-run Chinook Salmon in the Trinity River, which indicate similar mortality under Alternative 5 and the No Action Alternative (Appendix 9C, Table B-5).

The minor differences in temperature and mortality results suggest that conditions for Coho Salmon, spring-run Chinook Salmon, fall-run Chinook Salmon, steelhead and Green Sturgeon in the Trinity River generally would be similar under Alternative 5 and the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on salmonids and sturgeon in the Trinity River.

*Reservoir Fishes*

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage (less than 5 percent) under Alternative 5 (Appendix 5A) as compared to the No Action Alternative and these relatively small differences likely would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). The minor differences in storage and similar nesting success suggest that effects on reservoir fishes in Trinity Lake would be similar under Alternative 5 and the No Action Alternative.

*Other Species*

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey and Eulachon. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on the lamprey and Eulachon in the Trinity River.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the No Action Alternative would be similar (differences of less than 0.5°F) (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative also would be small (less than 3 percent) (Appendix 9N). The differences in water temperatures and temperature threshold exceedances predicted at locations in the downstream reaches are similar to those predicted at Keswick Dam. Egg mortality is anticipated to be similar under Alternative 5 and the No Action Alternative (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that available spawning habitat under Alternative 5 and the No Action Alternative would be similar (less than 5 percent difference) (Appendix 9E, Table C-17-3). The results were similar for fry and juvenile rearing (Appendix 9E, Table C-18-3 and Table C-19-3).

*Changes in SALMOD Output*

SALMOD results indicated that potential juvenile production under Alternative 5 would be the similar to the No Action Alternative in all water year types (Appendix 9D, Table B-4-11).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.35 for Alternative 5 and 0.349 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 were indistinguishable from the No Action Alternative in January, February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities also was indistinguishable between these two scenarios. In Old River, both upstream and downstream of the facilities, the median proportion of positive velocities was indistinguishable in the months when winter run Chinook Salmon are present. On the San Joaquin River downstream of the Head of Old River, there was no discernable difference in the median proportion of positive velocities between these two scenarios.

*Changes in Junction Entrainment*

For all junctions examined, the median entrainment probabilities under both Alternative 5 and the No Action Alternative were almost indistinguishable (Appendix 9L).

*Changes in Salvage*

There were no discernable differences in predicted salvage between Alternative 5 and No Action Alternative (Appendix 9M).

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement and Delta survival was modeled by the OBAN model for winter-run Chinook salmon. Escapement was similar under Alternative 5 as compared to the No Action Alternative (Appendix 9I) as was through-Delta survival.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and No Action Alternative median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.990 for the No Action Alternative.

*Summary of Effects on Winter-Run Chinook Salmon*

The analysis of temperatures suggested that the frequency of temperature threshold exceedance under Alternative 5 would be similar to the No Action Alternative. This was reflected in Reclamation’s salmon mortality model results, which predicted egg mortality would be similar under Alternative 5 and the No Action Alternative. The analysis of flow changes under Alternative 5 suggested that availability of spawning habitat for winter-run Chinook Salmon would similar under Alternative 5 and the No Action Alternative; SALMOD also indicated that there would be similar juvenile production under these two alternatives. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and the No Action Alternative as indicated by the DPM and the OBAN results. Median adult escapement to the Sacramento River would be similar under Alternative 5 and the No Action Alternative as indicated by the IOS and OBAN model results. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would be similar between Alternative 5 and the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on the winter-run Chinook Salmon in the Sacramento River and Delta.

*Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon*

*Changes in Water Temperature*

Average monthly water temperatures in the Sacramento River under Alternative 5 and the No Action Alternative would be similar (differences of less than 0.5°F) (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative would be relatively small (differences less than 2 percent) for the spring-run, fall-run, and late fall-run Chinook Salmon, steelhead, and sturgeon in the Sacramento River (Appendix 9N).

In Clear Creek, average monthly water temperatures at Igo under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-3-3). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be small (differences of up to 1 percent) (Appendix 9N).

In the Feather River, average monthly water temperatures in the low flow channel under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-20-3). Water temperatures at the downstream location also would be similar. Changes in the frequency of exceeding temperature thresholds would be relatively small (differences of 2 percent or less) between the two scenarios for the fall-run Chinook Salmon, spring-run Chinook Salmon, steelhead, and Green Sturgeon.

In the American River at Watt Avenue, average monthly water temperatures under Alternative 5 and the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-13-3). Changes in the frequency of exceeding temperature thresholds would be small (differences of 1 percent or less) between the two scenarios for fall-run Chinook Salmon and steelhead.

Egg mortality for all races Chinook Salmon within the Sacramento River system was predicted to be similar under Alternative 5 and the No Action Alternative (Appendix 9C, Tables B-1, B-6 and B-7).

*Changes in SALMOD Output*

SALMOD results indicated that potential spring-run Chinook Salmon juvenile production under Alternative 5 would be the similar to the No Action Alternative in all water year types (Appendix 9D, Table B-3-11).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run, fall-run and late fall-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J).

*Changes in Delta Hydrodynamics*

As described in Appendix 9K, the median proportion of time that velocity was positive at various junctions in the Delta were projected to be similar under Alternative 5 compared to the No Action Alternative.

*Changes in Junction Entrainment*

As described in Appendix 9L, median entrainment at various junctions is indistinguishable or lower under Alternative 5 compared to the No Action Alternative for fall-run, late fall-run, and spring-run Chinook Salmon.

*Changes in Salvage*

As described in Appendix 9M, salvage of migrating spring-run, late-fall run and fall-run smolts is similar or lower under Alternative 5 compared to the No Action Alternative.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be similar under the Alternative 5 and the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon*

The analysis of temperatures indicates similar temperatures and likelihood of exceedance of temperature thresholds under Alternative 5 as compared to the No Action Alternative in the Clear Creek, and the Sacramento, Feather, and American rivers. This was reflected in Reclamation’s salmon mortality model results for the fall-run on the Sacramento, Feather and American rivers which predicted similar Chinook Salmon mortalities under Alternative 5 and the No Action Alternative. There would be no change in flows in Clear Creek and Feather River low flow channel. Flows are expected to be similar in Sacramento River and American River. Flows in May in the Feather River are reduced (Appendix 5A). However, most of the spawning habitat in the Feather River is in the low flow channel; therefore, this reduction in May flow would only have minor effect on the availability of the habitat. SALMOD results indicate that the potential production for the fall-run, late fall-run and spring-run Chinook Salmon on the Sacramento River would be similar. Delta survival is expected to be similar as indicated by the Delta Passage Model and OBAN results, and the entrainment risk would be lower based on the expected changes in OMR flows under Alternative 5. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would be similar under Alternative 5 and the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 5 provides similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon relative to the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on salmonids and sturgeon in the Sacramento River and Delta.

*Delta Smelt*

A proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 will be nearly identical to the results estimated for the No Action Alternative in all water year types.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be similar to that estimated for the No Action Alternative.

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that fall X2 values under Alternative 5 would be nearly identical to the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on Delta Smelt.

*Longfin Smelt*

The effects of the Alternative 5 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

OMR flows generally would be negative in all months under both scenarios, except in April and May when the long-term average would positive. Flows under Alternative 5 during these two months would be more positive than under the No Action Alternative, especially in dry and critical years when OMR flows under Alternative 5 would be positive and flows under the No Action Alternative would be negative. Differences in OMR flow during April and May under Alternative 5 would up to about 1,350 cfs more positive than under the No Action Alternative.

Longfin Smelt abundance index values were calculated for long-term average conditions and for each water year type for the different alternatives (see Appendix 9G). Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be similar in all but critical years under Alternative 5 than they would be under the No Action Alternative. In critical water years, the Longfin Smelt abundance index value would be about 5 percent higher under Alternative 5 than it would be under the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on Longfin Smelt.

*Sacramento Splittail*

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be similar to the No Action Alternative (Appendix 5A, Table C-26-3), thus providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation) and the similar frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 5 and the No Action Alternative.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region (Appendix 5A). Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be similar under Alternative 5 as compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

In general, black bass nesting success would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May and June, the likelihood of high (>40 percent) nesting success would be similar in most of the reservoirs under Alternative 5 as compared to the No Action Alternative (Appendix 9F). Therefore, it is concluded that the effects on black bass species would be similar under both Alternative 5 and the No Action Alternative.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the generally similar water temperatures during their spawning and incubation period under Alternative 5, it is likely that thermal conditions for and effects on these other species in the Sacramento, Feather, and American rivers would be similar under Alternative 5 and the No Action Alternative. Alternative 5 would result in a similar X2 position as compared to the No Action Alternative during April, May, and June (Appendix 5A, Section C Table C-16-3). This similarity in the position of X2 would likely result in a similar survival index and habitat index as measured by salinity for Striped Bass and a similar abundance and habitat index for American Shad. Alternative 5 likely would have a similar potential for adverse effects on lampreys, American Shad, and Hardhead as the Second Basis of Comparison. Overall, the potential for effects on lamprey, Striped Bass, American Shad, and Hardhead would be similar under Alternative 5 and the No Action Alternative.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon and Steelhead*

*Changes in Water Temperature*

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. From August through November, water temperatures under Alternative 5 could be somewhat (0.6°F to 1.6°F) warmer, particularly in drier water years. This pattern in temperature changes under Alternative 5 was also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence and water temperatures in April and May could be up to 2.1°F cooler under Alternative 5.

The frequency of exceedance of temperature thresholds for steelhead adult migration in the fall months, steelhead smoltification thresholds in April and May at Knights Ferry, and steelhead rearing in summer and fall months are higher under (by up to 8 percent) under Alternative 5 as compared to the No Action Alternative. Frequency of exceedance of thresholds for steelhead spawning and smoltification at Orange Blossom Bridge in March through May are lower by up to 11 percent under Alternative 5 compared to the No Action Alternative.

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November up to 3 percent more frequently under Alternative 5 compared to the No Action Alternative, in the Stanislaus River at Orange Blossom Bridge. During May and June, the 56°F threshold for fall-run rearing is exceeded less frequently (by up to 10 percent) under Alternative 5 compared to the No Action Alternative.

These changes in temperatures are not reflected in Reclamation's salmon mortality model results for the fall-run Chinook Salmon in the Stanislaus River. As shown in Appendix 9C, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 16 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality is predicted to be similar under Alternative 5 and the No Action Alternative.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. San Joaquin River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period could have the potential to affect juvenile steelhead. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was slightly higher under Alternative 5 relative to the No Action Alternative in January and February and almost indistinguishable from March through June (Appendix 9K). On Old River upstream and downstream of the facilities, the median proportion of positive velocities was similar under Alternative 5 and the No Action Alternative in all months. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was similar under Alternative 5 and the No Action Alternative in all months.

*Changes in Entrainment at Junctions*

As described in Appendix 9L, median entrainment at various junctions is indistinguishable or lower under Alternative 5 compared to the No Action Alternative for fall-run Chinook Salmon.

*Summary of Effects on Fall-Run Chinook Salmon and Steelhead*

The analysis of temperatures indicates somewhat higher temperatures in some water year types and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon under Alternative 5 as compared to the No Action

Alternative in the Stanislaus River below Goodwin Dam. The effect of higher temperatures is not reflected in overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run Chinook Salmon in the Stanislaus River. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing could be more stressful under Alternative 5 compared to the No Action Alternative. However, the higher flows in April and May and lower temperatures in April and May under Alternative 5 may benefit steelhead spawning.

Given the variability in the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on fall-run Chinook Salmon and steelhead in the Stanislaus and lower San Joaquin rivers.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

Storage levels in New Melones Reservoir would be similar (within 5 percent) for Alternative 5 as compared to the No Action Alternative (Appendix 5A).

Results of the bass nesting success analysis indicate that for March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is 100 percent under both Alternative 5 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is predicted to be reasonably high but is somewhat (about 13 percent) lower under Alternative 5 as compared to the No Action Alternative. For May, the difference between alternatives is less with the likelihood of high nest survival being about 5 percent less under Alternative 5. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is similar under Alternative 5 and the No Action Alternative. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and the No Action Alternative. The likelihood of Spotted Bass nest survival being greater than 40 percent is about 7 percent less under Alternative 5 than under the No Action Alternative in April, but is still reasonably high (greater than 90 percent). During May, the likelihood of high (>40 percent) Spotted Bass nest survival is about 5 percent lower under Alternative 5 as compared to the No Action Alternative. During June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 5 as compared to approximately 98 percent of the years under the No Action Alternative.

Overall, the analysis suggests that conditions under Alternative 5 have the potential to negatively influence black bass nesting success, especially in April and May, by comparison to the No Action Alternative. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, it is concluded that there would be no definitive difference in effects on reservoir fish between Alternative 5 and the No Action Alternative.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other fishes such as lampreys, Hardhead, and Striped Bass.

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. From August through November, water temperatures under Alternative 5 could be somewhat (0.6°F to 1.6°F) warmer, particularly in drier water years. This pattern in temperature changes under Alternative 5 was also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence and water temperatures in April and May could be up to 2.1°F cooler under Alternative 5.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval lamprey.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and generally similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on lampreys, Hardhead, and Striped Bass in the Stanislaus and lower San Joaquin rivers. No definitive difference between Alternative 5 and the No Action Alternative could be discerned.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.6.1 Alternative 5 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified OMR flow criteria and New Melones Reservoir operations. Therefore, the comparison of Alternative 5 to the Second Basis of Comparison would be similar to the comparison of No Action Alternative to Second Basis of Comparison described above in Section 9.4.4.1, No Action Alternative.

*Trinity River Region*

*Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead*

Monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 generally would be similar (less than 0.5°F differences) to the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-6), with the exception of drier years when temperatures under Alternative 5 could be as much as 2.2°F cooler in November and 1.5°F warmer in December. Average monthly water temperatures could be slightly (up to 0.6°F) higher under Alternative 5 during July and August and lower (up to 0.7°F) in September in some water year types. The slightly lower September temperatures under Alternative 5 may result in slightly better conditions than under the Second Basis of Comparison for spring-run Chinook Salmon spawning. Similarly, temperature conditions under Alternative 5 could be slightly better than the Second Basis of Comparison for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years.

Under Alternative 5, water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September (Appendix 9N).

These temperature results are not entirely reflected in the egg mortality results for fall-run Chinook Salmon, which indicate similar levels of egg mortality under Alternative 5 compared to the Second Basis of Comparison (Appendix 9C, Table B-5).

The minor changes in water temperatures and mortality suggest that conditions for Coho Salmon, fall-run Chinook Salmon, and steelhead in the Trinity River would be similar under both Alternative 5 and the Second Basis of Comparison. However, the slight reduction in threshold exceedances for spring-run Chinook

Salmon spawning under Alternative 5, although small, could reduce the potential for adverse impacts in the Trinity River under Alternative 5.

In addition, implementation of a Hatchery Management Plan under Alternative 5 could reduce the impacts of hatchery Chinook Salmon on natural Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison, but the potential magnitude of these benefits is uncertain. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that Alternative 5 and Second Basis of Comparison are likely to have similar effects on Chinook Salmon and steelhead in the Trinity River.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Black bass species in Trinity Lake would be exposed to minor differences in storage under both Alternative 5 and the Second Basis of Comparison, and these relatively small differences would have negligible effect on nest survival. The nest survival under Alternative 5 would be generally similar to Second Basis of Comparison for Largemouth Bass, Smallmouth Bass, and Spotted Bass (Appendix 9F). These negligible differences in nest survival suggest that conditions for reservoir species in Trinity Lake would be similar under Alternative 5 and the Second Basis of Comparison.

*Other Species*

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the Second Basis of Comparison.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B). Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperature differences in September increasing (up to 2.8°F cooler at Bend Bridge) in September during the wetter years and up to 0.8°F warmer in critical years (Appendix 6B).

*Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 41 percent and 54 percent, respectively, in some months (Appendix 9N). Under Alternative 5, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded about 11 percent less frequently under Alternative 5 than under the Second Basis of Comparison. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 5 and the Second Basis of Comparison as high as about 90 percent in some months. Under Alternative 5, temperature exceedances generally would be more frequent (by up to 10 percent) than under the Second Basis of Comparison, with the exception of September, when exceedances under Alternative 5 would be about 30 percent less frequent under Alternative 5.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River below Keswick Dam are reflected in the analysis of egg mortality using the Reclamation Salmon Survival Model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5and the Second Basis of Comparison (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-17-6). Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-18-6). Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-19-6).

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be the same under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-4-26).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.350 for Alternative 5 and 0.352 for the Second Basis of Comparison Alternative. Overall, there would be little change in through-Delta survival for emigrating juvenile winter-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Winter run smolts are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was indistinguishable from the Second Basis of Comparison in January, February, and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February and slightly lower in March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February and March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 and the Second Basis of Comparison was essentially indistinguishable in January, February and March (Appendix 9L). Entrainment at the Head of Old River junction was similar to slightly lower under Alternative 5 relative to Second Basis of Comparison during the period of winter run Chinook Salmon migration through the Delta (January, February, and March). For the Turner Cut junction, median entrainment under Alternative 5 was slightly lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. At the Columbia Cut, Middle River and Old River junctions, patterns in entrainment between Alternative 5 and Second Basis of Comparison were similar. At these junctions, median entrainment was slightly to moderately lower under Alternative 5 during January and February and values were more similar in March.

*Changes in Salvage*

Salvage of winter-run Chinook salmon is predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March, predicted salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under Alternative 5 as compared to the Second Basis alternative (Appendix 9I). The median abundance under Alternative 5 was higher the Second Basis of Comparison. Median delta survival was approximately 15 percent higher under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and Second Basis of Comparison Alternative median escapement was 4,042).

Similar to adult escapement, the IOS model predicted similar egg survival for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.987 for the Second Basis of Comparison Alternative).

*Summary of Effects on Winter-Run Chinook Salmon*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison. This is not reflected in the similar survival of winter-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model. Flow changes under Alternative 5 would have small effects on the availability of spawning and rearing habitat for winter-run Chinook Salmon as indicated by the WUA analysis and the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results; the OBAN results suggest that Delta survival could be higher under Alternative 5. Entrainment may also be reduced under Alternative 5 as indicated by the salvage analysis based on OMR flows. Median adult escapement to the Sacramento River could be reduced slightly under Alternative 5 as indicated by the IOS model results which incorporate temperature, flow, and mortality effects on each life stage over the entire life cycle of winter-run Chinook Salmon. However, the OBAN model results indicate an increase in escapement over a more limited time period (1971 to 2002).

The model results suggest that effects on winter-run Chinook Salmon would be similar under both Alternative 5 and Second Basis of Comparison, with a small likelihood that winter-run Chinook Salmon escapement would be higher under the Alternative 5. Positive effects, however, likely would be greater because of the potential benefits of providing fish passage under Alternative 5 intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, benefits to winter-run Chinook Salmon may accrue under Alternative 5 as a result actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under Alternative 5 would be less likely to result in adverse effects on winter-run Chinook Salmon than would the Second Basis of Comparison. In consideration of the potentially beneficial effects resulting from actions under the Alternative 5 that are not included in the numerical models (see Appendix 5A, Section B), however, Alternative 5 has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of Shasta Dam to address long-term temperature increases associated with climate change; the Second Basis of Comparison does not. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 5 would clearly be less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years (Appendix 6B, Table B-9-6).

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years (Appendix 6B, Table B-20-6) under Alternative 5. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 80 percent and 79 percent for Alternative 5 and Second Basis of Comparison, respectively. Temperature thresholds would be exceeded less frequently in November (7 percent) and not exceeded at all during December through March. As water temperatures warm in the spring, the thresholds would be exceeded in April by 14 percent and 13 percent under Alternative 5 and Second Basis of Comparison. In the warmer months when exceedances occur (October, November, and April), temperature thresholds generally would be exceeded more frequently (by up to 2 percent in October) under Alternative 5 than under the Second Basis of Comparison (Appendix 9N, Table 9N.B.1).

*Clear Creek*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time. The differences between Alternative 5 and Second Basis of Comparison are small, with Alternative 5 exceeding thresholds about 1 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October (Appendix 9N).

*Feather River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing (Appendix 9N) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently. The frequency of exceedance was highest (about 98 percent) in October, a month in which average monthly water could get as high as about 68°F. However, water temperatures under Alternative 5 would exceed temperature thresholds less than 2 percent more frequently than the Second Basis of Comparison in October, November, and December, and about 1 percent less frequently in March. The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May (57 percent and 51 percent, respectively) and June (97 percent for both), but not at all in July and August.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 80 percent) occurring in critical dry years. In critical dry years the average egg mortality rate would be 13.1 percent greater under Alternative 5 than under the Second Basis of Comparison (Appendix 9C,

Table B-3). Overall, egg mortality under Alternative 5 and the Second Basis of Comparison would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that potential spring-run juvenile production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years when production could be 14 percent lower under Alternative 5 than under the Second Basis of Comparison (Appendix 9D).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run between Alternative 5 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for Alternative 5 and 0.286 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile spring-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Spring run Chinook salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity was positive was similar in March and April and slightly lower in May under Alternative 5 relative to the Second Basis of Comparison (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was similar in March and slightly to moderately higher under Alternative 5 relative to the Second Basis of Comparison in April and May. In the San Joaquin River downstream of the Head of Old River the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, whereas there was little difference between these scenarios in March. In Old River upstream of the facilities the median proportion of positive velocities was slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison and slightly lower in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 relative to Second Basis of Comparison in April and May and more similar in March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 was slightly lower than under the Second Basis of Comparison in April and May but essentially indistinguishable in March (Appendix 9L). Median entrainment at the Head of Old River junction was substantially higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and similar in March. For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and more similar in March. At the Columbia Cut, Middle River and Old River junctions, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in March and became moderately to substantially lower in April and May.

*Changes in Salvage*

Salvage of spring run Chinook salmon was predicted to be substantially lower under Alternative 5 relative the Second Basis of Comparison during April and May and only slightly lower in the month of March (Appendix 9M).

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 5 relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 5 and Second Basis of Comparison for spring-run Chinook Salmon relied on water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Feather River. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison. The effect of slightly increased temperatures is not reflected in the similar overall survival of spring-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for spring-run in the Sacramento River. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison.

Flow changes under Alternative 5 would likely have small effects due to changes in the availability of spawning and rearing habitat for spring-run Chinook Salmon in the Sacramento River as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile spring-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the salvage analysis.

The numerical model results suggest that, overall, Alternative 5 likely would have similar or somewhat greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under Alternative 5 intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, spring-run Chinook Salmon may benefit from actions under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including spring-run Chinook Salmon.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 5 suggested by the results of the numerical models would likely be offset by the potential benefits of the actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under Alternative 5 would be less than those under the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal water years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth under Alternative 5 generally would be lower than under the Second Basis of Comparison in September, especially in wetter water year types when water temperatures under Alternative 5 could be up to 1.7°F cooler.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon spawning and egg incubation (Table temperature targets) during some months, particularly in October, November, and April, when temperature thresholds would be exceeded. The frequency of exceedance would be greatest in October, a month in which average monthly water temperature could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 82 percent and 79 percent of the time, respectively. The differences in the frequency of exceedances between Alternative 5 and Second Basis of Comparison would be small. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally would be below 56°F, except in October. Under Alternative 5, the 56°F threshold would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison. At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under Alternative 5 and somewhat (about 8 percent) less frequently under the Second Basis of Comparison. During November and December, average monthly water temperatures generally would remain below 56°F at both locations.

For fall-run Chinook Salmon rearing (January through September), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold except in September when temperatures could increase to over 60°F. During September, water temperatures under Alternative 5 would exceed 56°F about 3 percent more frequently than under the Second Basis of Comparison. Downstream at the mouth, the average monthly temperatures would exceed 56°F more frequently, especially in July and August, when it always would be exceeded and average monthly temperatures would approach 64°F under both scenarios in September.

Under Alternative 5, temperature conditions at Igo would be slightly warmer than under the Second Basis of Comparison. Average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on fall-run Chinook Salmon in Clear Creek under Alternative 5 would likely be greater than under the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 5 and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 5 and the Second Basis of Comparison about 85 percent of the time in April. The differences in threshold exceedance between Alternative 5 and Second Basis of Comparison, would be small, with water temperatures under Alternative 5 generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period. However, average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on fall-run Chinook Salmon in the Feather River under Alternative 5 would likely be greater than under the Second Basis of Comparison.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

#### *Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-1).

#### *Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-7).

#### *American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-6).

### *Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

#### *Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in September and November under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-11-6). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (more than 20 percent), with a smaller decrease in November (around 6 percent). The latter month is during the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-10-6). Overall, spawning habitat availability would be slightly lower under Alternative 5 relative to the Second Basis of Comparison.

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from December to March under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-12-6). Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-13-6).

*Clear Creek*

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be a lesser amount of spawning habitat available in September (20 percent less) and greater amounts of incubation habitat available in February (6 percent more) under Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning WUA may be slightly (around 5 percent) increased in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-6). The decrease in long-term average spawning WUA during September would occur prior to the peak spawning period. Overall, spawning and incubation habitat availability would be similar under Alternative 5 relative to the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-25-6).

*Changes in SALMOD Output*

SALMOD results indicate that potential fall-run juvenile production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years when production could be 7 percent lower under Alternative 5 than under the Second Basis of Comparison (Appendix 9D, Table B-1-26).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for Fall-run between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.248 for Alternative 5 and 0.245 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities was slightly lower under Alternative 5 relative to the Second Basis of Comparison in May and June (Appendix 9K). The median proportion of positive velocities for Alternative 5 was similar in April. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, whereas values in June were similar. On Old River downstream of the facilities, the median proportion of positive velocities was substantially higher in April and May and slightly higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities was slightly higher under Alternative 5 April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, and similar in June.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 was slightly lower than the Second Basis of Comparison in June but essentially indistinguishable in all other months (Appendix 9L). Median entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in June. For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and slightly lower in June. At the Columbia Cut junction, median entrainment under Alternative 5 was slightly lower in June relative to the Second Basis of Comparison. Median entrainment was substantially lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin fall run was predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in April and May (Appendix 9M). During the month of June, salvage was moderately lower under Alternative 5.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on water temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 5 and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The analysis of temperatures indicates similar temperatures and slightly greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Feather River. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison. The effect of slightly increased temperatures is not reflected in the similar overall survival of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for fall-run in the Feather and American rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison.

Flow changes under Alternative 5 would likely have small effects on the availability of spawning and rearing habitat for fall-run Chinook Salmon in the Sacramento River system as indicated by the similarity in spawning WUA in the Sacramento, Feather, and American rivers under Alternative 5 and the Second Basis of Comparison. Fry and juvenile rearing WUA would be similar in the Sacramento River and this is reflected in the similarity in flow (habitat)-related mortality predicted by SALMOD under Alternative 5.

Through-Delta survival of juvenile fall-run Chinook Salmon would be similar under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the OMR flow analysis. Overall, Alternative 5 likely would have similar or slightly greater adverse effects on the fall-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types.

Additional actions implemented under Alternative 5 could help improve conditions for fall-run Chinook Salmon relative to the Second Basis of Comparison, such as structural improvements for temperature management in the American River and actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including fall-run Chinook Salmon. The implementation of fish passage under Alternative 5 intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is unlikely to benefit fall-run Chinook Salmon unless passage is provided for adult fall-run Chinook Salmon. The effects of providing similar fish passage at Folsom Dam would also be uncertain for the same reason.

Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is difficult because of the similarity in results (generally differences less than 5 percent), the inherent uncertainty of the models, and the potential for offsetting benefits. Thus, it is concluded that the effects on fall-run Chinook Salmon would be similar under Alternative 5 and the Second Basis of Comparison.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff during some months, particularly in October, November, and April. The frequency of exceedance would be greatest in October, a month in which average monthly water could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 80 percent and 79 percent of the time, respectively. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.4 to nearly 5 percent in all water year types under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-2).

*Changes in Weighted Usable Area*

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-14-6). Modeling results indicate that, in general, there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-15-6).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would be reduced amounts of suitable juvenile rearing habitat available in September (12 percent less) and November (8 percent less under Alternative 5 as compared to the Second Basis of Comparison. In other months the amount the amount of late fall-run Chinook Salmon juvenile rearing WUA would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-16-6).

*Changes in SALMOD Output*

SALMOD results indicate that potential juvenile production would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-2-26).

*Changes in Delta Passage Model Output*

For Late-Fall-Run, Delta survival was predicted to be slightly higher for Alternative 5 versus the Second Basis of Comparison for all 81 water years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.243 for Alternative 5 and 0.199 for the Second Basis of Comparison. Overall, there would be a slight increase in through-Delta survival for emigrating juvenile late fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook migration period overlaps with that of winter-run Chinook Salmon and they are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was indistinguishable from the Second Basis of Comparison in January, February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January and moderately higher in February. Values in

March were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February and slightly lower in March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February and March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 and the Second Basis of Comparison in January was essentially indistinguishable in January, February and March (Appendix 9L). Entrainment at the Head of Old River junction was similar to slightly lower under Alternative 5 relative to Second Basis of Comparison. For the Turner Cut junction, median entrainment under Alternative 5 was slightly lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. At the Columbia Cut, Middle River and Old River junctions, patterns in entrainment between Alternative 5 and the Second Basis of Comparison were similar. At these junctions, entrainment was moderately lower under Alternative 5 during January and February and values were more similar in March.

*Changes in Salvage*

Salvage of late fall-run Chinook salmon is predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential late fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 5 and the Second Basis of Comparison. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 5 relative to the Second Basis of Comparison in every month.

These model results suggest that overall, Alternative 5 is likely to have less adverse effect on late fall-run Chinook Salmon in the Sacramento River as compared to the Second Basis of Comparison. Potential benefits may be enhanced under Alternative 5 by actions intended to increase the efficiency of the

Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be less under Alternative 5 relative to the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years (Appendix 6B, Table B-9-6).

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower than the Second Basis of Comparison in September, especially in wetter water year types when Alternative 5 could be up to 1.7°F cooler.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 5 or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded at least 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under the Second Basis of Comparison compared to Alternative 5. Overall, thermal conditions for steelhead in the Sacramento River would be similar under Alternative 5 and the Second Basis of Comparison.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either Alternative 5 or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in throughout the year would not exceed 56°F at Igo. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 5 and the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both Alternative 5 and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N).There would be a 1 percent exceedance of the 56°F threshold in December and no exceedances of the 56°F threshold in January and February under both Alternative 5 and the Second Basis of Comparison. However, the differences in the frequency of exceedance between Alternative 5 and Second Basis of Comparison during March and April would be relatively small with water temperatures under Alternative 5 exceeding the threshold about 1 percent more frequently in March and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under Alternative 5 would exceed the rearing temperature threshold about 6 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 5 could be more likely to result in adverse effects on steelhead spawning and rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 56°F spawning threshold in March and the somewhat increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 5 and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences in exceedance frequency between Alternative 5 and Second Basis of Comparison, however, would be relatively small (differences within 1 percent), except in September, when average monthly water temperatures under Alternative 5 would exceed 65°F about 6 percent less frequently than under the Second Basis of Comparison. Temperature conditions in the American River under Alternative 5 could increase the likelihood of adverse effects on steelhead rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 65°F rearing threshold in some months.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-20-6).

*Clear Creek*

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River below Thermalito available from December through April under Alternative 5 and the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 5 and the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Sacramento River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was moderately lower relative to the Second Basis of Comparison from January to April and slightly lower in May and June (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January, February, April and May and similar in March and June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January, April, and May and moderately higher in February. Values in March and June were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February, slightly lower March and June, and slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February, March and June, but slightly to moderately lower in April and May.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 5 as compared to the Second Basis of Comparison. The analysis of the effects of Alternative and Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 5 and the Second Basis of Comparison. The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Sacramento and Feather rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison.

These numerical model results suggest that overall, effects on steelhead could be slightly more adverse under Alternative 5 than under the Second Basis of Comparison, particularly in the Feather and American rivers. However, implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under Alternative 5 in comparison to the Second Basis of Comparison. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 5 would be less than those under the Second Basis of Comparison.

*Green Sturgeon*

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

#### *Changes in Water Temperature*

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

##### *Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. (Appendix 6B). A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison.

##### *Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

#### *Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

##### *Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under Alternative 5 occurring about 7 percent of the time in August and about 12 percent of the time in September. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento

River under Alternative 5 could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with both Alternative 5 and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 5 would exceed the threshold about 7 percent more frequently in May than under the Second Basis of Comparison and about 33 percent less frequently in September. Temperature conditions in the Feather River under Alternative 5 could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have less effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Changes in Delta Outflow*

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 16 percent higher under Alternative 5 than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on Green Sturgeon*

The temperature threshold analysis in the Sacramento and Feather rivers both suggest that average monthly water temperatures under Alternative 5 would exceed thresholds for Green Sturgeon more frequently than under the Second Basis of Comparison, although the frequency of exceedance would be relatively small (1-2 percent). However, average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on Green Sturgeon under Alternative 5 would likely be greater than under the Second Basis of Comparison. The analysis based on Delta outflows suggests that Alternative 5 provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 5 and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 5 would exceed this threshold about 56 percent of the time (about 7 percent more frequently than under the Second Basis of Comparison). In June, the temperature under Alternative 5 would exceed the threshold about 87 percent of the time (about 13 percent more frequently than the Second Basis of Comparison). Average monthly water temperatures during May and June under Alternative 5 would as high as about 65°F.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

*Summary of Effects on White Sturgeon*

The increased frequency of exceedance of water temperature thresholds under Alternative 5 could increase the potential for adverse effects on White Sturgeon relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

*Delta Smelt*

The potential effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on differences in proportional entrainment and the fall abiotic index as described below.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under Alternative 5 would be similar to results under Second Basis of Comparison. Under the Second Basis of Comparison, the long-term average entrainment would be 9 percent.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be lower than results under the Second Basis of Comparison by up to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical dry water year conditions, at 23.6 percent.

The predicted position of Fall X2 (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010).

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.8 km to 92.3 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 5 would be similar to results under the Second Basis of Comparison in drier water year types. In wetter years, the X2 location would be further west under Alternative 5 than under the Second Basis of Comparison, by 6.1 to 9.8 km.

Overall, Alternative 5 likely would result in better conditions for Delta Smelt than would the Second Basis of Comparison, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

*Longfin Smelt*

The effects of the Alternative 5 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be greater in every water year type under Alternative 5 than under the Second Basis of Comparison, with a long-term average index for Alternative 5 that is about 10 percent higher than the long term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent greater under Alternative 5 than under the Second Basis of Comparison, with the greatest difference (30.8 percent) predicted under dry conditions.

Overall, based on the lower frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, Alternative 5 would be likely have a lower potential for adverse effects on the Longfin Smelt population as compared to the Second Basis of Comparison.

*Sacramento Splittail*

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be slightly lower compared to the Second Basis of Comparison (Appendix 5A, Table C-26-6), thus potentially providing lower value to Sacramento Splittail because of the lower area of potential habitat (inundation) and the lower frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that no definitive difference in effects on Sacramento Splittail between Alternative 5 and the Second Basis of Comparison could be discerned.

*Reservoir Fishes*

*Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under Alternative 5 as compared to the Second Basis of Comparison in the fall and winter months due to the inclusion of Fall X2 criteria under Alternative 5.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. The reduction in reservoir storage under Alternative 5 may suggest that the amount of habitat for reservoir fishes could be reduced under Alternative 5 as compared to the Second Basis of Comparison. However, it is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, such that this potential reduction in habitat may have little adverse effect on reservoir fishes.

*Changes in Black Bass Nesting Success*

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth Bass in Lake Shasta being in the 40 to 100 percent range is about 2 percent higher under Alternative 5 as compared to the Second Basis of Comparison. For June, the likelihood of nest survival being greater than 40 percent for Largemouth Bass is similar (within 1 percent) under Alternative 5 and Second Basis of Comparison; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Shasta exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (100 percent) in May under both Alternative 5 and the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is higher (by about 12 percent) under Alternative 5 as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under Alternative 5 as compared to the Second Basis of Comparison, about 13 percent higher in May and about 4 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is 100 percent in May under Alternative 5 as compared to about 94 percent under the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially higher (on the order of 20 percent) under Alternative 5 as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is somewhat (around 7 percent) higher under Alternative 5 than under the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is similar under Alternative 5 as compared to the Second Basis of Comparison.

*Summary of Effects on Reservoir Fishes*

Reservoir storage is anticipated to be reduced under Alternative 5 relative to the Second Basis of Comparison and this reduction could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under Alternative 5 would be similar under Alternative 5 and the Second Basis of Comparison. Overall, the results of the habitat and nest survival analysis suggest that effects on reservoir fishes would be similar under the No Action Alternative and the Second Basis of Comparison.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5 (Appendix 6B, Table 5-5-6). A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison. Given the generally minor differences in flows and water temperatures between Alternative 5 and the Second Basis of Comparison, it is anticipated that the effect on Pacific Lamprey in the Sacramento River generally would be the same under both scenarios.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through August, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through May, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The higher water temperatures during June and August may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval larvae. Given similarity in water temperatures during their spawning and incubation period, it is likely that Alternative 5 would have a similar potential to affect Pacific Lamprey in the Sacramento, Feather, and American rivers than would the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

As described above for lampreys, monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5 (Appendix 6B, Table 5-5-6). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under Alternative 5 relative to the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with the Sacramento River. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when differences under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June.

*Changes in Position of X2*

Alternative 5 would result in a more westward X2 position as compared to the Second Basis of Comparison during April and May, with similar values in June (Appendix 5A, Section C Table C-16-6). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely increase the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

*Summary of Effects on Striped Bass, American Shad, and Hardhead*

Because Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids, it is unlikely that the slightly increased temperatures during some months under Alternative 5 would have substantial adverse effects on these species in the American River. Given the generally minor differences in water temperatures between Alternative 5 and the Second Basis of Comparison, it is anticipated that the effect of water temperatures on Striped Bass, American Shad, and Hardhead generally would be the same under both scenarios. Overall, Alternative 5 likely would have similar effects on Hardhead and a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival for these two species during larval and juvenile life stages, and more favorable location of Spring X2 on average.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison (Appendix 6B, Table B-17-6).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison (Appendix 6B, Table B-19-6).

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November over 30 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 5 ((Appendix 6B, Figure B-17-1 and B-17-2)). Similar exceedances would occur under the Second Basis of Comparison, although up to 10 percent more frequently in November. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both conditions (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 5 would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 30 percent of the time) under Alternative 5 which is about 10 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-8).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively whereas values in June were similar (Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities was substantially higher in April and May and slightly higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities was slightly higher under Alternative 5 April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, and similar in June.

*Changes in Junction Entrainment*

Entrainment at the Head of Old River junction was substantially higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in June (Appendix 9L). For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and slightly lower in June. At the Columbia Cut junction, median entrainment under Alternative 5 was slightly lower in June relative to the Second Basis of Comparison. Median entrainment was substantially lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. In the Stanislaus River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The analysis of temperatures indicates lower temperatures and a slightly lower likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison in the Stanislaus

River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is not reflected in the similar overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon survival model for fall-run in the Stanislaus River. As described above, the instream flow patterns under Alternative 5 are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis.

Implementation of a fish passage project under Alternative 5, primarily intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, is not likely to provide benefit to fall-run Chinook Salmon unless passage for fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain. However, actions implemented under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

On balance, given the small differences in the modeling results and the potential benefits anticipated by actions not captured in the models, it is concluded that effects on fall-run Chinook Salmon under Alternative 5 and Second Basis of Comparison would be similar.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between

Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 10 percent more frequently than under the Second Basis of Comparison.

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 5 or Second Basis of Comparison during January or February. In March through May, however, exceedances would occur under both Alternative 5 and the Second Basis of Comparison in each month, with the threshold most frequently exceeded (40 percent) under Alternative 5 in May (Appendix 9N). Average monthly water temperatures under Alternative 5 would exceed the threshold 4 percent more frequently in March 26 percent less frequently in April and 5 percent less frequently in May than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 5 and Second Basis of Comparison in all months but November. The differences between Alternative 5 and Second Basis of Comparison, however, would be small, with average monthly water temperatures under Alternative 5 generally exceeding the threshold by 3 percent to 8 percent more frequently than under the Second Basis of Comparison.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 5 would exceed 52°F in March, April, and May about 8 percent, 37 percent, and 68 percent of the time, respectively. Alternative 5 would result in exceedances of the smoltification threshold occurring up to 6 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 5 and the Second

Basis of Comparison would not exceed the threshold during January through April. In May, the threshold would be exceeded 8 percent of the time under Alternative 5. Compared to the Second Basis of Comparison, the 57°F at Orange Blossom Bridge would be exceeded about 8 percent less frequently in April and 6 percent less frequently in May under Alternative 5.

Overall, the temperature differences between Alternative 5 and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 5 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 26 percent less. Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Stanislaus River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January, February, April and May and similar in March and June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January, April, and May and moderately higher in February. Values in March and June were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February, slightly lower in March and June, and slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February, March, and June, but slightly to moderately lower in April and May.

*Summary of Effects on Steelhead*

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison.

Implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, however, the extent of benefit is uncertain. In addition, the potential effects of Alternative 5 could be offset by actions intended to reduce predation risk on steelhead in the Stanislaus River and increase the efficiency of the Tracy and Skinner Fish Collection Facilities. The actions to augment spawning gravel in the Stanislaus River under Alternative 5 also could benefit steelhead.

The numerical model results for effects on steelhead under Alternative 5 and Second Basis of Comparison do not definitively show distinct differences. However, in consideration of the potentially beneficial effects resulting from the actions that would be implemented under Alternative 5 that are not included in the numerical models (see Appendix 5A, Section B), Alternative 5 has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on steelhead under Alternative 5 would clearly be less than that under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under Alternative 5 as compared to the Second Basis of

Comparison due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage levels in New Melones Reservoir would be lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 5A), especially in critical years when the difference could be as much as 23 percent. Using storage volume as an indicator of available availability for fish species inhabiting these reservoirs, these results suggest that the amount of habitat for reservoir fishes could be decreased under Alternative 5 as compared to the Second Basis of Comparison. However, it is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, such that this potential reduction in habitat may have little adverse effect on reservoir fishes.

Nest survival for black bass species in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is substantially less (about 25 percent) under Alternative 5 as compared to the Second Basis of Comparison. For May, the likelihood of high nest survival is similar under Alternative 5 and the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is somewhat (about 10 percent) higher under Alternative 5 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and Second Basis of Comparison. The likelihood of survival being greater than 40 percent is about 6 percent lower in April under Alternative 5 than under the Second Basis of Comparison, but is still reasonably high (about 90 percent). For May, the likelihood of high Spotted Bass nest survival is similar under Alternative 5 and the Second Basis of Comparison. For June, Spotted Bass nest survival would be greater than 40 percent in all of the simulation years under both Alternative 5 and the Second Basis of Comparison. Overall, the analysis suggests that conditions under Alternative 5 have the potential to influence black bass nesting success, especially in April and May in comparison to the Second Basis of Comparison. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, it is concluded that there would be no definitive difference in effects on reservoir fish between Alternative 5 and the Second Basis of Comparison.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### ***9.4.3.7 Summary of Environmental Consequences***

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 9.4 and 9.5, respectively.

**Table 9.4 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | **Trinity River Region**<br>Coho Salmon<br>Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent). Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.<br>Spring-run Chinook Salmon<br>Although the water temperatures under Alternative 1 could result in adverse effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures as compared to the No Action Alternative. However, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River. Given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, Alternative 1 and the No Action Alternative are likely to have similar effects on spring-run Chinook Salmon in the Trinity River.<br>Fall-run Chinook Salmon<br>Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (and similar egg mortality) between Alternative 1 and the No Action Alternative. In addition, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.<br>Steelhead<br>Although the analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between Alternative 1 and the No Action Alternative. Given these small differences in water temperatures and the inherent uncertainty in the temperature model, | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br>Mitigation measures for other substantial impacts have not been identified at this time. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Alternative 1 and the No Action Alternative are likely to have similar effects on steelhead in the Trinity River.<br><br><u>Green Sturgeon</u><br><br>Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under Alternative 1 and the No Action Alternative.<br><br><u>Reservoir Fishes</u><br><br>Overall, the comparison of storage and the analysis of nesting suggest that effects on reservoir fishes would be similar under Alternative 1 and the No Action Alternative.<br><br><u>Pacific Lamprey</u><br><br>On average, the temperature of water released at Lewiston Dam generally would be similar under Alternative 1 and the No Action Alternative. Given the similarities in water temperatures, it is likely that the effects on Pacific Lamprey would be similar.<br><br><u>Eulachon</u><br><br>Given that the highest increases in flow under Alternative 1 would be less than 10 percent in the Trinity River, with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 1 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.<br><br>**Sacramento River System**<br><br><u>Winter-run Chinook Salmon</u><br><br>Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would be more likely to result in adverse effects on winter-run Chinook Salmon than would the No Action Alternative. In addition, the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical suggest that the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Alternative 1. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 1 would be greater than those under the No Action Alternative, principally because Alternative 1 does not include fish passage to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.<br><br><u>Spring-run Chinook Salmon</u><br><br>Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on spring-run Chinook Salmon. However, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 1 would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030 | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | <u>Fall-run Chinook Salmon</u><br>Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on fall-run Chinook Salmon. This potential distinction between the two scenarios, however, may be partially balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is likely that the effects on fall-run Chinook Salmon would be similar.<br><u>Late Fall-run Chinook Salmon</u><br>The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 in every month.<br>Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that the effects on late fall-run Chinook Salmon would be similar.<br><u>Steelhead</u><br>The numerical model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. However, Alternative 1 would not include fish passage and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery that would occur under the No Action Alternative. Therefore, it is concluded that the adverse effects on steelhead under Alternative 1 would be greater than those under the No Action Alternative.<br><u>Green Sturgeon</u><br>Overall, the temperature model outputs suggest that thermal conditions and effects on Green Sturgeon generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative.<br><u>White Sturgeon</u><br>Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile White Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Delta Smelt<br>Overall, Alternative 1 is likely to result in increased adverse effects on Delta Smelt primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between Alternative 1 and the No Action Alternative may be important.<br>Longfin Smelt<br>Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be greater.<br>Sacramento Splittail<br>Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 1 and the No Action Alternative.<br>Reservoir Fishes<br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 1 would be similar to or slightly lower than under and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative.<br>Pacific Lamprey<br>Based on the similar water temperatures during their spawning and incubation period, it likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br>Striped Bass, American Shad, and Hardhead<br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, however, Alternative 1 likely would have slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on fall- | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | run Chinook Salmon. This potential distinction between the two scenarios, however, may be partially balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.<br><br>Steelhead<br><br>The temperature model outputs suggest that the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages have the potential for adverse effects on the steelhead populations in the Stanislaus River under Alternative 1. However, the magnitude of this effect is uncertain. It is concluded that the potential for adverse effects on steelhead would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.<br><br>White Sturgeon<br><br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.<br><br>Reservoir Fishes<br><br>Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival would vary among months. In June, the likelihood of survival being greater than 40 percent is lower under Alternative 1. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, effects on black bass nesting success would be similar.<br><br>Other Species<br><br>In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72ºF during their entire life history. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar.<br><br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Pacific Ocean**<br>Killer Whale<br>Given conclusions from NMFS (2009c), and the fact that at approximately 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |
| Alternative 2 | **Trinity River Region**<br>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon<br>Similar effects.<br>**Sacramento River System**<br>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead<br>The effects under Alternative 2 may become more adverse due to the lack of fish passage and other actions, such as structural improvements for temperature control on the American River; gravel augmentation, floodplain restoration and pulse flows, in Clear Creek; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. Thus, it is concluded that the potential for adverse effects on salmonids and sturgeon under Alternative 2 would be greater than under the No Action Alternative.<br>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, Striped Bass, American Shad, and Hardhead<br>Similar effects.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The effects under Alternative 2 may become more pronounced due to the lack of fish passage and other actions that would occur under the No Action Alternative such as gravel augmentation, floodplain restoration and inundation flows, and freshwater migratory habitat restoration in the Stanislaus River; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities.<br>White Sturgeon, Reservoir Fishes, and Other Species<br>Similar effects.<br>**Pacific Ocean**<br>Killer Whale<br>Similar effects. | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead. |
| Alternative 3 | **Trinity River Region**<br>Coho Salmon and Spring-run Chinook Salmon<br>Overall, the water temperature model outputs suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent (by 1 to 2 percent) under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River. This conclusion also applies to spring-run Chinook Salmon, | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br>Mitigation measures for other substantial impacts have not been identified at this time. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | although the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.<br><br>Fall-run Chinook Salmon<br><br>Overall, the temperature model outputs suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent (by up to 2 percent) under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), Alternative 3 is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.<br><br>Steelhead<br><br>Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River. This slight reduction in the frequency of threshold exceedance provided by Alternative 3 suggest that temperature conditions under Alternative 3 could be slightly less likely to affect steelhead than under the No Action Alternative. However, the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative would likely have similar effects on steelhead in the Trinity River as compared to the No Action Alternative.<br><br>Green Sturgeon<br><br>Given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar.<br><br>Reservoir Fishes<br><br>Overall, while reservoir storage and nest survival would be slightly higher under Alternative 3, it is uncertain whether these differences would be biologically meaningful. Thus, it is concluded that effects on black bass likely would be similar for Alternative 3 and the No Action Alternative.<br><br>Pacific Lamprey<br><br>Overall, it is likely that effects on Pacific Lamprey would be similar. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br><br>Eulachon<br><br>Given that the highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Klamath River estuary, and that water temperatures in the Klamath River would unlikely to be affected by changes upstream at Lewiston Dam, it is likely that effects would have a similar potential to influence Eulachon in the Klamath River.<br>**Sacramento River System**<br>Winter-run Chinook Salmon<br>Overall, given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term.<br>Spring-run Chinook Salmon<br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse. However, the ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality. These non-operational components could benefit spring-run Chinook Salmon over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed through fish passage under the No Action Alternative. It is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term.<br>Fall-run Chinook Salmon<br>Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. However, Alternative 3 does not contain the RPA actions that could provide benefit under the No Action Alternative. Thus, effects on fall-run Chinook Salmon would be similar.<br>Late Fall-run Chinook Salmon<br>Overall, the results of the numerical models suggest that potential effects on late fall-run Chinook Salmon would be similar. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Because fish passage under the No Action Alternative is not expected | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | to directly benefit late fall-run Chinook Salmon, the non-operational actions intended to benefit salmonids under both alternatives are expected to balance. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative.<br><br><u>Steelhead</u><br><br>The model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. The ocean harvest restriction component and predator control measures could reduce steelhead mortality. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 3 would be greater than those under the No Action Alternative.<br><br><u>Green Sturgeon</u><br><br>The temperature model outputs suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 3. By contrast, the analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class, and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. Therefore, based primarily on the analysis of water temperatures, adverse effects on Green Sturgeon would be less likely.<br><br><u>White Sturgeon</u><br><br>Given the general similarity in results and the inherent uncertainty associated with the resolution of the temperature model, the effects likely would be similar. However, the analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting effects of increased Delta outflow and improved salvage survival under the No Action Alternative, there would be no definitive difference in effects on White Sturgeon.<br><br><u>Delta Smelt</u><br><br>Overall, likely would result in increased adverse effects, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between alternatives may be important.<br><br><u>Longfin Smelt</u><br><br>Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects likely would be greater. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | <u>Sacramento Splittail</u><br>Flows entering the Yolo Bypass generally would be somewhat higher than under the No Action Alternative from December through March, especially during wetter years, providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the No Action Alternative.<br><u>Reservoir Fishes</u><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar in March, April, and May, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Overall, the results of the habitat and nest survival analysis suggest that conditions in the reservoirs likely to support self-sustaining populations of black bass would be similar under Alternative 3 and the No Action Alternative.<br><u>Pacific Lamprey</u><br>Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Based on the somewhat increased water temperatures from January through the summer, it is likely that there would be little difference in potential effects on Pacific Lamprey in the Sacramento, Feather, and American rivers This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><u>Other Species</u><br>Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative.<br>Alternative 3 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-2). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.<br>In addition, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.<br>Overall, Alternative 3 likely would have similar effects on Hardhead, but slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | juvenile life stages, and less favorable location of Spring X2 on average.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.<br>Beneficial effects to juvenile fall-run Chinook Salmon could result from implementation of trap and haul passage through the Delta and ocean harvest restrictions.  It remains uncertain, however, if predator management actions under Alternative 3 would benefit fall-run Chinook Salmon.<br>Steelhead<br>Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months.  The differences in temperature exceedance between Alternative 3 and the No Action Alternative would be relatively small, with no clear benefit associated with either alternative.  However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, it may have slightly less impact than under the No Action Alternative.  Alternative 3 also could provide additional beneficial effects to juvenile steelhead as a result of trap and haul passage through the Delta.  It remains uncertain, however, if predator management actions under Alternative 3 would benefit steelhead.<br>This potential distinction between the two alternatives, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for in the Stanislaus River reaches downstream of New Melones Dam.  In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative.<br>Implementation of the fish passage program under the No Action could provide a benefit to Central Valley steelhead in the Stanislaus River.  This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030.  In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative.  Thus, it is concluded that the potential for adverse effects on steelhead would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.<br>White Sturgeon<br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer.  The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin | |

<table>
<tr><th>Alternative</th><th>Potential Change</th><th>Consideration for Mitigation Measures</th></tr>
<tr><td></td><td>rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br><br><u>Reservoir Fishes</u><br><br>While the analyses suggest that the effects could be more adverse, most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative.<br><br><u>Other Species</u><br><br>In general, lampreys, Striped Bass and Hardhead also can tolerate higher water temperatures than salmonids. Thus, temperature effects on these species are expected to be similar under both alternatives.<br><br>Predator controls related to Striped Bass could result in adverse effects.<br><br>Pacific Ocean<br><br><u>Killer Whale</u><br><br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.</td><td></td></tr>
<tr><td>Alternative 4</td><td>Trinity River Region<br><br><u>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon</u><br><br>The effects are identical as described under Alternative 1 as compared to the No Action Alternative.<br><br>Sacramento River System<br><br><u>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead</u><br><br>CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore the effects in the Sacramento River system would be similar to those described under Alternative 1.<br><br>Conditions related to salmonid survival could be improved under Alternative 4 by implementation of a trap and haul program, changes in Striped Bass bag limits, and changes in PMFC/NMFS harvest limits. However, these benefits would not likely exceed those described for the No Action Alternative, particularly in consideration of the provision of fish passage to address long-term temperature challenges on listed salmonids caused by climate change.<br><br><u>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead</u><br><br>The effects in the Sacramento River system would be similar to those described under Alternative 1.<br><br><u>Striped Bass</u><br><br>The effects in the Sacramento River system would be similar to those described under Alternative 1.<br><br>Conditions for Striped Bass could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch</td><td>Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br><br>Mitigation measures for other substantial impacts have not been identified at this time.</td></tr>
</table>

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.<br>**Stanislaus River/Lower San Joaquin River**<br><u>Fall-run Chinook Salmon and Steelhead</u><br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar to those described under Alternative 1.<br>Beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br><u>White Sturgeon, Reservoir Fishes, and Other Species</u><br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar to those described under Alternative 1.<br><u>Striped Bass</u><br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Conditions for Striped Bass could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.<br>**Pacific Ocean**<br><u>Killer Whale</u><br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected. | |
| Alternative 5 | **Trinity River Region**<br><u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon</u><br>Effects would be similar.<br><u>Reservoir Fishes</u><br>Effects would be similar.<br><u>Pacific Lamprey</u><br>Effects would be similar.<br><u>Eulachon</u><br>Effects would be similar.<br>**Sacramento River System**<br><u>Winter-run Chinook Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon, and White Sturgeon</u><br>Effects would be similar.<br><u>Delta Smelt, Longfin Smelt, and Sacramento Splittail</u><br>Effects would be similar.<br><u>Reservoir Fishes</u><br>Effects would be similar.<br><u>Pacific Lamprey and Other Species</u><br>Effects would be similar. | Mitigation measures for other substantial impacts have not been identified at this time. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The analysis of temperatures indicates somewhat higher temperatures in some water year types and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing could be more stressful. However, the higher flows in April and May and lower temperatures in April and May could benefit steelhead spawning. Given the variability in the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 is likely to have similar effects on fall-run Chinook Salmon and steelhead in the Stanislaus and lower San Joaquin rivers.<br>White Sturgeon<br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br>Reservoir Fishes<br>Overall, the analysis suggests that conditions under Alternative 5 have the potential to negatively influence black bass nesting success, especially in April and May. However, nesting success under Alternative 5 would still exceed 40 percent most of the time. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar.<br>Other Species<br>Given the similar water temperatures, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar.<br>Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar water temperatures, it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected. | |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 9.5 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | **Trinity River Region**<br>Coho Salmon<br>Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent). Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.<br>Spring-run Chinook Salmon<br>Overall, water temperature could have adverse effects on spring-run Chinook Salmon in the Trinity River; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. However, the implementation of the Hatchery Management Plan could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River.<br>Fall-run Chinook Salmon<br>Although the combined analysis based on water temperature suggests that operations could be slightly more adverse, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality). In addition, these potential adverse effects could be offset by implementation of the Hatchery Management Plan (RPA Action II.6.3), which could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that the No Action Alternative is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.<br>Steelhead<br>Although the combined analysis based on water temperature suggests that operations could be slightly more adverse, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperature exceedances. Overall, given these small differences and the inherent uncertainty in the temperature model, these two scenarios are likely to have similar effects on the steelhead population in the Trinity River. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Green Sturgeon<br>Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar.<br>Reservoir Fishes<br>Overall, the comparison of storage and the analysis of black bass nesting suggest that effects would be similar.<br>Pacific Lamprey<br>Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that the effects would be similar. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br>Eulachon<br>Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely the conditions would be similar for Eulachon in the Klamath River.<br>**Sacramento River System**<br>Winter-run Chinook Salmon<br>Overall, the quantitative results from the numerical models suggest that the No Action Alternative would be less likely to result in adverse effects on winter-run Chinook Salmon. In consideration of the potentially beneficial effects resulting from the RPA actions that are not included in the numerical models, the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.<br>Spring-run Chinook Salmon<br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. However, it is concluded that the potential for adverse effects on spring-run Chinook Salmon suggested by the results of the numerical models would likely be offset by the potential benefits of the RPA actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon would be less than those under the Second Basis of Comparison.<br>Fall-run Chinook Salmon<br>Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under the No Action Alternative as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | because of the similarity in results and the inherent uncertainty of the models. In addition, any adverse effect of the No Action Alternative could be offset by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Thus, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative than under the Second Basis of Comparison.<br><br>Late Fall-run Chinook Salmon<br><br>The model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly less adverse. Potential effects may be lessened further due to actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be lower under the No Action Alternative compared to the Second Basis of Comparison.<br><br>Steelhead<br><br>The numerical model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers. However, implementation of a fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to the Second Basis of Comparison. Thus, it is concluded that the effects on steelhead would be less adverse under the No Action Alternative than under the Second Basis of Comparison.<br><br>Green Sturgeon<br><br>The increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. However, the analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile Green Sturgeon relative to the Second Basis of Comparison. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of Green Sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.<br><br><u>White Sturgeon</u><br><br>Overall, the increased frequency of exceedance of temperature thresholds in June under the No Action Alternative could increase the potential for effects on White Sturgeon in the Sacramento River relative to the Second Basis of Comparison, however, these effects are uncertain and may include reduced spawning and/or increased growth. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile White Sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.<br><br><u>Delta Smelt</u><br><br>Overall, likely to result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between alternatives may be important.<br><br><u>Longfin Smelt</u><br><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less.<br><br><u>Sacramento Splittail</u><br><br>Overall, the slight flow decreases under the No Action Alternative could result in less spawning habitat for Sacramento Splittail than under the Second Basis of Comparison because of the decreased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between the No Action Alternative and Second Basis of Comparison.<br><br><u>Reservoir Fishes</u><br><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar from March through May and somewhat higher in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison.<br><br><u>Pacific Lamprey</u><br><br>Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | likely that effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><br><u>Striped Bass, American Shad, and Hardhead</u><br><br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, the No Action Alternative likely would be similar for Hardhead and have a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival during larval and juvenile life stages, and more favorable location of Spring X2 on average.<br><br>**Stanislaus River/Lower San Joaquin River**<br><br><u>Fall-run Chinook Salmon</u><br><br>The water temperature model outputs for each of the life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar, although water temperatures under the No Action Alternative could be somewhat more suitable for fall-run Chinook Salmon spawning/egg incubation. Because the No Action Alternative has the potential for beneficial effects resulting from the RPA actions, it is concluded that the effects on fall-run Chinook Salmon would be less adverse relative to the Second Basis of Comparison.<br><br><u>Steelhead</u><br><br>The water temperature model outputs suggest that the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages could have the potential for adverse effects on steelhead in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. It is concluded that the potential for adverse effects on steelhead would be lower, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.<br><br><u>White Sturgeon</u><br><br>Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | distinguish potential effects on White Sturgeon between alternatives.<br><br>Reservoir Fishes<br><br>Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival would vary among months. Given the relatively high survival in general and the uncertainty caused by the inconsistency in changes in survival, it is likely that effects would be similar.<br><br>Other Species<br><br>In general, Pacific Lamprey, Striped Bass, and Hardhead also can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect these species in the Stanislaus and San Joaquin rivers would be similar.<br><br>**Pacific Ocean**<br><br>Killer Whale<br><br>Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |
| Alternative 1 | No effects on aquatic resources. | Not considered for this comparison. |
| Alternative 2 | **Trinity River Region**<br><br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.<br><br>**Sacramento River System**<br><br>The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in physical conditions that affect aquatic resources in the Central Valley Region would be the same as the impacts described for the No Action Alternative Compared to the Second Basis of Comparison. However, actions to provide fish passage to portions of the Sacramento, American, and Stanislaus rivers upstream of their dams would not be undertaken under Alternative 2 or the Second Basis of Comparison.<br><br>**Stanislaus River/Lower San Joaquin River**<br><br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.<br><br>**Pacific Ocean**<br><br>Killer Whale<br><br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | **Trinity River Region**<br><br>Coho Salmon and Chinook Salmon<br><br>Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the Second Basis of | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Comparison are likely to have similar effects on Coho Salmon and Chinook Salmon in the Trinity River.<br><br>Steelhead<br><br>Differences in water temperature conditions for steelhead in the Trinity River would be minor as described above for salmon. These results suggest that conditions for steelhead in the Trinity River generally would be similar.<br><br>Green Sturgeon<br><br>The results of the water temperature analysis suggests similar effects on Green Sturgeon in the Trinity River and lower Klamath River and estuary.<br><br>Reservoir Fishes<br><br>Overall, reservoir storage and nest survival suggest similar effects on black bass.<br><br>Pacific Lamprey and Eulachon<br><br>Overall, water temperature conditions for Pacific Lamprey and Eulachon in the Trinity River and Klamath River downstream of the confluence generally would be similar. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br><br>**Sacramento River System**<br><br>Winter-run Chinook Salmon<br><br>The numerical model results suggest that effects on winter-run Chinook Salmon would be similar, with a small likelihood that winter-run Chinook Salmon escapement would be higher. The ocean harvest restrictions under Alternative 3 could provide a benefit, although the effects of the predator management program are uncertain. Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components could benefit winter-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. Thus, the potential for adverse effects on winter-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.<br><br>Spring-run Chinook Salmon<br><br>The numerical model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower. Although the operational components could have greater adverse effects on spring-run Chinook Salmon, the non-operational components could benefit spring-run Chinook Salmon over the short term if successful. The ocean harvest restrictions could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival. The effects of the trap and haul and predator management programs are uncertain. Thus, the potential for adverse effects on spring-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.<br><br>Fall-run Chinook Salmon<br><br>Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, the potential for adverse effects on fall-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.<br><br><u>Late Fall-run Chinook Salmon</u><br><br>Overall, the results of the numerical models suggest the potential for less adverse effects on late fall-run Chinook Salmon. However, discerning meaningful differences based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.<br><br><u>Steelhead</u><br><br>Overall, the results of the numerical models suggest a slightly greater potential for adverse effects on steelhead. However, discerning a meaningful difference between based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects could be offset by the potentially beneficial effects resulting from predator control. Thus, the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.<br><br><u>Green and White Sturgeon</u><br><br>The slightly reduced frequency of exceedance of temperature thresholds could reduce the potential for adverse effects on sturgeon in the Sacramento and Feather rivers. The analysis based on Delta outflows suggests that there would be similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.<br><br><u>Delta Smelt</u><br><br>Overall, effects would be similar with regard to estimated entrainment and predicted location of Fall X2. However, given the current condition of the Delta Smelt population, even small differences between alternatives may be important.<br><br><u>Longfin Smelt</u><br><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values in drier years, the potential for adverse effects likely to be lower. Given the current condition of the Longfin Smelt population, even these small differences between alternatives may be important.<br><br><u>Sacramento Splittail</u><br><br>Flows entering the Yolo Bypass generally would be similar. Given the relatively minor changes in flows into | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the Second Basis of Comparison.<br><br>Reservoir Fishes<br><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar. Thus, it is likely that effects on black bass would be similar.<br><br>Other Species<br><br>Changes in average monthly water temperature would be small. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), likely to have similar effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers.<br><br>However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.<br><br>**Stanislaus River/Lower San Joaquin River**<br><br>Fall-run Chinook Salmon<br><br>Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.<br><br>Beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under fall-run Chinook Salmon would benefit the fall-run Chinook Salmon population.<br><br>Steelhead<br><br>Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would be generally similar. Discerning a meaningful difference based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Thus, the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.<br><br>White Sturgeon<br><br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br><br>Reservoir Fishes<br><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in New Melones would be similar to or higher. This suggests that conditions in New Melones could be more likely to support self-sustaining populations of black bass.<br><br>Other Species<br><br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br><br>However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.<br><br>**Pacific Ocean**<br><br>Killer Whale<br><br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected. | |
| Alternative 4 | **Trinity River Region**<br><br>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon<br><br>The effects would be identical.<br><br>**Sacramento River System**<br><br>The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison. Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta would be the same as under the Second Basis of Comparison.<br><br>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead<br><br>The effects in the Sacramento River system would be similar, although Alternative 4 could produce beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. However, the magnitude of these potential benefits remain uncertain.<br><br>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead<br><br>The effects in the Sacramento River system would be identical.<br><br>Striped Bass<br><br>The effects in the Sacramento River system would be similar, although predator control would result in adverse effects on Striped Bass. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | **Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar.  Beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions.  It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br>White Sturgeon, Reservoir Fishes, and Other Species<br>The effects in the Stanislaus River/Lower San Joaquin River system would be identical.<br>Striped Bass<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar.  Predation controls related to Striped Bass would result in adverse effects.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.<br>Beneficial effects due to benefits to fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions.  It remains uncertain, however, if predator management actions would benefit the fall-run Chinook Salmon population. | |
| Alternative 5 | **Trinity River Region**<br>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead<br>Monthly water temperature generally would be similar (less than 0.5°F differences), with the exception of drier years when temperatures could be as much as 2.2°F cooler in November and 1.5°F warmer in December. Average monthly water temperatures could be slightly (up to 0.6°F) higher during July and August and lower (up to 0.7°F) in September.  Lower September temperatures may result in slightly better conditions for spring-run Chinook Salmon spawning.  Similarly, temperature conditions could be slightly better for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years.<br>Water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September.<br>Discerning a meaningful difference based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, implementation of a Hatchery Management Plan could reduce the impacts of hatchery Chinook Salmon on natural Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks, but the potential magnitude of these benefits is uncertain.<br>Alternative 5 is likely to have similar effects on Chinook Salmon and steelhead in the Trinity River.<br>Reservoir Fishes<br>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | <u>Other Species</u><br>The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the Second Basis of Comparison.<br>**Sacramento River System**<br><u>Winter-run Chinook Salmon</u><br>Overall, the quantitative results from the numerical models suggest that operations would be less likely to result in adverse effects on winter-run Chinook Salmon. In consideration of the potentially beneficial effects resulting from actions that are not included in the numerical models, the potential for adverse effects on winter-run Chinook Salmon under Alternative 5 would clearly be less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.<br><u>Spring-run Chinook Salmon</u><br>The numerical model results suggest that, overall, Alternative 5 likely would have similar or slightly greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison. The potential for adverse effects on spring-run Chinook Salmon suggested by the results of the numerical models would likely be offset by the potential benefits of the actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under Alternative 5 would be less than those under the Second Basis of Comparison.<br><u>Fall-run Chinook Salmon</u><br>Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference between these two scenarios based on the quantitative results is difficult because of the similarity in results (generally differences less than 5 percent), the inherent uncertainty of the models, and the potential for offsetting benefits. Thus, the effects on fall-run Chinook Salmon would be similar.<br><u>Late Fall-run Chinook Salmon</u><br>The numerical model results suggest that overall, Alternative 5 is likely to have less adverse effect on late fall-run Chinook Salmon in the Sacramento River. Benefits may be enhanced by actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, the potential for adverse effects on late fall-run Chinook Salmon would be less under Alternative 5 relative to the Second Basis of Comparison. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | <u>Steelhead</u><br>The numerical model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers. However, implementation of a fish passage program intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 5 would be less than those under the Second Basis of Comparison.<br><u>Green Sturgeon</u><br>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers. However, analysis based on Delta outflows suggests that Alternative 5 provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.<br><u>White Sturgeon</u><br>The increased frequency of exceedance of temperature thresholds under Alternative 5 could increase the potential for adverse effects on White Sturgeon relative to the Second Basis of Comparison. However, the analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. Early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.<br><u>Delta Smelt</u><br>Overall, likely would result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.<br><u>Longfin Smelt</u><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | <u>Sacramento Splittail</u><br>Overall, the slight adverse effects related to spawning habitat for Sacramento Splittail because of the decreased area of potential habitat (inundation) and the potential for a slight decrease in the frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model, no definitive difference in effects on Sacramento Splittail could be discerned.<br><u>Reservoir Fishes</u><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar. Overall, the results of the nest survival analysis suggest that effects on reservoir fishes would be similar.<br><u>Pacific Lamprey</u><br>Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs),it is likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><u>Striped Bass, American Shad, and Hardhead</u><br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, Alternative 5 likely would have similar effects on Hardhead and a slightly lower potential for adverse effects on Striped Bass, American Shad, and Hardhead as compared to the Second Basis of Comparison, primarily due to the potential for increased survival for these two species during larval and juvenile life stages, and more favorable location of Spring X2 on average.<br>**Stanislaus River/Lower San Joaquin River**<br><u>Fall-run Chinook Salmon</u><br>The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. As described above, the instream flow patterns are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis.<br>Implementation of a fish passage project under Alternative 5, intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would not provide benefit to fall-run Chinook Salmon unless passage was provided and additional habitat could be accessed. Potential benefits to fall-run Chinook Salmon associated with fish passage is nevertheless uncertain. However, actions implemented under Alternative 5 intended to increase the efficiency of the Tracy and | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.Overall, given the small differences in the modeling results and the potential benefits anticipated by actions not captured in the models, effects on fall-run Chinook Salmon would be similar.<br>Steelhead<br>Given the frequency of exceedance and the generally stressful temperature conditions in the river, the substantial lower temperatures in October and April suggest that there would be less potential to result in adverse effects on steelhead.<br>Implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead,  In addition, the potential effects of Alternative 5 could be offset by actions intended to reduce predation risk on steelhead in the Stanislaus River and increase the efficiency of the Tracy and Skinner Fish Collection Facilities.  The actions to augment spawning gravel in the Stanislaus River under Alternative 5 also could benefit steelhead.<br>The numerical model results for effects on steelhead under Alternative 5 and Second Basis of Comparison do not definitively show distinct differences.  However, in consideration of the potentially beneficial effects resulting from the actions that would be implemented under Alternative 5 that are not included in the numerical models, Alternative 5 has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, the potential for adverse effects on steelhead under Alternative 5 would clearly be less than that under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.<br>White Sturgeon<br>Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River.  While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer.  The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers.  The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River.  In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.<br>Reservoir Fishes<br>Overall, the analysis suggests that conditions under Alternative 5 have the potential to influence black bass | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | nesting success, especially in April and May in comparison to the Second Basis of Comparison. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, there would be no definitive difference in effects on reservoir fish between Alternative 5 and the Second Basis of Comparison.<br><br><u>Other Species</u><br><br>In general, Striped Bass and Hardhead can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br><br>**Pacific Ocean**<br><br><u>Killer Whale</u><br><br>Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

#### *9.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would result in adverse impacts. Potential mitigation measures that could be considered to reduce the adverse water temperature impacts include implementation of fish passage programs. Mitigation measures for other substantial adverse impacts have not been identified at this time.

##### 9.4.3.8.1 Fish Passage Programs

Implementation of Alternatives 1, 2, 3, and 4 would result in adverse impacts due to high water temperatures in the streams downstream of the dams. A potential mitigation measure to reduce these effects would be:

- Implement fish passage programs at Shasta and Keswick, Oroville and Thermalito, Folsom and Nimbus, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead under Alternatives 1, 2, 3, and 4.

These programs would be similar to programs implemented under the 2009 NMFS BO, as included in the No Action Alternative and Alternative 5. This mitigation measure would be in response to the climate change effects anticipated in 2030 in addition to the changes under Alternatives 1, 2, 3, and 4.

#### *9.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis under Alternatives 1 through 5 for Fish and Aquatic Resources are summarized in Table 9.6.

**Table 9.6 Summary of Cumulative Effects on Fish and Aquatic Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions Included in the No Action Alterantive and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives)<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise:<br>• Implementation of Federal and state policies and programs, including Clean Water Act (e.g. Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>• General plans for 2030.<br>• Trinity River Restoration Program.<br>• Central Valley Project Improvement Act programs<br>• Iron Mountain Mine Superfund Site<br>• Nimbus Fish Hatchery Fish Passage Project<br>• Folsom Dam Water Control Manual Update | These effects would be the same under all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce carryover storage in reservoirs, stream flows and Delta outflow, and the availability of CVP and SWP water supplies as compared to past conditions.<br>These future actions could modify surface water conditions (e.g., flow) and affect habitat for fish and aquatic resources. However, many of these actions are intended to improve habitat conditions for aquatic resources or water quality, and thus the alternatives would not contribute to an adverse cumulative effect on aquatic resources. In addition, these actions were or would be subject to compliance with ESA, CESA, and other environmental laws and requirements, which serve to reduce the potential for impacts on aquatic resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | • FERC Relicensing for the Middle Fork of the American River Project<br>• Lower Mokelumne River Spawning Habitat Improvement Project<br>• Dutch Slough Tidal Marsh Restoration<br>• Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>• Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>• San Joaquin River Restoration Program<br>• Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>• Grasslands Bypass Project<br>• Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) | |
| Future Actions Considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>• Bay-Delta Water Quality Control Plan Update<br>• FERC Relicensing Projects<br>• Bay Delta Conservation Plan (including the California WaterFix alternative)<br>• Shasta Lake Water Resources Investigation, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>• El Dorado Water and Power Authority Supplemental Water Rights Project<br>• Sacramento River Water Reliability Project<br>• Semitropic Water Storage District Delta Wetlands | <u>These effects would be the same under all alternatives.</u><br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, and increased water allocated to improve habitat conditions. It is unclear how these future reasonably foreseeable actions would influence aquatic resources because project details are not available. However, as described above, these actions would be subject to environmental regulations that avoid or limit the potential for cumulative effects on aquatic resources. Some of these actions (e.g., FERC relicensing projects) could cumulatively contribute to reducing adverse effects of climate change on aquatic resources if fish passage and improved water temperature control result from the FERC process. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | • North Bay Aqueduct Alternative Intake<br>• Irrigated Lands Regulatory Program<br>• San Luis Reservoir Low Point Improvement Project<br>• *Westlands Water District v. United States Settlement*<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | |
| No Action Alternative with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative would result in changes in stream flows, increased Delta outflow, and reduced CVP and SWP water supplies as compared to conditions prior to the BOs. These RPA actions are intended and anticipated to put fish and aquatic resources on a more favorable trajectory than would occur without these actions. |
| Alternative 1 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable actions. |
| Alternative 2 with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions.<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | The effects of Alternative 2 on water temperature relative to the No Action Alternative could contribute incrementally to the cumulative effects on listed salmonids because the alternative provides no mechanism for addressing long-term temperature increases. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 3 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased ocean salmon fishing harvest limitations | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable actions. |
| Alternative 4 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased ocean salmon fishing harvest limitations<br>No implementation of the USACE vegetation standards for levees | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable actions. |
| Alternative 5 with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in changes in stream flows, increased Delta outflows, and reduced CVP and SWP water exports as compared to the No Action Alternative with these added actions. |

## 9.5 References

Aasen, G. 2011. Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during the 2010 Water Year. IEP Newsletter. Vol. 24, Number 1, Spring.

Aasen, G. 2012. Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during the 2011 Water Year. IEP Newsletter. Vol. 25, Number 1, Fall/Winter.

Aceituno, M. E. 1993. The Relationship Between Instream Flow and Physical Habitat Availability for Chinook Salmon in the Stanislaus River, California. U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office, Sacramento, California.

Acuna et al. (Acuna, S., D. Deng, P. Lehman, S. the). 2012. Sublethal Dietary Effects of Microcystis on Sacramento Splittail, Pogonichthys macrolepidotus. Aquat Toxicol no. 110-111:1-8. doi: 10.1016/j.aquatox.2011.12.004.

Adams et al. (Adams, P. B., C. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley). 2007. Population Status of North American Green Sturgeon, Acipenser medirostris. Environmental Biology of Fishes 79: 339-356.

AFRP (Anadromous Fish Restoration Program). 2011. Videography monitoring of Adult Sturgeon in the Feather River Basin, California.

AFRP (Anadromous Fish Restoration Program). 2012. Draft CVPIA Fiscal Year 2012 Annual Work Plan. 3406(b)(1).

Ainsley et al. (Ainsley, S., J. Pombo, T. Wright, and E. Loury). 2013. Pilot study: the Feasibility of Using Fyke Traps in the Lower San Joaquin River to Capture Adult Striped Bass. FISHBIO, Oakdale, California. July.

Aplers et al. (Alpers, C., C. Eagles-Smith, C. Foe, S. Klasing, M. Marvin-DiPasquale, D. Slotton, and L. Winham-Myers). 2008. Mercury Conceptual Model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Anderson et al. (Anderson, J., C. Watry, and A. Gray). 2007. Upstream Fish Passage at a Resistance Board Weir using Infrared and Digital Technology in the Lower Stanislaus River, California. 2006–2007 Annual Data Report. Prepared for the U.S. Fish and Wildlife Service.

ARG (American River Group). 2011. Annual Report of Activities, October 1, 2010 to September 30, 2011. October.

ARG (American River Group). 2012. Annual Report of Activities, October 1, 2011 to September 30, 2012. September.

Arthur et al. (Arthur, J. F., M. D. Ball, and S. Y. Baughman). 1996. Summary of Federal and State Water Project Environmental Impacts in the San Francisco Bay-Delta estuary, California. In The San Francisco Bay: The Ecosystem, edited by J.T. Hollibaugh, 445-495. Seventy-fifth annual meeting of the Pacific Division, American Association for the Advancement of Science. Held at San Francisco State University, June 19-24, 1994. San Francisco, California.

Azat, J. 2012. Central Valley Chinook salmon harvest and escapement. Interagency Ecological Program Newsletter: 25(2).

Baerwald et al. (Baerwald, M. R., B. M. Schreier, G. Schumer, and B. May). 2012. Detection of Threatened Delta Smelt in the Gut Contents of the Invasive Mississippi Silverside in the San Francisco Estuary using TaqMan Assays, Transactions of the American Fisheries Society 141: 1600-1607.

Bain, M. B., and N. J. Stevenson, editors. 1999. Aquatic Habitat Assessment: Common Methods. American. Fisheries Society, Bethesda, Maryland.

Barnett-Johnson, R., C. B. Grimes, C. F. Royer, and C. J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (Oncorhynchus tshawytscha) to the ocean fishery using otolith microstructure as natural tags. Canadian Journal of Fisheries and Aquatic Sciences 64:1683–1692.

Bartholomew, J. L. 2012. 3.2.4 Salmonid ceratomyxosis. AFS-FHS (American Fisheries Society-Fish Health Section). FHS Blue Book: Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens, 2014 Edition.

Baxa et al. (Baxa, D.V., A. Stover, M. Clifford, T. Kurobe1, S.J. Teh, P. Moyle, and R.P. Hedrick). 2013. Henneguya sp. in Yellowfin Goby Acanthogobius flavimanus from the San Francisco Estuary. SpringerPlus 2013, 2:420.

Baxter, R. D. 1999. Status of Splittail in California. California Fish and Game 85: 28–30.

Baxter et al. (Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer, and K. Souza). 2008. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Technical Report 227. Interagency Ecological Program for the San Francisco Estuary.

Baxter et al. (Baxter, R., R. Breuer, L. Brown, L. Conroy, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza). 2010. Pelagic Organism Decline Work Plan and Synthesis of Results. Interagency Ecological Program for the San Francisco Estuary.

Beamesderfer et al. (Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko). 2004. Historical and Current Information on Green Sturgeon Occurrence in the Sacramento and San Joaquin Rivers and Tributaries. Prepared by for State Water Contractors, Sacramento, California.

Beamesderfer et al. (Beamesderfer, R., M. Simpson, and G. Kopp). 2007. Use of Life History Information in a Population Model for Sacramento Green Sturgeon. Environmental Biology of Fishes 79: 315-337.

Bennett, W. A. 2005. Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3: Article 1.

Bennett, W. A., and P. B. Moyle. 1996. Where Have All The Fishes Gone? Interactive Factors Producing Fish Declines in the Sacramento-San Joaquin Estuary. San Francisco Bay: the ecosystem. Edited by J. T. Hollibaugh, 519-542. American Association for the Advancement of Science, Pacific Division, San Francisco, California.

Bennett et al. (Bennett, W. A., J. A. Hobbs, and S. J. the). 2008. Interplay of Environmental Forcing and Growth-Selective Mortality in the Poor Year-Class Success of Delta Smelt in 2005. Final Report. Fish Otolith and Condition Study 2005. Prepared for the Pelagic Organism Decline Management Team.

Benson et al. (Benson, R. L., S. Turo, and B. W. McCovey). 2007. Migration and Movement Patterns of Green Sturgeon (Acipenser medirostris) in the Klamath and Trinity Rivers, California, USA. Environmental Biology of Fishes 79: 269-279.

BLM (Bureau of Land Management). 1995. Mainstem Trinity River watershed analysis.

Bootland, L. M., and J. C. Leong. 1999. Infectious Hematopoietic Necrosis Virus (IHNV). Viral, Bacterial and Fungal Infections, Vol. II. Edited by P. T. K. Woo and D. W. Bruno, 519-542. CAB International Publishing.

Bourez, W. 2011. Subject: Relating Delta Smelt Index to X2 position, Delta Flows, and Water Use. Memorandum from MBK Engineers to the Northern California Water Association. December 15.

Bowen et al. (Bowen, M., S. Siegfried, C. Liston, L. Hess, and C. Karp). 1998. Fish Collections and Secondary Louver Efficiency at the Tracy Fish Collection Facility, October 1993 to September 1995. Tracy Fish Collection Facility Studies, Volume 7. Bureau of Reclamation.

Brandes, P. L., and J. S. McClain. 2001. Juvenile Chinook Salmon Abundance, Distribution, and Survival in the Sacramento-San Joaquin Estuary. Edited by R. L. Brown. Contributions to the biology of Central Valley Salmonids. California Department of Fish and Game Fish Bulletin 179: 39-137.

Brown, K. 2007. Evidence of Spawning by Green Sturgeon, Acipenser medirostris, in the Upper Sacramento River, California. Environmental Biology of Fishes 79: 297-303.

Brown, M. 2011. Clear Creek Technical Team report for the OCAP BiOps Integrated Annual Review. U.S. Fish and Wildlife Service.

Brown, L. 2013. Ecological Contest for the Delta: A Lot Can Happen in 150 Years. USGS California Water Science Center.

Brown, L. R., and J. T. May. 2006. Variation in Spring Nearshore Resident Fish Species Composition and Life Histories in the Lower San Joaquin Watershed and Delta. San Francisco Estuary and Watershed Science 4(1).

Brown, L. R., and D. Michniuk. 2007. Littoral Fish Assemblages of the Alien-dominated Sacramento–San Joaquin Delta, California 1980–1983 and 2001–2003. Estuaries and Coasts 30: 186-200.

Brown, L. R., and P. B. Moyle. 1993. Distribution, Ecology, and Status of Fishes of the San Joaquin River Drainage, California. California Fish and Game 79: 96-113.

Brown et al. (Brown, L. R., R. Baxter, G. Castillo, L. Conrad, S. Culberson, G. Erickson, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, J. Kirsch, A. Mueller-Solger, S. B. Slater, T. Sommer, K. Souza, and E. Van Nieuwenhuyse). 2014. Synthesis of Studies in the Fall Low-Salinity Zone of the San Francisco Estuary, September–December 2011. Scientific Investigations Report 2014–5041. Reston, Virginia. U.S. Geological Survey.

Brown et al. (Brown R., S. Greene, P. Coulston, and S. Barrow). 1996. An Evaluation of the Effectiveness of Fish Salvage Operations at the Intake of the California Aqueduct, 1979-1993. San Francisco Bay: the ecosystem. Edited by J.T. Hollibaugh, 497-518. Pacific Division of the American Association for the Advancement of Science, San Francisco, California.

Brown et al. (Brown, R., B. Cavallo, and K. Jones). 2004. The Effects of the Feather River Hatchery on naturally spawning Salmonids. Oroville Facilities Relicensing (FERC Project Number 2100). Draft Report SP-F9. Prepared by California Department of Water Resources, Sacramento, California, and Pacific States Marine Fisheries Commission, Portland, Oregon.

Brown et al. (Brown, M., S. Giovannetti, J. Earley, and P. Bratcher). 2012. Clear Creek Technical Team Report for the Coordinated Long-term Operation BiOps Integrated Annual Review. U.S. Fish and Wildlife Service.

Buchanan R. A., J. R. Skalski, P. L. Brandes and A. Fuller. 2013. Route Use and Survival of Juvenile Chinook Salmon through the San Joaquin River Delta, North American Journal of Fisheries Management, 33(1): 216-229.

Budy et al. (Budy, P., G. P. Thiede, N. Bouwes, C. E. Petrosky, and H. Schaller). 2002. Evidence Linking Delayed Mortality of Snake River Salmon to their Earlier Hydrosystem Experience. North American Journal of Fisheries Management 22: 35–51.

Burau et al. (Burau, J. R., S. G. Monismith, M. T. Stacey, R. N. Oltmann, J. R. Lacy, and D. H. Schoellhamer). 2000. Recent Research on the Hydrodynamics of the Sacramento-San Joaquin River Delta and North San Francisco Bay. Interagency Ecological Program Newsletter 13: 45-53.

Busby et al. (Busby, P. J., T. C. Wainwright, and R. S. Waples). 1994. Status Review for Klamath Mountains Province steelhead. NOAA Technical Memorandum NMFS-NWFSC-19. National Marine Fisheries Service.

Busby et al. (Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino). 1996. Status Review of West Coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS–NWFSC–27. June.

Calduch-Verdiell N, MacKenzie BR, Vaupel JW, Andersen KH. 2014. A life history evaluation of the impact of maternal effects on recruitment and fisheries reference points. Can J Fish Aquat Sci 71: 1113–1120. doi: 10.1139/cjfas-2014-0034. June.

CALFED Bay-Delta Program. 2000a. Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed. Ecosystem Restoration Program Plan.

CALFED Bay-Delta Program. 2000b. Multi-species Conservation Strategy. Final Programmatic Environmental Impact Statement/Environmental Impact Report.

CALFED. 2004. Environmental Water Program Pilot Flow Augmentation Project: Concept Proposal for Flow Acquisition on Lower Clear Creek. August.

CALFED Bay-Delta Program. 2007. Green Sturgeon (Acipenser medirostris). In Delta Regional Ecosystem Restoration Implementation Plan. Draft Report.

CalFish (California Fish). 2014. Fish Species by Location – 'Lake Piru-Piru Creek'. California Fish Site accessed October 30, 2014. http://calfish.ucdavis.edu/

CA Lakes. 2014. Lake Piru Fishing. California's Greatest Lakes. Site accessed October 30, 2014. http://www.californiasgreatestlakes.com/piru/piru_fishing.html

Carey, M.P., Sanderson, B.L., Barnas, K.A., and Olden, J.D. 2012. Native invaders – challenges for science, management, policy, and society. Fron. Eco. Environ. 10(7):373-381.

Castillo et al. (Castillo, G., J. Morinaka, J. Lindberg, R. Fujimura, B. Baskerville-Bridges, J. Hobbs, G. Tigan, L. Ellison). 2012. Pre-screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California. San Francisco Estuary and Watershed Science, 10(4).

Cavallo et al. (Cavallo, B., J. Merz, and J. Setka). 2012. Effects of Predator and Flow Manipulation on Chinook Salmon (Oncorhynchus tshawytscha) Survival in an Imperiled Estuary. Environmental Biology of Fishes: doi. 10.1007/s10641-012-9993-5

CCTT (Clear Creek Technical Team). 2014. 2014 Clear Creek Technical Team Report for the Coordinated Long-Term Operation Biological Opinions Integrated Annual Review. October 3.

CCWA (Central Coastal Water Authority). 2013. Central Coast Water Authority Fiscal Year 2013/14 Budget. April 25.

Cech et al. (Cech, J. J., S. J. Mitchell, and T. E. Wragg). 1984. Comparative Growth of Juvenile White Sturgeon and Striped Bass: effects of Temperature and Hypoxia. Estuaries 7: 12-18.

CHSRG (California Hatchery Scientific Review Group). 2012. California Hatchery Review Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June.

City of Hemet. 2012. City of Hemet General Plan 2030, Environmental Impact Report, Final. January 12.

City of San Diego. 2014a. El Capitan Reservoir. Site accessed October 30. 2014 http://www.sandiego.gov/water/recreation/reservoirs/lowerotay.shtml

City of San Diego. 2014b. Lower Otay Reservoir. Site accessed May 29. http://www.sandiego.gov/water/recreation/reservoirs /elcapitan.shtml

Clemens et al. (Clemens, B. J., M. G. Mesa, R. J. Magie, D. A. Young, and C. B. Schreck). 2012. Pre-spawning Migration of Adult Pacific Lamprey, Entosphenus tridentatus, in the Willamette River, Oregon, U.S.A. Environmental Biology of Fishes 93: 245-254.

Cooke et al. (Cooke, S. J., S. G. Hinch, G. T. Crossin, D. A. Patterson, K. A. English, M. C. Healy, J. M. Shrimpton, G. Van Der Kraak, and A. P. Farrell). 2006. Mechanistic Basis of Individual Mortality in Pacific salmon during spawning migrations. Ecology 87: 1575–1586.

County of San Bernardino. 2011. County of San Bernardino General Plan Amendment and Greenhouse Gas Reduction Plan, Draft Supplemental Program Environmental Impact Report. March.

CRA (California Resources Agency). 2005. Delta Smelt Action Plan.

CSP (California State Parks). 2010. Silverwood Lake State Recreation Area Nature Center Interpretive Project Plan. April.

CSP (California State Parks). 2013. Bethany Reservoir State Recreation Area.

Cunningham, C., N. Hendrix, E. Dusek-Jennings, R. Lessard, and R. Hilborn. 2015. Delta Chinook Final Report to the Delta Science Panel. Available online: deltacouncil.ca.gov/sites/default/files/2039%20Final%20Report.pdf

CVPIA (Central Valley Project Improvement Act). 2014. Draft CVPIA Fiscal Year 2015 Annual Work Plan, Clear Creek Restoration, CVPIA Section 3406 (b)(12).

CVRWQCB (Central Valley Regional Water Quality Control Board). 2002. Upper Sacramento River TMDL for Cadmium, Copper, and Zinc. Final Report.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2011. Water Quality Control Plan (Basin Plan) for the California Water Quality Control Board Central Valley Region, 4th Edition, Revised October 2011, with Approved Amendments: The Sacramento River Basin and the San Joaquin River Basin.

Davis et al. (Davis, J. A., D. Yee, J. N. Collins, S. E. Schwarzbach, and S. N. Luoma). 2003. Potential for Increased Mercury Accumulation in the Estuary Food Web. San Francisco Estuary and Watershed Science 1.

Dege, M., and L. R. Brown. 2004. Effect of Outflow on Spring and Summertime Distribution and Abundance of Larval and Juvenile Fishes in the Upper San Francisco Estuary. Early life history of fishes in the San Francisco Estuary and watershed. Edited by F. Feyrer, L. R. Brown, R. L. Brown, and J.J. Orsi, 49-66. American Fisheries Society Symposium 39.

Del Rosario et al. (Del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece, R. Vincik). 2013. Migration Patterns of Juvenile winter-run-sized Chinook Salmon (Oncorhynchus tshawytscha) through the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science, 11(1).

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1985. Status of winter-run Chinook Salmon, Oncorhynchus tshawytscha, in the Sacramento River. January 25.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1992. A Re-examination of Factors Affecting Striped Bass Abundance in the Sacramento-San Joaquin estuary. WRINT-DFG-Exhibit 2. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Rights Phase of the Bay-Delta Estuary Proceedings.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1998a. Age, Growth, And Life History Of Klamath River Basin steelhead trout (Oncorhynchus mykiss irideus) as Determined from Scale Analysis. Inland Fisheries Division. Administration Report 98-3.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1998b. A Status Review of the spring-run Chinook Salmon in the Sacramento River Drainage. Candidate species status report 98-1. Report to the Fish and Game Commission.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2002a. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2002b. Fishing California's Sacramento Valley–Central Sierra Region. October.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2007. San Joaquin River Fshery and Aquatic Resources Inventory. Final Report September 2003–September 2005.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2008a. California Aquatic Invasive Species Management Plan. State of California Resources Agency.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2008b. 2007 Sturgeon Fishing Report Card: Preliminary Data Report.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2009a. A Status Review of the Longfin Smelt (Spirinchus thaleichthys) in California. Report to the Fish and Game Commission. January 23.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2009b. 2008 Sturgeon Fishing Report Card: Preliminary Data Report. June 17.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2010. 2009 Sturgeon Fishing Report Card: Preliminary Data Report. March 29.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2011. 2010 Sturgeon Fishing Report Card: Preliminary Data Report. April 20.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012a. Central Valley Chinook Salmon In-River Escapement Monitoring Plan. Fisheries Branch Administrative Report Number: 2012-1. January.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012b. 2011 Sturgeon Fishing Report Card: Preliminary Data Report. March 23.

DFG and USFWS (California Department of Fish and Game [now known as Department of Fish and Wildlife] and U.S. Fish and Wildlife Service). 2010. Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement. Final. January.

DFW (California Department of Fish and Wildlife). 2013b. 2012 Sturgeon Fishing Report Card: Preliminary Data Report. July 12.

DFW (California Department of Fish and Wildlife). 2014a. 2014. Annual Report Trinity River Basin Salmon and Steelhead Monitoring Project: Chinook and Coho Salmon and Fall Midwater Trawl-run Steelhead

Run-Size Estimates Using Mark-Recapture Methods 2013 Annual Fish Abundance Summary received by Scott Wilson, Regional Manager, Region 3/California Department of Wildlife via technical memorandum from Dave Contreras, Environmental Scientist/California Department of Wildlife. 2014. -2014 Season. August 2014. 92 pp.

DFW (California Department of Fish and Wildlife). 2014b. Trends in Abundance of Selected Species, dated January 15, 2014. Site accessed July 17, 2015. http://www.dfg.ca.gov/delta/data/fmwt/Indices/.

DFW (California Department of Fish and Wildlife). 2015. GrandTab California Central Valley Chinook Population Database Report compiled on April 15, 2015. Site accessed 2015. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381&inline=1.

DOI (U.S. Department of the Interior). 2000. Record of Decision for the Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Environmental Impact Report.

DOI (U.S. Department of the Interior). 2012. Assessment of Action in the Central Valley of California between 1992 and 2011.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report. December.

Dugdale et al. (Dugdale, R. C., F. P. Wilkerson, V. E. Hogue, and A. Marchi). 2007. The Role of Ammonium and Nitrate in Spring Bloom Development in San Francisco Bay. Estuarine, Coastal and Shelf Science 73: 17-29.

Durand, J. 2008. Delta foodweb conceptual model. Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). Sacramento, California.

DVM (Diamond Valley Marina). 2014. Diamond Valley Lake Fishing. Site accessed October 30, 2014. http://www.dvmarina.com/fishing/index.php.

DWR (California Department of Water Resources). 1980. Upper Sacramento River Spawning Gravel Study Executive Summary. December.

DWR (California Department of Water Resources). 1985. Sacramento River Spawning Gravel Studies, Executive Summary. June.

DWR (California Department of Water Resources). 1987. Recreation Use Survey of San Luis Reservoir, O’Neill Forebay, and Los Banos Detention Reservoir, Merced County, 1986.

DWR (California Department of Water Resources). 1994. Sacramento River Bank Erosion Investigation. Memorandum Progress Report. September 23.

DWR (California Department of Water Resources). 1997. Quail Lake. July.

DWR (California Department of Water Resources). 2000a. Suisun Marsh Monitoring Program. Reference Guide. Version 2. June.

DWR (California Department of Water Resources). 200b. Pyramid Lake. May.

DWR (California Department of Water Resources). 2003a. Fish Distribution in the Feather River downstream of Thermalito diversion dam to the Confluence with the Sacramento River. SP-F3.2 Task 1 and F21 Task 2. Draft Report. Oroville Facilities Relicensing FERC Project No. 2100.

DWR (California Department of Water Resources). 2003b. Final Assessment of Sturgeon Distribution and Habitat Use. Oroville Facilities Relicensing FERC Project No. 2100. SP-F3.2 Task 3a.

DWR (California Department of Water Resources). 2004a. Assessment of Potential Project Effects on Splittail Habitat. SP-F3.2 Task 3B. Final Report. Oroville Facilities Relicensing, FERC Project No. 2100.

DWR (California Department of Water Resources). 2004b. Evaluation of Project Effects on Instream Flows and Fish Habitat. SP F-16 Phase 2 Report. Oroville Facilities Relicensing, FERC Project No. 2100.

DWR (California Department of Water Resources). 2004c. Evaluation of Project Effects on Fish Disease. SP-F2. Oroville Facilities Relicensing, FERC Project No. 2100.

DWR (California Department of Water Resources). 2004d. Draft Environmental Impact Report for the Simulation of Natural Flows in Middle Piru Creek. November.

DWR (California Department of Water Resources). 2004e. Oroville Facilities Relicensing, Final report: Evaluation of methods and devices used in the capture, sorting, holding, transport, and release of fish SP-F15, Task 3.

DWR (California Department of Water Resources). 2005. Fish passage Improvement, an Element of CALFED's Ecosystem Restoration Program. Bulletin 250.

DWR (California Department of Water Resources). 2006. Settlement Agreement for Licensing of the Oroville Facilities, FERC Project No. 2100. March.

DWR (California Department of Water Resources). 2007. Monterey Plus Draft Environmental Impact Report. October.

DWR (California Department of Water Resources). 2009a. Central Valley spring-run Chinook Salmon and steelhead in the Sacramento River Basin. Background Report.

DWR (California Department of Water Resources). 2009b. East Branch Extension Phase I Improvements Project, Draft Supplemental Environmental Impact Report No. 2. March.

DWR (California Department of Water Resources). 2010a. Perris Dam Remediation Program, Draft Environmental Impact Report. January.

DWR (California Department of Water Resources). 2010b. Release Site Predation Study. Fishery Improvements Section, Bay-Delta Office. Sacramento, California.

DWR (California Department of Water Resources). 2012. Implementation Strategy: Habitat Restoration and Other Actions for Listed Delta Fish. Fish Restoration Program Agreement.

DWR (California Department of Water Resources). 2013a. Thermalito Facilities. Site accessed March 4, 2013. http://www.water.ca.gov/swp/facilities/Oroville/thermalito.cfm

DWR (California Department of Water Resources). 2013b. Upper Feather River Lakes. April.

DWR et al. (California Department of Water Resources, Yuba County Water Agency, Bureau of Reclamation). 2007. Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord. June.

DWR et al. (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. Environmental Impact Report/ Environmental Impact Statement for the Bay Delta Conservation Plan. Draft. December.

Earley et al. (Earley, J. T., D. J. Colby, and M. R. Brown). 2010. Juvenile Salmonid Monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service.

EBMUD (East Bay Municipal Utility District). 1999. East Bay Watershed Master Plan. February 29, 1996 (Revised March 15, 1999). March 15.

EBMUD (East Bay Municipal Utility District). 2012. Mokelumne River hatchery fish information received by Jose Setka, Fisheries and Wildlife Division.

EBMUD (East Bay Municipal Utility District). 2013. Draft Environmental Impact Report Chabot Dam Seismic Upgrade. December.

EBMUD (East Bay Municipal Utility District). 2014. San Pablo Reservoir. Site accessed October 30, 2014. https://www.ebmud.com/recreation/san-pablo-reservoir.

EBPRD (East Bay Parks and Recreation District). 2014. Del Valle Regional Park. Site accessed April 18, 2014. http://www.ebparks.org/parks/del_valle.

Edmunds, J. L., K. M. Kuivila, B. E. Cole, and J. E. Cloern. 1999. Do Herbicides Impair Phytoplankton Primary Production in the Sacramento-San Joaquin River Delta? In Proceedings of the Technical Meeting: Toxic Substances Hydrology Program, Volume 2: Contamination of Hydrologic Systems and Related Ecosystems. U.S. Geological Survey Water Resources Investigation Report 99.4018B.

Emmett et al. (Emmett, R. L., S. L. Stone, S. A. Hinton, and M. E. Monaco). 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume 2: Species Life History Summaries. Estuarine Living Marine Resources Program Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

Engle et al. (Engle, J., C. Enos, K. McGourty, T. Porter, B. Reed, J. Scammell-Tinling, K. Schaeffer, S. Siegel, and E. Crumb). 2010. Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model. Chapter 2: Aquatic Environment. Final Review Draft. Suisun Marsh Habitat Management, Restoration, and Preservation Plan.

Erickson et al. (Erickson, D. L., J. A. North, J. E. Hightower, J. Weber, and L. Lauck). 2002. Movement and Habitat Use of Green Sturgeon Acipenser medirostris in the Rogue River, Oregon, USA. Journal of Applied Ichthyology 18: 565-569.

Everest, L. 1997. Summer steelhead Surveys, North Fork Trinity River, Trinity County, California, 1978–1997. USDA Forest Service, Weaverville Ranger District, Shasta-Trinity National Forests.

Farley, T. C. 1966. Striped Bass, Roccus Saxatilis, Spawning in the Sacramento–San Joaquin River Systems during 1963 and 1964. In J. L. Turner and D. W. Kelley (eds.), Ecological Studies of the Sacramento–San Joaquin Estuary, Part II – Fishes of the Delta. California Department of Fish and Game, Fish Bulletin 136.

Faulkner et al. 2010 Trap and Haul from Cramer

FERC (Federal Energy Regulatory Commission). 2007a. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F.

FERC (Federal Energy Regulatory Commission). 2007b. Final Environmental Impact Statement for Hydropower License, Oroville Facilities, FERC Project No. 2100-052, California.

FERC (Federal Energy Regulatory Commission). 2013. Draft Environmental Impact Statement for the Drum-Spaulding Hydroelectric Project (Project No. 2310-193) and Yuba-Bear Hydroelectric Project (Project No. 2266-102). May.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Feyrer, F. 2004. Ecological Segregation of Native and Alien Larval Fish Assemblages in the Southern Sacramento-San Joaquin Delta. Early Life History of Fishes in the San Francisco Estuary and Watershed. Symposium 39. Edited by F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, 67-79. American Fisheries Society, Bethesda, Maryland.

Feyrer, F., and M. Healey. 2003. Fish Community Structure and Environmental Correlates in the Highly Altered Southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes 66: 123-132.

Feyer et al. (Feyrer, F., B. Herbold, S. A. Matern, and P. B. Moyle). 2003. Dietary Shifts in a Stressed Fish Assemblage: Consequences of a Bivalve Invasion in the San Francisco Estuary. Environmental Biology of Fishes 67: 277-288.

Feyrer et al. (Feyrer, F., T. R. Sommer, and R. D. Baxter). 2005. Spatial-Temporal Distribution and Habitat Associations of Age-0 Splittail in the Lower San Francisco Estuary Watershed. Copeia, 2005(1), pp. 159-168.

Feyer et al. (Feyrer, F., T. Sommer, and W. Harrell). 2006. Managing Floodplain Inundation for Native Fish: Production Dynamics of Age-0 Splitail (Pogonichthys macrolepidotus) in California's Yolo Bypass. Hydrobiologia 573: 213–226.

Feyer et al. (Feyrer, F., M. L. Nobriga, and T. R. Sommer). 2007. Multi-decadal Trends for Three Declining Fish Species: Habitat Patterns and Mechanisms in the San Francisco Estuary, California, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 64: 723-734.

Feyer et al. (Feyrer, F, K. Newman, M. Nobriga, and T. Sommer). 2010. Modeling the Effects of Future Freshwater Flow on the Abiotic Habitat of an Imperiled Estuarine Fish. Estuaries and Coasts 34: 120-128.

Fish, M. A. 2010. A White Sturgeon Year-Class Index for the San Francisco Estuary and Its Relation to Delta Outflow. IEP Newsletter. Vol. 23, Number 2, Spring.

FISHBIO (FISHBIO Environmental, LLC). 2007. 2007 Stanislaus River data report. Final Data.

FISHBIO (FISHBIO Environmental, LLC). 2010a. Fall/Winter Migration Monitoring at the Tuolumne River Weir 2009/10 Annual Report. Prepared For: Turlock Irrigation District and Modesto Irrigation District. March.

FISHBIO (FISHBIO Environmental, LLC). 2010b. FISHBIO Fall-Run Chinook Salmon Update. Posted on the FISHBIO blog on December 15, 2010. Accessed at http://fishbio.com/field-notes/population-dynamics/fishbio-fall-run-chinook-salmon-update-2 on October 13, 2015.

FISHBIO (FISHBIO Environmental, LLC). 2011. Fall/Winter Migration Monitoring at the Tuolumne River Weir 2010 Annual Report. Prepared For: Turlock Irrigation District and Modesto Irrigation District. March.

FISHBIO (FISHBIO Environmental, LLC). 2013a. 2013 Seine Report and Summary Update, Tuolumne River. Prepared For: Turlock Irrigation District and Modesto Irrigation District. March.

FISHBIO (FISHBIO Environmental, LLC). 2013b. Outmigrant Trapping of Juvenile Salmon in the Lower Tuolumne River, 2013. Prepared For: Turlock Irrigation District and Modesto Irrigation District. March.

Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. Conservation Biology 8: 870–873.

Foott et al. (Foott, J. S., K. True, and R. Stone). 2006. Histological Evaluation and Viral Survey of Juvenile Longfin Smelt (Spirinchus thaleichthys) and Threadfin Shad (Dorosoma petenense) collected in the Sacramento-San Joaquin River Delta, April-October 2006.

Ford, J.K.B., and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales Orcinus orca in British Columbia. Marine Ecology Progress Series. 316:185-199.

Franks, Sierra E.; & Lackey, Robert T. 2015. Forecasting the Most Likely Status of Wild Salmon in the California Central Valley in 2100. San Francisco Estuary and Watershed Science, 13(1). jmie_sfews_25999. Retrieved from: http://escholarship.org/uc/item/3vt5z15p

Frantzich, J. 2014. Yolo Bypass as a Source of Delta Phytoplankton: Not Just a Legend of the Fall? Presented at the Interagency Ecological Program 2014 Annual Workshop, Friday February 28, 2014. Site accessed May 19, 2015. http://www.water.ca.gov/aes/staff/frantzich.cfm.

Gingras, M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-screening Loss to Juvenile Fishes, 1976-1993. Technical Report 55. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. September.

Glibert, P. M. 2010. Long-Term Changes in Nutrient Loading and Stoichiometry and Their Relationships with Changes in the Food Web and Dominant Pelagic Fish Species in the San Francisco Estuary, California. Reviews in Fisheries Science, 18: 2, 211 — 232. First published on 27 August 2010.

Glibert et al. (Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana). 2011. Ecological Stoichiometry, Biogeochemical Cycling, Invasive Species, and Aquatic Food Webs: San Francisco Estuary and Comparative Systems. Reviews in Fisheries Science, 19:4, 358-417.

Glibert et al. (Glibert, P. M., F. P. Wilkerson, R. C. Dugdale, A. E. Parker, J. Alexander, S. Blaser, and S. Murasko). 2014. Phytoplankton communities from San Francisco Bay Delta respond differently to oxidized and reduced nitrogen substrates—even under conditions that would otherwise suggest nitrogen sufficiency. Frontiers in Marine Science, Vol 1, Article 17, 1-16.

Good et al. (Good, T. P., R. S. Waples, and P. Adams, editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. Technical Memorandum NMFS-NWFSC-66.

Greene et al. (Greene, V. E., L. J. Sullivan, J. K. Thompson, W. J. Kimmerer). 2011. Grazing Impact of the Invasive Clam Corbula amurensis on the Microplankton Assemblage of the Northern San Francisco Estuary. Marine Ecology Progress Series Vol. 431: 183–193, 2011.

Greenfield et al. (Greenfield, B. K., S. J. Teh, J. R. M. Ross, J. Hunt, G. H. Zhang, J. A. Davis. G. Ichikawa, D. Crane, S. O. Hung, D. F. Deng, F. C. Teh, P. G. Green). 2008. Contaminant Concentrations and Histopathological Effects in Sacramento Splittail (Pogonichthys macrolepidotus). Environmental Contamination & Toxicology, August, Vol. 55, Issue 2, p270-281.

Gregory, R. S., and C. D. Levings. 1998. Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. Transactions of the American Fisheries Society 127: 275–285.

Grimaldo et al. (Grimaldo, L. F., R. E. Miller, C. M. Peregrin, and Z. P. Hymanson). 2004. Spatial and Temporal Distribution of Native and Alien Ichthyoplankton in Three Habitat Types of the Sacramento-San Joaquin Delta. American Fisheries Society Symposium 39: 81-96.

Grimaldo et al. Grimaldo, L. F., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. B. Moyle, B. Herbold, and P. Smith). 2009. Factors Affecting Fish Entrainment into Massive Water Diversions in a Freshwater Tidal Estuary: Can Fish Losses be Managed? North American Journal of Fisheries Management 29: 1253-1270.

Grimaldo et al. Grimaldo, L., R. E. Miller, C. M. Peregrin, and Z. Hymanson). 2012. Fish Assemblages in Reference and Restored Tidal Freshwater Marshes of the San Francisco Estuary. San Francisco Estuary and Watershed Science, 10(1).

Grossmann et al. (Grossman, G. D., T. Essington, B. Johnson, J. Miller, N. E. Monsen, and T. N. Pearsons). 2013. Effects of Fish Predation on Salmonids in the Sacramento River-San Joaquin Delta and Associated Ecosystems. September 25.

Grover, A., A. Low, P. Ward, J. Smith, M. Mohr, D. Viele, and C. Tracy. 2004. Recommendations for developing fishery management objectives for Sacramento River winter Chinook and Sacramento River spring Chinook. Pacific Fishery Management Council Interagency Work Group, Progress Report, Portland, Oregon.

Gruber et al. (Gruber, J. J., Z. J. Jackson, and J. P. Van Eenennaam). 2012. 2011 San Joaquin River Sturgeon Spawning Survey.

Hallock, R. J. 1989. Upper Sacramento River steelhead, Oncorhynchus mykiss, 1952–1988. Report to the U.S. Fish and Wildlife Service, Red Bluff, California.

Hallock et al. (Hallock, R. J., W. F. Van Woert, and L. Shapovalov). 1961. An Evaluation of Stocking Hatchery-reared Steelhead Rainbow Trout (Salmo gairdnerii gairdnerii) in the Sacramento River System. California Department of Fish and Game Fish Bulletin 114: 1-74

Hallock et al. (Hallock, R. J., R. F. Elwell, and D. H. Fry, Jr). 1970. Migrations of Adult King Salmon, Oncorhynchus tshawytscha, in the San Joaquin Delta. California Department of Fish and Game Bulletin 151: 1-92.

Hankin, D.G., and M.C. Healey. 1986. Dependence of exploitation rates for maximum yield and stock collapse on age and sex structure of chinook salmon stocks. Can. J. Fish. Aquat. Sci. 43: 1746-1759.

Hankin, D.G., J.W. Nicholas and T.W. Downey. 1993. Evidence for inheritance of age of maturity in chinook salmon, Onchorhynchus tshawytscha. Can. J. fish. Aquat. Sci. 50:347-358.

Hanni et al. (Hanni, J., B. Poytress, and H. N. Blalock-Herod). 2006. Spatial and Temporal Distribution Patterns of Pacific and River Lamprey in the Sacramento and San Joaquin Rivers and Delta. Poster. U.S. Fish and Wildlife Service.

Hannon, J., and B. Deason. 2008. American River steelhead Spawning 2001–2007. Bureau of Reclamation.

Hannon et al. (Hannon, J., M. Healey, and B. Deason). 2003. American River steelhead Spawning 2001–2003. Bureau of Reclamation.

Hanson, C. H. 2001. Are Juvenile Chinook Salmon Entrained at Unscreened Diversions in Direct Proportion to the Volume of Water Diverted? Contributions to the Biology of Central Valley Salmonids. California Department of Fish and Game Fish Bulletin 179: 331-342.

Hanson et al. (Hanson, M.B., Baird, R.W., Ford, J.K.B., Hempelmann, J.A., Van Doornik, D.M., Candy, J.R., Emmons, C.K., Schorr, G.S., Gisborne, B., Ayres, K.L., Wasser, S.K., Balcomb, K.C., Balcomb-Bartok, K., Sneva, J.G., and Ford, M.J.) 2010. Species and Stock Identification of Prey Consumed by Endangered Southern Resident Killer Whales in their Summer Range. Endangered Species Research 11: 69–82. doi: 10.3354/esr00263.

Hanson, M.B., R.W. Baird, C. Emmons, J. Hempelmann, G.S. Schorr, J. Sneva, and D. Van. 2007. Summer diet and prey stock identification of the fish-eating “southern resident” killer whales: Addressing a key recovery need using fish scales, fecal samples, and genetic techniques. Abstract from the 17th Biennial Conference on the Biology of Marine Mammals, Capetown, South Africa. As cited in National Marine Fisheries Service *Endangered Species Act Section 7 Consultation Final Biological Opinion and Magnusen-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Implementation of National Flood Insurance Program in the State of Washington, Phase One Document – Puget Sound Region*, September 22, 2008.

Hardy, T. D. B., and R. M.C. Addley. 2001. Evaluation of Interim Instream Flow Needs in the Klamath River. Phase II. Final report. Prepared for U.S. Department of the Interior, Washington, D.C.

Harrell, W. C., and T. R. Sommer. 2003. Patterns of Adult Fish Use on California's Yolo Bypass Floodplain. California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration. 2001 Riparian Habitat and floodplains Conference Proceedings. Edited by P. M. Faber, 88-93. Riparian Habitat Joint Venture.

Hassler, T. J. 1988. Species Profiles: Life Histories and Environmental Requirements of Coast Fishes and Invertebrates (Pacific Southwest) – Striped Bass. U.S. Fish and Wildlife Service Biological Report 82(11.82). U.S. Army Corps of Engineers, TR EL-82-4.

Healey, M. C. 1991. Life History of Chinook Salmon (Oncorhynchus tshawytscha). In: C Groot, L. Margolis (eds.). Pacific Salmon Life-Histories. Vancouver: UBC Press. Pages 313–393.

Hennessy, A. and T. Enderlein. 2013. Zooplankton Monitoring 2011. IEP Newsletter 26(1):23-30.

Herren, J. R., and S. S. Kawasaki. 2001. Inventory of Water Diversions in Four Geographic Areas in California's Central Valley. Contributions to the Biology of Central Valley Salmonids, Vol. 2. Edited by R. L. Brown. California Department of Fish and Game. Fish Bulletin 179: 343-355.

Heublein, J. C. 2006. Migration of Green Sturgeon Acipenser medirostris in the Sacramento River. Master's thesis. California State University, San Francisco.

Heublein et al. (Heublein, J. C., J. T. Kelly, C. E. Crocker, A. P. Klimley, and S. T. Lindley). 2009. Migration of Green Sturgeon Acipenser medirostris in the Sacramento River. Environmental Biology of Fishes 84: 245-258.

Hilborn et al. (Hilborn, R., S.P. Cox, F.M.D. Gulland, D.G. Hankin, N.T. Hobbs, D.E. Schindler, and A.W. Trites). 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. Prepared for National Marine Fisheries Service and Fisheries and Oceans Canadas.

Hill, A.M. 2010. Trinity River Tributaries steelhead Spawning Survey Report. California Department of Fish and Game. July.

Honey et al. (Honey, K., R. Baxter, Z. Hymanson, T. Sommer, M. Gingras, and P. Cadrett). 2004. IEP Long-term Fish Monitoring Program Element Review. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. December.

IEP MAST (Interagency Ecological Program: Management, Analysis, and Synthesis Team). 2015. An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish. Technical Report 90. San Francisco Bay/Delta Estuary.

IRP (Independent Review Panel). 2010. Anderson, J. J., R. T. Kneib, S. A. Luthy, and P. E. Smith. Report of the 2010 Independent Review Panel on the Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria and Plan (OCAP) for State/Federal Water Operations. Delta Stewardship Council/Delta Science Program.

IRP (Independent Review Panel). 2011. Anderson, J. J., J. A. Gore, R. T. Kneib, M.S. Lorang, and J. Van Sickle. Report of the 2011 Independent Review Panel (IRP) on the Implementation of Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria And Plan (OCAP) for State/Federal Water Operations. Delta Stewardship Council/Delta Science Program.

IRP (Independent Review Panel). 2012. Anderson, J. J., J. A. Gore, R. T. Kneib, M.S. Lorang, J. M. Nestler, and J. Van Sickle. Report of the 2012 Delta Science Program Independent Review Panel (IRP) on the Long-term Operations Opinions (LOO) Annual Review. Delta Stewardship Council/Delta Science Program.

IRP (Independent Review Panel). 2013. Anderson, J. J., J. A. Gore, R. T. Kneib, M.S. Lorang, J. M. Nestler, and J. Van Sickle. Report of the 2013 Independent Review Panel (IRP) on the Long-term Operations Biological Opinions (LOBO) Annual Review. Delta Stewardship Council/Delta Science Program.

IRP (Independent Review Panel). 2014. Anderson, J. J., J. A. Gore, R. T. Kneib, N. E. Monsen, J. M. Nestler, and J. Van Sickle. Independent Review Panel (IRP) Report for the 2014 Long-term Operations Biological Opinions (LOBO) Annual Science Review. Delta Stewardship Council/Delta Science Program.

Israel, J. 2006. Determining Spawning Population Estimates for Green Sturgeon with Microsatellite DNA. Presentation at the 2006 CALFED Science Conference. Sacramento, California. As cited in Department of Water Resources,*Programmatic Biological Assessment for the 2013-17 Temporary Barriers Project for National Marine Fisheries Service-Managed Species*, October 2012.

Israel, J. A., and A. P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (Acipenser medirostris). Prepared for DRERIP. University of California, Davis, California.

Israel et al. (Israel, J. A., J. F. Cordes, M. A. Blumberg, and B.) May. 2004. Geographic Patterns of Genetic Differentiation Among Collections of Green Sturgeon. North American Journal of Fisheries Management 24: 922-931.

Israel et al. (Israel, J., A. Drauch, and M. Gingras). 2008. Life History Conceptual Model for White Sturgeon (Acipenser transmontanus). University of California, Davis and California Department of Fish and Game, Stockton.

Jackson, Z. 2013. San Joaquin River Sturgeon Investigations – 2011/12 Season Summary. IEP Quarterly Highlights. IEP Newsletter Vol. 26 (1): 4-6.

Jackson, Z. J., and J. P. Van Eenennaam. 2013. 2012 San Joaquin River Sturgeon Spawning Survey. Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service.

Jassby et al. (Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski). 1995. Isohaline Position as a Habitat Indicator for Estuarine Populations. Ecological Applications 5: 272–289.

Jassby et al.(Jassby, A. D., J. E. Cloern, and B. E. Cole). 2002. Annual Primary Production: Patterns and Mechanisms of Change in a Nutrient-rich Tidal Ecosystem. Limnology and Oceanography 47: 698-712.

Johnston, S., and K. Kumagai. 2012. Steps Toward Evaluating Fish Predation in the Sacramento River Delta. HTI Hydroacoustic Technology, Inc. Poster for 7th Biennial Bay-Delta Science Conference.

Keefer, M.L., C.C. Caudill, C.A Peery, and S.R. Lee. 2008. Transporting juvenile salmonids around dams impairs adult migration. Ecological Applications 18:1888-1900.

Kelly et al. (Kelly, J. T., A. P. Klimley, and C. E. Crocker). 2007. Movements of Green Sturgeon, Acipenser medirostris, in the San Francisco Bay Estuary, California. Environmental Biology of Fishes 79: 281-295.

Kennedy, T., and T. Cannon. 2005. Stanislaus River Salmonid Density and Distribution Survey Report (2002-2004). Final Draft. Prepared for the Bureau of Reclamation by the Fishery Foundation of California. October.

Kimmerer, W. J. 2002. Effects of Freshwater Flow on Abundance of Estuarine Organisms: Physical Effects or Trophic Linkages. Marine Ecology Progress Series 243: 39-55.

Kimmerer, W. J. 2004. Open Water Processes of the San Francisco Estuary: from Physical Forcing to Biological Responses. San Francisco Estuary and Watershed Science 2 (1).

Kimmerer, W. J. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt (Hypomesus transpacificus) to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 6, Issue 2 (June), Article 2.

Kimmerer, W. J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science, 9(1). San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis. http://escholarship.org/uc/item/0rd2n5vb.

Kimmerer, W. J., and M. Nobriga. 2008. Investigating Particle Transport and Fate in the Sacramento San Joaquin Delta Using a Particle Tracking Model. San Francisco Estuary and Watershed Science, 6(1).

Kimmerer et al. (Kimmerer, W. J., J. R. Burau, W. A. Bennett). 1998. Tidally Oriented Vertical Migration and Position Maintenance of Zooplankton in a Temperate Estuary. Limnol. Oceanogr., 43(7), 1998, 1697-1709.

Kimmerer et al. (Kimmerer, W. J., J. H. Cowan, Jr., L. W. Miller, and K. A. Rose). 2000. Analysis of an Estuarine Striped Bass (Morone saxatilis) Population: Influence of Density-dependent Mortality Between Metamorphosis and Recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57: 478-486.

Kimmerer, W. J. 2002a. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275–1290.

Kimmerer, W.J. 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. Marine Ecology Progress Series 243:39–55.

Kimmerer et al. (Kimmerer, W. J., J. H. Cowan, Jr., L. W. Miller, and K. A. Rose). 2001. Analysis of an Estuarine Striped Bass Population: Effects of Environmental Conditions during Early Life. Estuaries, Vol. 24, No. 4, p. 557-575. August.

Kimmerer et al. (Kimmerer, W. J., N. Ferm, M. H. Nicolini, C. Penalva). 2005. Chronic Food Limitation of Egg Production in Populations of Copepods of the Genus Acartia in the San Francisco Estuary. Estuaries, Vol. 28, No. 4, p. 541-550. August.

Kimmerer et al. (Kimmerer, W., L. Brown, S. Culberson, P. Moyle, M. Nobriga, and J. Thompson). 2008. Aquatic Ecosystems. The State of Bay-Delta Science. Edited by M. Healey, 73-101. CALFED Science Program.

Kimmerer et al. (Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams). 2009. Is the Reponse of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts, 32:375-389. Doi 10.1007/s12237-008-9124-x.

Kimmerer et al. (Kimmerer, W. J., M. L. MacWilliams, E. S. Gross). 2013. Variation of Fish Habitat and Extent of the Low-Salinity Zone with Freshwater Flow in the San Francisco Estuary. San Francisco Estuary and Watershed Science, 11(4). San Francisco Estuary and Watershed Science.

Kjelson, M. A., and P. L. Brandes. 1989. The Use of Smolt Survival Estimates to Quantify the Effects of Habitat Changes on Salmonid Stocks in the Sacramento-San Joaquin Rivers, California. Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Eds. C. D. Levings, L. B. Holtby, and M. A. Henderson. Canadian Special S publication of Fisheries and Aquatic Sciences 105, p. 100-115.

Kjelson et al. (Kjelson, M. A., P. F. Raquel, and F. W. Fisher). 1981. Influences of Freshwater Inflow on Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin Estuary. Edited by R. D. Cross and D. L.

Williams, 88-108. Proceedings of the National Symposium on Freshwater Inflow to Estuaries, FWS/ OBS-81/04. U.S. Fish and Wildlife Service, Washington, D.C.

Klimley et al. (Klimley, A. P., P. J. Allen, J. A. Israel, and J. T. Kelly). 2007. The Green Sturgeon and Its Environment: Introduction. Environmental Biology of Fishes 79: 187-190.

Kogut, N. 2008. Overbite clam, Corbula amurensis, Defecated Alive by White Sturgeon, Acipenser transmontanus. California Fish and Game 94: 143-149.

Kohlhorst, D. W. 1976. Sturgeon Spawning in the Sacramento River, as Determined by Distribution of Larvae. California Fish and Game Bulletin 62: 32-40.

Kohlhorst et al. (Kohlhorst, D. W., L. W. Botsford, J. S. Brennan, and G. M. Cailliet). 1991. Aspects of the Structure and Dynamics of an Exploited Central California Population of White Sturgeon (Acipenser transmontanus). Acipenser. Edited by P. Williot, 277-293. CEMAGREF, Bordeaux, France.

Kolar, C.S., Courtneay, W.R. Jr, and Nico, L.G. 2010. Managing undesired and invading fishes. In Hubert, W.A. and Quist, M.C. (eds.). Inland fisheries management in North America. Third Edition. Am. Fish. Soc., Bethesda, MD. p 213-260.

Kondolf et al. (Kondolf, G.M., J. C. Vick, and T. M. Ramirez). 1996. Salmon Spawning Habitat Rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: An Evaluation of Project Planning and Performance. Water Resources Center Report No. 90. University of California, Davis.

Kondolf et al. (Kondolf, G., R. Larsen, and J. Williams). 2000. Measuring and Modeling the Hydraulic Environment for Assessing Instream Flows. North American Journal of Fisheries Management 20: 1016-1028.

Kondolf et al. (Kondolf, G. M., A. Falzone, and K. S. Schneider). 2001. Reconnaissance-level Assessment of Channel Change and Spawning Habitat on the Stanislaus River downstream of Goodwin Dam.

Kormos et al. (Kormos, B., M, Palmer-Zwahlen, and A. Low. 2012. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010. California Department of Fish and Game Fisheries Branch Administrative Report 2012-02. March 2012. 44 pp.

Kuivila, K. M., and C. G. Foe. 1995. Concentrations, Transport and biological Effects of dormant spray Pesticides in the San Francisco Estuary, California. Environmental Toxicology and Chemistry 14: 1141-1150.

LACSD (Lake Arrowhead Community Services District). 2014a. Lake Arrowhead. Site accessed May 19, 2014. http://www.lakearrowhead.com/activities.html.

LACSD (Lake Arrowhead Community Services District). 2014c. Lake Arrowhead, Fishing. Site accessed October 30, 2014. http://www.lakearrowhead.com/fishing.html.

Lafayette Chamber of Commerce. 2014. Lafayette Reservoir. Site accessed August 14, 2014. http://www.lafayettechamber.org/community/lafayette-reservoir/

Lampman, R. T. 2011. Passage, Migration, Behavior, and Autoecology of Adult Pacific Lamprey at Winchester Dam and Within the North Umpqua River Basin, Oregon. Master's thesis. Oregon State University, Department of Fisheries and Wildlife, Corvallis.

Larson, Z. S., and M. R. Belchik. 1998. A Preliminary Status Review of Eulachon and Pacific Lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, California. April.

LARTF [Lower American River Task Force]. 2002. River Corridor Management Plan (RCMP) for the Lower American River. 116 pages + 4 Appendices. Available online: http://www.safca.org/Protection/NR_Documents/RCMP_5_Appendix.A.Chapter3.pdf

Lee, D. P. 1999. Water Level Fluctuation Criteria for Black Bass in California Reservoirs. California Department of Fish and Game. Reservoir Research and Management Project–Informational Leaflet No. 12. 12 pp.

Lee, D. P., and J. Chilton. 2007. Hatchery and genetic management plan for Nimbus Fish Hatchery winter-run steelhead Program. Draft Report. Prepared by DFG under Contract 03CS200006 Modification 0004 with Bureau of Reclamation, Folsom, California, and Nimbus Fish Hatchery, Rancho Cordova.

Lee, G. F. and Jones-Lee, A. 2003. Summary of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA. Report of G. Fred Lee & Associates, El Macero, CA, March 2003. http://www.gfredlee.com/psjriv2.htm

Leet et al. (Leet, W. S., C. M. Dewees, R. Klingbeil, and E. J. Larson). 2001. California's Living Marine Resources: a Status Report. Agriculture and Natural Resources, University of California, Berkeley.

Lehman et al. (Lehman, P. W., G. Boyer, C. Hall, and K. Gehrts). 2005. Distribution and Toxicity of a New Colonial Microcystis aeruginosa Bloom in the San Francisco Bay Estuary, California. Hydrobiologia (2005) 541: 87-99. DOI 10.1007/s10750-004-4670-0

Lehman et al. (Lehman, P. W., T. Sommer, and L. Rivard). 2008a. The Influence of Floodplain Habitat on the Quantity of Riverine Phytoplankton Carbon Produced During the Flood Season in San Francisco Estuary. Aquatic Ecology 42: 363-378.

Lehman et al. (Lehman, P. W., G. Boyer, M. Satchwell, and S. Waller). 2008b. The Influence of Environmental Conditions on the Seasonal Variation of Microcystis Cell Density and Mocrocystins Concentration in San Francisco estuary. Hydrobiologia Vol. 600, Issue 1, pp 187-204.

Lehman et al. (Lehman, P. W., S. J. Teh, G. L. Boyer, M. L. Nobriga, E. Bass, C. Hogle). 2010. Initial Impacts of Microcystis aeruginosa Blooms on the Aquatic Food Web in the San Francisco Estuary. Hydrobiologia (2010) 637: 229-248. DOI 10.1007/s10750-009-9999-y

Leidy, R. A. 2007. Ecology, Assemblage Structure, Distribution, and Status of Fishes in Stream Tributary to the San Francisco Estuary, California. SFEI Contribution #530. San Francisco Estuary Institute. Oakland, California.

Leidy et al. (Leidy, R.A., G.S. Becker, B.N. Harvey). 2005. Historical Distribution and Current Status of Steelhead/Rainbow Trout (Oncorhynchus mykiss) in Streams of the San Francisco Estuary, California. Center for Ecosystem Management and Restoration, Oakland, CA.

Lindberg, J. B. Baskerville-Bridges, and S. Doroshov. 2000. Update on Delta Smelt Culture with an Emphasis on Larval Feeding Behavior. IEP Newsletter. Vol. 13, Number 1. Winter.

Lindley, S. and Mohr, M.A. 2003. Modeling the effect of striped bass (Morone saxatalis) on the population viability of Sacramento River winter-run Chinook salmon (Oncorhynchus tshawytscha). Fish. Bull. 101:321-331.

Lindley, S. T., R. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESU in California's Central Valley Basin. NOAA-TM-NMFS-SWFSC-360. NMFS Southwest Science Center, Santa Cruz, California.

Lindley et al. (Lindley, S. T., R. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams). 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5: 26.

Lindley et al. (Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. Rechisky, J. T. Kelly, J. Heublein, and A. P. Klimley). 2008. Marine Migration of North American Green Sturgeon. Transactions of the American Fisheries Society 137: 182–194.

Lindley et al. (Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L. W. Botsford, D. L. Bottom, C.A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams). 2009. What Caused the Sacramento River Fall Chinook Stock Collapse? Pre-publication report to the Pacific Fishery Management Council.

Linville et al. (Linville, R. G., S. N. Luoma, L. Cutter, and G. A. Cutter). 2002. Increased Selenium Threat as a Result of Invasion of the Exotic Bivalve Potamocorbula amurensis into the San Francisco Bay-Delta. Aquatic Toxicology 57: 51-64.

Loboschefsky et al. (Loboschefsky, E., G. Benigno, T. Sommer, K. Rose, T. Ginn, A. Massoudieh, and F. Loge). 2012. Individual-level and Population-level Historical Prey Demand of San Francisco Estuary Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Science, 10(1).

Lund et al. (Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle). 2007. Envisioning Futures for the Sacramento San-Joaquin Delta. Public Policy Institute of California.

MacFarlane, R. B. and E. C. Norton. 2002. Physiological Ecology of juvenile Chinook Salmon (Oncorhynchus tshawytscha) at the Southern End of Their Distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin 100:244–257.

Mac Nally, R., Thomson, J.R., Kimmerer, W.J., Feyrer, F., Newman, K.B., Sih, A. et al. (2010). Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecol. Appl., 20, 1417–1430.

Magneson, M.D. 2013. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity River and Lower Klamath River, CA, April to October 2012. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2013-30, Arcata, California.

Magneson, M.D. 2014. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity River and Lower Klamath River, CA, April to October 2013. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2014-36, Arcata, California.

Manly et al. (Manly, B. F., J. D. Fullerton, A. N. Hendrix, K. P. Burnham). 2015. Comments on Feyrer et al. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. Estuaries and Coasts 38(5): 1815-1820.

Marston et al. (Marston, D., C. Mesick, A. Hubbard, D. Stanton, S. Fortmann-Roe, S. Tsao, and T. Heyne). 2012. Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River fall-run Chinook Salmon (Oncorhynchus tshawytscha). San Francisco Estuary and Watershed Science, 10(4).

Martin et al. (Martin, C. D., P. D. Gaines, and R. R. Johnson). 2001. Estimating the Abundance of Sacramento River Winter Chinook Salmon with Comparisons to Adult Escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U. S. Fish and Wildlife Service.

Matern et al. (Matern, S. A., P. B. Moyle, and L. C. Pierce). 2002. Native and Alien Fishes in a California Estuarine Marsh: Twenty-one Years of Changing Assemblages. Transactions of the American Fisheries Society, 131:5, 797-816, DOI: 10.1577/1548-8659(2002)131<0797:NAAFIA>2.0.CO;2

Maunder, M. N. and R. B. Deriso. 2011. A state-space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (Hyposmesus transpacificus). NRC Research Press.

McBain & Trush, Inc. (eds.), 2002. San Joaquin River Restoration Study Background Report, prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council, San Francisco, CA.

McBain and Trush and Stillwater Sciences. 2006. Special Run Pool 9 and 7/11 Reach: Post-project Monitoring Report. Prepared for Tuolumne River Technical Advisory Committee, Turlock and Modesto Irrigation Districts, U.S. Fish and Wildlife Service Anadromous Fish Restoration Program, California Bay-Delta Authority.

McCabe, G. T., and C. A. Tracy. 1994. Spawning and Early-life History of White Sturgeon, Acipenser transmontanus, in the Lower Columbia River. Fishery Bulletin 92: 760-772.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-42,156 p.

McEnroe, M., and J. J. Cech, Jr. 1985. Osmoregulation in Juvenile and Adult White Sturgeon, Acipenser transmontanus. Environmental Biology of Fishes 14: 23-30.

McEwan, D. 2001. Central Valley steelhead. Contributions to the Biology of Central Valley Salmonids. Volume 1. California Department of Fish and Game, Sacramento. Fish Bulletin 179.

McEwan, D., and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, Inland Fisheries Division, Sacramento.

McMichael, GA, JR Skalski and KA Deters. 2011. Survival of juvenile Chinook salmon during barge transport. North American Journal of Fisheries Management 31:1187-1196.

Meng, L., and P. B. Moyle. 1995. Status of Splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 124: 538–549.

Merz et al. (Merz, J. E., S. Hamilton, P. S. Bergman, and B. Cavallo. 2011. Spatial Perspective for Delta Smelt: a Summary of Contemporary Survey Data. California Fish and Game, 97(4):164-189.

Merz et al. (Merz, J., B. Rook, C. Watry, and S. Zeug). 2012. Evaluation of the 2008-2010 Sailor Bar Gravel Placements on the Lower American River, California. 2010-2011 Data Report. Prepared for City of Sacramento Water Forum, and U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service, CVPIA Gravel Program. Contract 2010-1049.

Mesick, C. 2001. The Effects of San Joaquin River flows and Delta export Rates during October on the Number of Adult San Joaquin Chinook Salmon that Stray. Contributions to the Biology of Central Valley Salmonids, Volume 2. Fish Bulletin 179.

Mesick, C. 2002. Gravel Mining and Scour of Salmonid Spawning Habitat in the Lower Stanislaus River. Prepared by Carl Mesick Consultants, El Dorado, California.

Michel, C. J. 2010. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus tshawytscha*) Smolts and the Influence Of Environment. Masters Thesis. University of California Santa Cruz.

Michel, C.J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. Canadian Journal of Fisheries and Aquatic Sciences. Published on the web 18 June 2015, 10.1139/cjfas-2014-0528.

Miller et al. (Miller, W. J., B. F. J. Manly, D. D. Murphy, D. Fullerton, and R. R. Ramey). 2012. An Investigation of Factors Affecting the Decline of Delta Smelt (Hypomesus transpacificus) in the Sacramento-San Joaquin Estuary. Reviews in Fisheries Science 20: 1-19.

Monsen et al. (Monsen, N. E., J. E. Cloern, and J. R. Burau). 2007. Effects of Flow Diversions on Water and Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science, 5(3)

Mount et al. (Mount, J., W. Bennett, J. Durand, W. Fleenor, E. Hanak, J. Lund, and P. B. Moyle). 2012. Aquatic Ecosystem Stressors in the Sacramento-San Joaquin Delta. Public Policy Institute of California, San Francisco.

Moyle, P. B. 2002. Inland Fishes of California. Second edition. University of California Press, Berkeley.

Moyle, P. B. 2008. The Future of Fish in Response to Large-Scale Change in the San Francisco Estuary, California. Mitigating impacts of natural hazards on fishery ecosystems. Symposium 64. Edited by K. D. McLaughlin. American Fisheries Society, Bethesda, Maryland.

Moyle, P. B., and W. A. Bennett. 2008. The Future of the Delta Ecosystem and Its Fish. Technical Appendix D. Comparing futures for the Sacramento–San Joaquin Delta. Public Policy Institute of California.

Moyle, P.B., and W.A. Bennett. 2010. Re: Striped bass predation on listed fishes: can a control program be justified. Letter to Jim Kellogg, President, Fish and Game Commission. Dated August 26, 2010.

Moyle et al. (Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller). 1992. Life History and Status of Delta Smelt in the Sacramento–San Joaquin Estuary, California. Transactions of the American Fisheries Society 121: 67–77.

Moyle et al. (Moyle, P. B., P. K. Crain, K. Whitener, and J. F. Mount). 2003. Alien Fishes in Natural Streams: Fish Distribution, Assemblage Structure, and Conservation in the Cosumnes River, California, USA. Environmental Biology of Fishes 68: 143-162.

Moyle et al. (Moyle, P. B., R. D. Baxter, T. Sommer, T.C. Foin, and S. A. Matern). 2004. Biology and Population Dynamics of Sacramento Splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: a Review. San Francisco Estuary and Watershed Science 2: Article 3.

Moyle et al. (Moyle, P. B., L. R. Brown, S. D. Chase, and R. M. Quinones). 2009. Status and Conservation of Lampreys in California. American Fisheries Society Symposium 72: 279-292.

Moyle et al. (Moyle, P., W. Bennett, J. Durand, W. Fleenor, B. Gray, E. Hanak, J. Lund, and J. Mount). 2012. Where the Wild Things Aren't: Making the Delta a Better Place For Native Species. Public Policy Institute of California, San Francisco, California. Available at: http://www.ppic.org/content/pubs/report/R_612PMR.pdf.

Mueller-Solger et al. (Mueller-Solger, A. B., A. D. Jassby, and D. C. Muller-Navarra). 2002. Nutritional Quality of Food Resources for Zooplankton (Daphnia) in a Tidal Freshwater System (Sacramento–San Joaquin River Delta). Limnol. Oceanogr., 47(5), 2002, 1468–1476.

Muir, WD, DM Marsh, BP Sandford, SG Smith and JG Williams. 2006. Post-hydropower system delayed mortality of transported Snake River stream-type Chinook salmon: unraveling the mystery. Transactions of the American Fisheries Society 135:1523-1534.

Murphy, D. D. and S. A. Hamilton. 2013. Eastward Migration or Marshward Dispersal: Exercising Survey Data to Elicit an Understanding of Seasonal Movement of Delta Smelt. San Francisco Estuary and Watershed Science, 11(3). San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis.

MWD (Metropolitan Water District of Southern California). 2014. Diamond Valley Lake, Southwestern Riverside County Multi-Species Reserve. Site accessed October 5, 2014. http://www.dvlake.com/shipley01.html

Myers et al. (Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples). 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Myrick, C. A., and J. J. Cech, Jr. 2004. Temperature Effects on Juvenile Anadromous Salmonids in California's Central Valley: what don't we know? Reviews in Fish Biology and Fisheries 141: 113-123.

National Research Council. 2010. A scientific assessment of alternatives for reducing water management effects on threatened and endangered fishes in California’s Bay–Delta. The National Academies Press, Washington, D.C.

Naughton et al. (Naughton, G. P., C. C. Caudill, M. L. Keefer, T. C. Bjornn, L. C. Stuehrenberg, and C. A. Perry). 2005. Late-season Mortality during Migration of Radio-Tagged Adult Sockeye Salmon (Oncorhynchus nerka) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 62: 30–47.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment. June.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board, Bureau of Reclamation, Bureau of Land Management). 2013. Trinity River Channel Rehabilitation Sites: Douglas City (River Mile 93.6-94.6) and Lorenz Gulch (River Mile 89.4-90.2), Final Environmental Assessment/Initial Study. May.

Newcomb, J. and L. Pierce. 2010. Low Dissolved Oxygen Levels in the Stockton Deep Water Shipping Channel, Adverse Effects on Salmon and Steelhead and Potential Beneficial Effects of Raising Dissolved Oxygen Levels with the Aeration Facility. Fish Passage Improvement Program Flood Safe Environmental Stewardship and Statewide Resources Office Department of Water Resources. 28 pp.

Newman, K. B. 2003. Modeling Paired Release-recovery Data in the Presence of Survival and Capture Heterogeneity with Application to Marked Juvenile Salmon. Statistical Modeling 3: 157-177.

Newman, K. B. 2008. An Evaluation of four Sacramento-San Joaquin River Delta Juvenile Salmon Studies. Prepared for CALFED Science Program. Project No. SCI-06-G06-299. March.

Newman, K. B., and P. L. Brandes. 2010. Hierarchical Modeling of Juvenile Chinook Salmon Survival as a Function of Sacramento–San Joaquin Delta Water Exports. North American Journal of Fisheries Management 30:157-169.

Newman, K. B., and J. Rice. 2002. Modeling the Survival of Chinook Salmon Smolts Outmigrating Through the Lower Sacramento River system. Journal of the American Statistical Association 97: 983-993.

NID (Nevada Irrigation District). 2005. Raw Water Master Plan Update, Phase I: Technical Analysis, Volume I, Final Report. September.

NID (Nevada Irrigation District). 2008. Yuba-Bear Hydroelectric Project FERC Project No. 2266 Relicensing Pre-Application Document (PAD) Public Information. April.

NID (Nevada Irrigation District). 2009. Combie Reservoir Water Supply and Maintenance Project Preliminary Biological Evaluation for CEQA Initial Study. July.

Nielsen et al. (Nielsen, J. L., S. A. Pavey, T. Wiacek, and I. Williams). 2005. Genetics of Central Valley O. mykiss populations: Drainage and Watershed Scale Analysis. San Francisco Estuary and Watershed Science 3 (2).

Nixon, S. W. 1988. Physical Energy Inputs and the Comparative Ecology of Lake and Marine Ecosystems. Limnology and Oceanography, Part II 33: 1005–1025.

NMFS (National Marine Fisheries Service). 1993. Designated Critical Habitat; Sacramento River winter-run Chinook Salmon. Federal Register 58: 33212-33219.

NMFS (National Marine Fisheries Service). 1999. Designated Critical Habitat; Central California Coast and Southern Oregon/Northern California Coasts Coho Salmon. Federal Register 64: 24049.24062.

NMFS (National Marine Fisheries Service). 2000. Biological Opinion for the Trinity River Mainstem Fishery Restoration EIS and its effects on Southern Oregon/Northern California Coast Coho Salmon, Sacramento River winter-run Chinoook Salmon, Central Valley spring-run Chinook Salmon, and Central Valley Steelhead.

NMFS (National Marine Fisheries Service). 2000. Endangered Species Act-Reinitiated Section 7 Consultation Biological Opinion and Incidental Take Statement Effects of the Pacific coast salmon plan on California Central Valley spring-run chinook, and California coastal chinook salmon. NMFS, Page(s): 31

NMFS (National Marine Fisheries Service). 2010. Endangered Species Act Section 7 Consultation Biological Opinion: Authorization of ocean salmon fisheries pursuant to the Pacific Coast Salmon Fishery Management Plan and additional protective measures as it affects Sacramento River winter Chinook salmon. NMFS, Page(s): 97

NMFS (National Marine Fisheries Service). 2004. Biological Opinion on the Long-term Central Valley Project and State Water Project Operations, Criteria, and Plan.

NMFS (National Marine Fisheries Service). 2005a. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. Federal Register 70: 37160-37204.

NMFS (National Marine Fisheries Service). 2005b. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 70: 17386-17401.

NMFS (National Marine Fisheries Service). 2005c. Green Sturgeon (Acipenser medirostris) Status Review Update.

NMFS (National Marine Fisheries Service). 2008. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*).

NMFS (National Marine Fisheries Service). 2009a. Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project.

NMFS (National Marine Fisheries Service). 2009b. Endangered and Threatened Wildlife and Plants; Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 74: 52300-52351.

NMFS (National Marine Fisheries Service). 2009c. Biological Opinion: Effects of the Pacific Coast Salmon Plan on the Southern Resident killer whale (Orcinus orca) Distinct Population Segment. National Marine Fisheries Service, Northwest Region. May 5, 2009. As cited in NMFS *Endangered Species Act Section 7 Consultation Authroization of Ocean Salmon Biological Opinion Pursuant to the Pacific Coast Salmon Fisheries Management Plan and Additional Protective Measures as it Affects Sacramento River Winter-run Chinook Salmon, April 30, 2010*.

NMFS (National Marine Fisheries Service). 2011a. Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon. Federal Register 76: 65324.

NMFS (National Marine Fisheries Service). 2011b. Critical Habitat for the Southern Distinct Population Segment of Eulachon, Final Section 4(b)(2) Report. NMFS Northwest Region, Protected Resources Division. Portland, OR.

NMFS (National Marine Fisheries Service). 2012a. Biological Opinion on Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities on and Around Englebright Reservoir. NMFS, Southwest Region, Long Beach, California.

NMFS (National Marine Fisheries Service). 2012b. Final implementation of the 2010 Reasonable and Prudent Alternative Sacramento River winter-run Chinook management framework for the Pacific Coast Salmon Fishery Management Plan. Memorandum for Sacramento River winter Chinook ocean salmon fishery. April 30, 2012.

NMFS (National Marine Fisheries Service). 2014a. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA.

NMFS (National Marine Fisheries Service). 2014b. Recovery Plan for the Evolutionarily Significant Units of Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley steelhead. California Central Valley Area Office. March 2014. 430 p.

NMFS (National Marine Fisheries Service). 2015. Eualchon (Thaleichthys pacificus). Site accessed June 18, 2015. http://www.nmfs.noaa.gov/pr/species/fish/pacificeulachon.htm

Nobriga, M. L. 2002. Larval Delta Smelt Composition and Feeding Incidence: Environmental and Ontogenetic Influences. California Fish and Game 88: 149-164.

Nobriga, M. L. 2009. Bioenergetic Modeling Evidence for a Context-dependent Role of Food Limitation in California's Sacramento-San Joaquin Delta. California Fish and Game 95(3): 111-121.

Nobriga, M. and P. Cadrett. 2001. Differences among Hatchery and Wild steelhead: Evidence from Delta Fish Monitoring Programs. IEP Newsletter Vol. 14, No. 3. Summer.

Nobriga, M. L., and F. Feyrer. 2007. Shallow-Water Piscivore-Prey Dynamics in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5(2): Article 4.

Nobriga, M.L., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: Does trophic adaptability have its limits? Environmental Biology Fish 83: 495 -503.

Nobriga et al. (Nobriga, M. L., Z. Matica, and Z. P. Hymanson). 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: a Comparison among Open-Water Fishes. Early life history of fishes in the San Francisco Estuary and watershed. Edited by F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, 281-295. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Nobriga et al. (Nobriga, M. L., F. Feyrer, R. D. Baxter, and M. Chotkowski). 2005. Fish Community Ecology in an Altered River Delta: Spatial Patterns in Species Composition, Life History Strategies and Biomass. Estuaries: 776-785.

Nobriga et al. (Nobriga, M. L., T. R. Sommer, F. Feyrer, and K. Fleming). 2008. Long-term Trends in Summertime Habitat Suitability for Delta Smelt, Hypomesus transpacificus. San Francisco Estuary and Watershed Science 6: Article 1.

NRC (National Research Council). 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. The National Academies Press, Washington, D.C.

NRC (National Research Council). 2012. Sustainable Water and Environmental Management in the California Bay-Delta. Prepared by the Committee on Sustainable Water and Environmental Management in the California Bay-Delta. The National Academies Press, Washington, D.C.

OEHHA (Office of Environmental Health Hazard Assessment). 2005. Health Advisory: Safe Eating Guidelines for Fish from Trinity Lake, Lewiston Lake, Carrville Pond, Trinity River Upstream from Trinity Lake, and the East Fork Trinity River (Trinity County) – A Fact Sheet. California Environmental Protection Agency, Sacramento, California.

OEHHA (Office of Environmental Health Hazard Assessment). 2009. Health Advisory: Safe Eating Guidelines for Fish from San Pablo Reservoir (Contra Costa County). California Environmental Protection Agency, Sacramento, California.

OEHHA (Office of Environmental Health Hazard Assessment). 2013a. Health Advisory and Guidelines for Eating Fish from Pyramid Lake (Los Angeles County).

OEHHA (Office of Environmental Health Hazard Assessment). 2013b. Health Advisory and Guidelines for Eating Fish from Silverwood Lake (San Bernardino County).

Painter et al. (Painter, R. L., L. Wixom, and L. Meinz). 1979. American Shad Management Plan for the Sacramento River Drainage. Anadromous Fish Conservation Act Project AFS-17, Job 5. CDFG, Sacramento.

Palmer-Zwahlen, M. and B. Kormos. 2013. Recovery of Coded-Wire Tags from Chinook salmon in California's Central Valley Escapement and Ocean Harvest in 2011. Fisheries Branch Administrative Report 2013-02.

Parker et al. (Parker, A. E., R. C. Dugdale, and F. P. Wilderson). 2012. Elevated Ammonium Concentrations from Wastewater Discharge Depress Primary Productivity in the Sacramento River and the Northern San Francisco Estuary. Marine Pollution Bulletin 64: 574-86.

Perry, R. W. 2010. Survival and migration dynamics of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento–San Joaquin River Delta. Doctoral dissertation. University of Washington, Seattle.

Perry, R. W., and J. R. Skalski. 2008. Migration and Survival of Juvenile Chinook Salmon Through the Sacramento-San Joaquin River Delta During the Winter of 2006-2007.

Perry, R. W., P. L. Brandes, P. T. Sandstrom, A. Ammann, B. MacFarlane, A. P. Klimley, and J. R. Skalski. 2010. Estimating survival and migration route probabilities of juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. North American Journal of Fisheries Management 30:142–156.

Perry et al. (Perry, R. W., Romine, J. G., Brewer, S. J., LaCivita, P. E., Brostoff, W. N., and Chapman, E.D). 2012. Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta During the Winter of 2009–10: U.S. Geological Survey Open-File Report 2012-1200, 30 p.

Perry, R. W., P. L. Brandes, J. R. Burau, P. T. Sandstrom, and J. R. Skalski. 2015. Effect of Tides, River Flow, and Gate Operations on Entrainment of Juvenile Salmon into the Interior Sacramento–San Joaquin River Delta. Transactions of the American Fisheries Society 144:445-455.

Petersen Lewis, R. S. 2009. Yurok and Karuk traditional Ecological Knowledge: Insights into Pacific Lamprey Populations of the Lower Klamath Basin. American Fisheries Society Symposium 72: 1-39.

Pickard et al. (Pickard, A., A. Grover, and F. Hall). 1982. An Evaluation of Predator Composition at Three Locations on the Sacramento River. Technical Report No. 2. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary.

Pinnix, W.D., and S. Quinn. 2009. Juvenile Salmonid Monitoring on the Mainstem Trinity River at Willow Creek, California, 2006-2007. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2009-16, Arcata, California.

Pinnix et al. (Pinnix, W.D., A. Heacock, and P. Petros). 2013. Juvenile Salmonid Monitoring on the Mainstem Trinity River, California, 2011. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Yurok Tribal Fisheries Program, and Hoopa Valley Tribal Fisheries Department. Arcata Fisheries Data Series Report Number DS2013-29, Arcata, California.

Polis, G.A. and Strong, D.R. 1996. Food web complexity and community dynamics. Am. Nat. 147: 813-846.

Porter, R. 2010. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin Experimental Northern Pikeminnow Management Program. Annual Report. US Department of Energy, Bonneville Power Administration, Portland, Oregon.

Porter, R. 2012. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin Experimental Northern Pikeminnow Management Program. Annual Report. US Department of Energy, Bonneville Power Administration, Portland, Oregon.

PSFMC (Pacific States Marine Fisheries Commission). 2014. Juvenile Salmonid Emigration Monitoring in the Lower American River, California January – June 2013. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California. 54 pp.

Pyper et al. (Pyper, B., J. B. Lando, and C. Justice). 2006. Analysis of Weir Counts and Spawning Surveys of Adult Chinook Salmon in the Stanislaus River. September.

Pyper et al. (Pyper, B.J., S.P. Cramer, R.P. Ericksen, and R. M. Sitts. 2012. Implications of Mark- Selective Fishing for Ocean Harvests and Escapements of Sacramento River Fall Chinook Salmon Populations, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 4:1, 373-390 Available: http://dx.doi.org/10.1080/19425120.2012.679575

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. Seattle, WA: University of Washington Press.

Radtke, L. D. 1966. Distribution of Smelt, Juvenile Sturgeon, and Starry Flounder in the Sacramento-San Joaquin Delta with Observations on Food of Sturgeon. Edited by S. L. Turner and D. W. Kelley. Ecological Studies of the Sacramento-San Joaquin Delta, Part II. California Department of Fish and Game Fish Bulletin 136: 115-129.

Rechisky et al. 2012 Trap and Haul from Cramer

Reclamation (Bureau of Reclamation). 2003. Ecosystem Restoration Opportunities in the Upper Sacramento River Region.

Reclamation (Bureau of Reclamation). 2005. Lake Natoma Temperature Curtain and Channel Modification Study, 2001–2002. Hydraulic Laboratory Report HL-2005-02.

Reclamation (Bureau of Reclamation). 2007. Folsom General Plan/Resource Management Plan: Folsom Lake Recreation Area and Folsom Powerhouse State Historic Park.

Reclamation (Bureau of Reclamation). 2008a. Biological Assessment on the Continued Long-Term Operations of the Central Valley Project and the State Water Project.

Reclamation (U.S. Bureau of Reclamation). 2008b. Plan Formulation Report, Upper San Joaquin River Basin Storage Investigation. October.

Reclamation (Bureau of Reclamation). 2009. Whiskeytown Dam Hydraulics and Hydrology. June 4. Site accessed January 26, 2015 http://www.usbr.gov/projects/

Reclamation (Bureau of Reclamation). 2010a. CVPIA Sacramento River Spawning Gravel Addition Project at Keswick Dam. Categorical Exclusion Checklist. October 5.

Reclamation (Bureau of Reclamation). 2010b. New Melones Lake Area Final Resource Management Plan and Environmental Impact Statement. February 2010.

Reclamation (Bureau of Reclamation). 2010c. Cachuma Lake Final Resource Management Plan/Environmental Impact Statement. May 2010.

Reclamation (Bureau of Reclamation). 2012a. Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability. Revised Milestone Draft.

Reclamation (Bureau of Reclamation). 2012b. Stanislaus River Focus Group Meeting October 10, 2012, Handouts.

Reclamation (Bureau of Reclamation). 2013a. Draft CVPIA Fiscal Year 2014 Work Plan. Clear Creek Restoration – CVPIA Section 3406(b)(12). April 28.

Reclamation (Bureau of Reclamation). 2013b. Shasta Lake Water Resources Investigation, California. Draft Environmental Impact Statement. June.

Reclamation (Bureau of Reclamation). 2013c. Shasta Lake Water Resources Investigation, California. Draft Water Quality Technical Report. June

Reclamation (Bureau of Reclamation). 2014a. Draft Resource Management Plan and Draft Environmental Impact Statement, Contra Loma Reservoir and Recreation Area. May.

Reclamation (Bureau of Reclamation). 2014b. Battle Creek Salmon and Steelhead Restoration Project. Site accessed September 19, 2014. http://www.usbr.gov/mp/battlecreek/about.html

Reclamation (Bureau of Reclamation). 2014c. Habitat Assessment Final Report: Shasta Dam Fish Passage Evaluation. United States Department of the Interior, Mid-Pacific Region.

Reclamation (Bureau of Reclamation). 2014d. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014e. *Appendix L: Biological Review for Endangered Species Act Compliance for Extended Water Transfer Period*. Final Environmental Assessment/Initial Study, Water Transfers for the San Luis & Delta-Mendota Water Authority. April.

Reclamation and CSP (Bureau of Reclamation and California Department of Parks and Recreation. 2010. Millerton Lake Final Resource Management Plan/General Plan Final Environmental Impact Statement/ Environmental Impact Report. April.

Reclamation and CSP (Bureau of Reclamation and California Department of Parks and Recreation). 2013. San Luis Reservoir State Recreation Area Final Resource Management Plan/General Plan and Final Environmental Impact Statement/ Environmental Impact Report. June.

Reclamation and DFG (Bureau of Reclamation and California Department of Fish and Game). 2011. Final Environmental Impact Statement/Environmental Impact Report for the Nimbus Hatchery Fish Passage Project.

Reclamation and DWR (Bureau of Reclamation and California Department of Water Resources). 2010. Appendix E. Fisheries Management Plan: A Framework for Adaptive Management in the San Joaquin River Restoration Program. November.

Reclamation and DWR (Bureau of Reclamation and California Department of Water Resources). 2011. San Joaquin River Restoration Program Draft Program Environmental Impact Statement/Environmental Impact Report. April.

Reclamation and DWR (Bureau of Reclamation and California Department of Water Resources). 2015. Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project Description. Prepared for State Water Resources Control Board. Available online: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/apr2015_req032415.pdf

Reclamation and Trinity County (Bureau of Reclamation and Trinity County). 2006. Indian Creek rehabilitation site: Trinity River Mile 93.7 to 96.5. Revised Environmental Assessment/Recirculated Partial Draft Environmental Impact Report. November 14.

Reclamation et al. (Bureau of Reclamation, Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2003. Environmental Water Account Draft Environmental Impact Statement / Environmental Impact Report.

Reclamation et al. (Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game [now known as Department of Fish and Wildlife], and Water Forum). 2006. Lower American River flow management standard. Draft Report.

Reed et al. (Reed, D., J. Hollibaugh, J. Korman, E. Peebles, K. Rose, P. Smith, and P. Montagna). 2014. Workshop on Delta Outflows and Related Stressors Panel Summary Report. Delta Stewardship Council/Delta Science Program.

Reis-Santos et al. (Reis-Santos, P., S. D. McCormick, and J. M. Wilson). 2008. Ionoregulatory Changes during Metamorphosis and Salinity Exposure of Juvenile Sea Lamprey (Petromyzon marinus L.). The Journal of Experimental Biology 211: 978-988.

Ricker, W.E. 1981. Changes in the average size and average age of Pacific salmon. Can J Fish Aquat Sci 38: 1636–1656. doi: 10.1139/f81-213

Riverside County (County of Riverside). 2014. Lake Skinner. Site accessed March 9, 2014. http://www.rivcoparks.org/parks/lake-skinner/lake-skinner-home.

Roberts, J. 2007. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, October 2001-July 2002. California Department of Fish and Game, North Central Region Fisheries Program.

Robinson, T. C., and J. M Bayer. 2005. Upstream Migration of Pacific Lampreys in the John Day River, Oregon: Behavior, Timing, and Habitat Use. Northwest Science 79: 106-119.

Rose et al. (Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett). 2013a. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: I. Model Description and Baseline Results. Transactions of the American Fisheries Society, 142:5, 1238-1259.

Rose et al. (Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett). 2013b. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: II. Alternative Baselines and Good versus Bad Years. Transactions of the American Fisheries Society, 142:5, 1260-1272.

Rosenfield, J. A., and R. D. Baxter. 2007. Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary. Transactions American Fisheries Society 136: 1577-1592.

Rutter, C. 1908. The fishes of the Sacramento-San Joaquin basin, with a study of their Distribution and Variation. Document No. 637.

Saiki, M. K. 1984. Environmental Conditions and Fish Faunas in Low Elevation Rivers on the Irrigated San Joaquin Valley floor, California. California Fish and Game 70: 145 157.

Saiki et al. (Saiki, M. K., M. R. Jennings, and R. H. Wiedmeyer). 1992. Toxicity of Agricultural Subsurface Drainwater from the San Joaquin Valley, California, to Juvenile Chinook Salmon and Striped Bass. Transactions of American Fisheries Society 121: 73–93.

SBCWD (San Benito County Water District). 2012. Initial Study, Zebra Mussel Eradication Project: San Justo Reservoir, Hollister Conduit, & San Benito County Water District Subsystems. January.

Schaffter, R. 1997. White Sturgeon Spawning Migrations and Location of Spawning Habitat in the Sacramento River, California. California Department of Fish and Game 83: 1-20.

Scheiff, T., and P. Zedonis. 2010. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2009. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2010-17, Arcata, California.

Scheiff, T. and P. Zedonis. 2011. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2010. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2011-22, Arcata, California

Scheiff, T., and P. Zedonis. 2012. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2012. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2012-30, Arcata, California.

Scheiff et al. (Scheiff, A. J., J. S. Lang, and W. D. Pinnix). 2001. Juvenile Salmonid Monitoring on the Mainstem Klamath River at Big Bar and Mainstem Trinity River at Willow Creek 1997–2000. Annual report of the Klamath River Fisheries Assessment Program. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Schick et al. (Schick, R. S., A. L. Edsall, and S. T. Lindley). 2005. Historical and Current Distribution of Pacific Salmonids in the Central Valley, CA. Technical Memorandum 369. National Marine Fisheries Service, Santa Cruz, California.

Schneider, K. S., G. M. Kondolf, and A. Falzone. 2003. Channel-floodplain Disconnection on the Stanislaus River: a Hydrologic and Geomorphic Perspective. Edited by P. M. Faber, 163-168. California Riparian Systems: Processes and Floodplain Management, Ecology, and restoration. Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California.

Schoellhamer, D. H. 2011. Sudden Clearing of Estuarine Waters upon Crossing the Threshold from Transport to Supply Regulation of Sediment Transport as an Erodible Sediment Pool Is Depleted: San Francisco Bay, 1999. Estuaries and Coasts. DOI 10.1007/s12237-011-9382-x.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Fish. Res. Board Can., Bull. No. 184. 966 pp.

SCVWD (Santa Clara Valley Water District). 2010. Urban Water Management Plan.

SDCWA and USACE (San Diego County Water Authority and U.S. Army Corps of Engineers). 2008. Final Environmental Impact Report/Environmental Impact Statement for the Carryover Storage and San Vicente Dam Raise Project. April 2008.

SDFish. 2014. Dixon Lake. Sdfish.com Site accessed October 30, 2014. http://sdfish.com/lakes/dixon-lake

SDFish. 2015. Lake Jennings. Sdfish.com Site accessed May 11, 2015. http://sdfish.com/lakes/lake-jennings

Seeholtz et al. (Seesholtz, A., B. J. Cavallo, J. Kindopp, and R. Kurth). 2004. Juvenile Fishes of the Lower Feather River: Distribution, Emigration Patterns, and Associations with Environmental Variables. Early Life History of Fishes in the San Francisco Estuary and Watershed. Edited by F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, 141-166. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Seeholtz et al. (Seesholtz, A., M.J. Manuel, and J.P. Van Eenennaam). (2014). First Documented Spawning and Associated Habitat Conditions for Green Sturgeon in the Feather River, California. Environmental Biology of Fishes DOI: 10.1007/s10641-014-0325-9: 1-8.

SJTA (San Joaquin Tributaries Authority). 2012. Review of Scientific Information Pertaining to SWRCB's February 2012 Technical Report on the Scientific Basis for Alternative San Joaquin River Flow Objectives. Prepared for State Water Resources Control Board Phase II Comprehensive Review Workshops, Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by Doug Demko, Michael Hellmair, Matt Peterson, Shaara Ainsley, Michele Palmer, and Andrea Fuller.

Siegel et al. (Siegel, S., C. Enright, C. Toms, C. Enos, and J. Sutherland). 2010. Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model. Chapter 1: Physical Processes. Suisun Marsh Habitat Management, Restoration and Preservation Plan. Final Review Draft. Prepared by WWR and DWR.

SJRGA (San Joaquin River Group Authority). 2010. 2009 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP).

SJRGA (San Joaquin River Group Authority). 2011. 2010 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP).

SJRGA (San Joaquin River Group Authority). 2013. 2011 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP).

Skinner, J. E. 1962. An Historical Review of the Fish and Wildlife Resources of the San Francisco Bay Area. (Water Projects Branch Report No. 1.) California Department of Fish and Game. Sacramento, CA.

Smelt Working Group. 2015. Smelt Working Group Meeting Notes. June 8.

Snider, B., and R. Titus. 2000a. Lower American River Emigration Survey October 1996–September 1997. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program.

Snider, B., and R. G. Titus. 1998. Evaluation of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, November 1995-July 1996. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program.

Snider, B., and R. G. Titus. 2000b. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, October 1996-September 1997. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 00-04.

Snider, B., and R. G. Titus. 2000c. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, October 1997-September 1998. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 00-05

Snider, B., and R. G. Titus. 2000d. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, October 1998-September 1999. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical Report No. 00-6

Snider, B., and R. Titus. 2002. Lower American River Emigration Survey October 1998–September 1999. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program.

Snider et al. (Snider, B., R. Titus, and K. Vyberberg). 2001. Evaluation of Effects of Flow Fluctuations on the Anadromous Fish Populations in the Lower American River. California Department of Fish and Game Stream Evaluation Program.

SOG (Stanislaus Operations Group). 2011. Annual Report of Activities, October 1, 2010 to September 30, 2011. October.

SOG (Stanislaus Operations Group). 2012. Annual Report of Activities, October 1, 2011 to September 30, 2012. October.

Sommer, T. and F. Mejia. 2013. A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science, 11(2). San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis.

Sommer et al. (Sommer, T. R., R. Baxter, and B. Herbold). 1997. Resilience of Splittail in the Sacramento–San Joaquin Estuary. Transactions of the American Fisheries Society 126: 961–976.

Sommer et al. (Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel). 2001a. California's Yolo Bypass: Evidence that Flood Control can be Compatible with Fisheries, Wetlands, Wildlife, and Agriculture. Fisheries 26: 6-16.

Sommer et al. (Sommer, T.R., D. McEwan and R. Brown). 2001b. Factors affecting chinook salmon spawning in the lower Feather River. California Department of Fish and Game Fish Bulletin 179:269-297

Sommer et al. (Sommer, T. R., W. C. Harrell, M. L. Nobriga, and R. Kurth). 2003. Floodplain as Habitat for Native Fish: Lessons from California’s Yolo Bypass. California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings. Edited by P. M. Faber, 81–87. Riparian Habitat Joint Venture, Sacramento, California.

Sommer et al. (Sommer, T. R., W. C. Harrell, A. Mueller-Solger, B. Tom, and W. Kimmerer). 2004. Effects of Flow Variation on Channel and Floodplain Biota and Habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14:247-261.

Sommer et al. (Sommer, T, W. Harrell, and M. Nobriga). 2005. Habitat Use and Stranding Risk of Juvenile Chinook Salmon on a Seasonal Floodplain. North American Journal of Fisheries Management 25: 1493-1504.

Sommer et al. (Sommer, T. R., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza). 2007a. The Collapse of Pelagic Fishes in the upper San Francisco Estuary. Fisheries 32: 270-277.

Sommer et al. (Sommer, T., R. Baxter, and F. Feyrer). 2007b. Splittail revisited: how recent population trends and restoration activities led to the "delisting" of this native minnow. Pages 25-38 in M.J. Brouder and J.A. Scheuer, editors. Status, distribution, and conservation of freshwater fishes of western North America. American Fisheries Society Symposium 53. Bethesda, Maryland.

Sommer et al. (Sommer, T. R., W. C. Harrell, Z. Matica, and F. Feyrer). 2008. Habitat Associations and Behavior of Adult and Juvenile Splittail (Cyprinidae: Pogonichthys macrolepidotus) in a Managed Seasonal Floodplain Wetland. San Francisco Estuary and Watershed Science 5(2): Article 3. http://www.escholarship.org/uc/item/85r15611

Sommer et al. (Sommer, T., F. Mejia, M. Nobriga, F. Feyrer, and L. Grimaldo). 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science: 9(2).

Sommer et al. (T.R. Sommer, W.C. Harrell, and F. Feyrer. 2014. Large-bodied fish migration and residency in a flood basin of the Sacramento River, California, USA. Ecology of Freshwater Fish 2014: 23: 414–423

Sonke, C. and A. Fuller. 2012. Outmigrant Trapping of Juvenile Salmon in the Lower Tuolumne River, 2012. Prepared for Turlock and Modesto Irrigation Districts by FISHBIO, Oakdale, CA.

S.P. Cramer and Associates, Inc. 1998. Evaluation of Juvenile Chinook Behavior, Migration Rate and Location of Mortality in the Stanislaus River Through the Use of Radio Tracking. Final report prepared for the Tri-dam Project. December.

Speegle, J., J. Kirsch, and J. Ingram. 2013. Annual report: Juvenile Fish Monitoring During the 2010 and 2011 Field Seasons within the San Francisco Estuary, California. Stockton Fish and Wildlife Office.

SRFG (Stanislaus River Fish Group). 2003. A Plan to Restore Anadromous Fish Habitat in the Lower Stanislaus River. Review Draft.

SRFG (Stanislaus River Fish Group). 2004. A Summary of Fisheries Research in the Lower Stanislaus River. Working Draft. March 10.

SRTTG (Sacramento River Temperature Task Group). 2012. Annual Report of Activities: 1 October 2011 through 30 September 2012.

Staley, J. R. 1976. American River steelhead, Salmo gairdnerii gairdnerii, management, 1956-1974. Anadromous Fisheries Branch Administrative Report 76–2. California Department of Fish and Game.

Stevens 1966. Food habits of striped bass (Roccus caxatilis) in the Sacramento-San Joaquin Delta. Pages 68-96 in J.L. Turner and D.W. Kelley, eds. Ecological studies of the Sacramento-San Joaquin Estuary, part II: fishes of the Delta. CDFG Fish. Bull. 136.

Stevens, D. E., and L. W. Miller. 1970. Distribution of Sturgeon Larvae in the Sacramento-San Joaquin River system. California Fish and Game 56: 80-86.

Stevens et al. (Stevens, D. E., D. W. Kohlhorst, L. W. Miller, and D. W. Kelley). 1985. The Decline of Striped Bass in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 114: 12-30.

Stewart et al. (Stewart, A. R., S. N. Luoma, C. E. Schlekat, M. A. Doblin, and K. A Hieb). 2004. Food Web Pathway Determines How Selenium Affects Aquatic Ecosystems: A San Francisco Bay Case Study. Environ. Sci. Technol. 2004, 38, 4519-4526.

Stillwater Sciences. 2007. The Merced River Alliance Project Interim Biological Monitoring and Assessment Report. Prepared for East Merced Resource Conservation District, Merced, California, and State Water Resources Control Board.

Strange, J. S. 2010. Upper Thermal Limits to Migration in Adult Chinook Salmon: evidence from the Klamath River basin. Transactions of the American Fisheries Society 139: 1091–1108.

Suisun Ecological Workgroup. 2001. Suisun Ecological Workgroup Final Report to the State Water Resources Control Board.

Swanson et al. (Swanson, C., P. S. Young, and J. J. Cech Jr). 1998. Swimming Performance of Delta Smelt: Maximum Performance and Behavioral and Kinematic Limitations of Swimming at Submaximal Velocities. Journal of Experimental Biology 201: 333-345.

Sweetwater Authority. 2013. Sweetwater Reservoir Wetlands Habitat Recovery Project Initial Study/Mitigated Negative Declaration. December.

SWRCB (State Water Resources Control Board). 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Sacramento, California.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2010a. Staff Report for 2010 Integrated Report Clean Water Act Sections 303(d) and 305(b). April. Site accessed December 2, 2013.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWRCB (State Water Resources Control Board). 2015. *Response from U.S. Bureau of Reclamation on New Melones Operations.* E-mail from Ronald Milligan (Reclamation) to Tom Howard (SWRCB) with Attachments. Dated April 8, 2015. Available online at http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/index.shtml

SWRI (Surface Water Resources, Inc.). 2001. Aquatic Resources of the Lower American River: Baseline Report. Draft Report. Prepared for the Lower American River Fisheries and Instream Habitat (FISH) Working Group.

TCCA (Tehama-Colusa Canal Authority). 2008. Fishery Resources, Appendix B. Fish passage improvement project at the Red Bluff Diversion Dam EIS/EIR. Prepared by CH2M HILL, State Clearinghouse No. 2002-042-075.

Teh et al. (Teh, S., I. Flores, M. Kawaguchi, S. Lesmeister, and C. the). 2011. Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of Pseudodiaptomus forbesi to Ammonia/Ammonium. Submitted to: Chris Foe and Mark Gowdy, State Water Board / UC Davis Agreement No. 06-447-300 SUBTASK No. 14. August 31.

TID/MID (Turlock Irrigation District/Modesto Irrigation District). 1992. Lower Tuolumne River Predation Study Report. Appendix 22 to Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299 Vol. VII. Prepared by T. Ford, Turlock and Modesto Irrigation Districts and EA Engineering, Science, and Technology, Lafayette, California.

TID/MID (Turlock Irrigation District/Modesto Irrigation District). 2013. Predation Study W&AR-17. Initial Study Report Don Pedro Project, FERC No. 2299. Prepared by FISHBIO, Oakdale, CA.

TNC (The Nature Conservancy). 2007a. Sacramento River Ecological Flows Study. Gravel Study Final Report.

TNC (The Nature Conservancy). 2007b. Linking Biological Responses to River Processes: Implications for Conservation and Management of the Sacramento River—a Focal Species Approach. Final Report.

Thomson et al. (Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. MacNally, W. A. Bennett, F. Feyrer, and E. Fleishman). 2010. Bayesian Change Point Analysis of Abundance Trends for Pelagic Fishes in the Upper San Francisco Estuary. Ecological Applications, 20(5), 2010, pp. 1431–1448

Toft et al. (Toft, J.D., C.A. Simenstad, J.R. Cordell, and L.F. Grimaldo). 2003. The Effects of Introduced Water Hyacinth on Habitat Structure, Invertebrate Assemblages, and Fish Diets. Estuaries 26(3): 746–758.

Tri Dam Project. 2003. Letter from Steve Felte, General Manager, to interested agencies Re: Request for Preliminary Input on the Proposed Goodwin Hydroelectric Project. Dated 8, August, 2003.

TRRP (Trinity River Restoration Program). 2014. Review of the Trinity River Restoration Program Following Phase 1, With Emphasis on the Program’s Channel Rehabilitation Strategy. April.

TRTAC (Tuolumne River Technical Advisory Committee), Turlock and Modesto Irrigation Districts, USFWS Anadromous Fish Restoration Program, and California Bay-Delta Authority. 2006. Lower Tuolumne River Predation Assessment Final Report. Prepared by Stillwater Sciences, Berkeley, CA and McBain & Trush, Arcata, CA.

Trush et al. (Trush, W. J., S. McBain, and L. Leopold). 2000. Attributes of an Alluvial River and Their Relation to Water Policy and Management. Proceedings of the National Academy of Sciences 97: 11858-11863.

Tucker et al. (Tucker, M.E., C.M. Williams, and R.R. Johnson). 1998. Abundance, Food Habits and Life History Aspects of Sacramento Squawfish and Striped Bass at the Red Bluff Diversion Complex, including the Research Pumping Plant, Sacramento River, California, 1994-1996. Red Bluff Research Pumping Plant Report Series, Volume 4. U. S. Fish and Wildlife Service, Red Bluff, California.

Tucker et al. (Tucker, M. E., C. D. Martin, and P. D. Gaines). 2003. Spatial and Temporal Distribution of Sacramento Pikeminnow and Striped Bass at the Red Bluff Diversion Complex, including the Research Pumping Plant, Sacramento River, California: January, 1997 to August, 1998. Red Bluff Research Pumping Plant Report Series. U. S. Fish and Wildlife Service, Red Bluff, California.

USACE (U.S. Army Corps of Engineers), Bureau of Reclamation, Sacramento Area Flood Control Agency, and California Central Valley Flood Protection Board. 2012. Folsom Dam Modification Project Approach Channel, Draft Supplemental Environmental Impact Statement/ Environmental Impact Report. July.

USACE (U.S. Army Corps of Engineers). 2013. Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River. October.

USFWS (U. S. Fish and Wildlife Service). 1983. Final Environmental Impact Statement: Trinity River Basin Fish and Wildlife Management Program. INT/FES 83-53.

USFWS (U. S. Fish and Wildlife Service). 1994a. Endangered and Threatened Wildlife and Plants; Critical Habitat Determination for the Delta Smelt. Federal Register 59: 65256-65278.

USFWS (U. S. Fish and Wildlife Service). 1994b. Rehabilitation of the Mainstem Trinity River Background Report. 1994.

USFWS (U.S. Fish and Wildlife Service). 1995. Working paper: Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. Volume 2. May 9, 1995.

USFWS (U. S. Fish and Wildlife Service). 1997. Klamath River (Iron Gate Dam to Seiad Creek), Life Stage Periodicities for Chinook, Coho, and steelhead. July.

USFWS (U.S. Fish and Wildlife Service). 1999. Trinity River Flow Evaluation Final Report.

USFWS (U.S. Fish and Wildlife Service). 2000. Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Environmental Impact Report.

USFWS (U. S. Fish and Wildlife Service). 2001a. Final Restoration Plan for the Anadromous Fish Restoration Program: a Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California.

USFWS (U. S. Fish and Wildlife Service). 2001b. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary: 1997 and 1998. Annual Progress Report Sacramento-San Joaquin Estuary.

USFWS (U. S. Fish and Wildlife Service). 2002b. Stanislaus River Anadromous Fish Surveys 2000-2001. Snorkel Survey. Anadromous Fish Restoration Program.

USFWS (U. S. Fish and Wildlife Service). 2003a. Flow-habitat Relationships for steelhead and fall-run, late-fall, and winter-run Chinook Salmon Spawning in the Sacramento River between Keswick Dam and Battle Creek.

USFWS (U. S. Fish and Wildlife Service). 2003b. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary: 1999. Annual Progress Report.

USFWS (U. S. Fish and Wildlife Service). 2005a. Flow-habitat Relationships for fall-run Chinook Salmon Spawning in the Sacramento River between Battle Creek and Clear Creek.

USFWS (U. S. Fish and Wildlife Service). 2005b. Flow-habitat Relationships for Chinook Salmon Rearing in the Sacramento River between Keswick Dam and Battle Creek.

USFWS (U. S. Fish and Wildlife Service). 2006. Relationships between Flow Fluctuations and Redd Dewatering and Juvenile Stranding for Chinook Salmon and steelhead in the Sacramento River between Keswick Dam and Battle Creek.

USFWS (U. S. Fish and Wildlife Service). 2007. Central Valley Steelhead and late fall-run Chinook Salmon Redd Surveys on Clear Creek, California.

USFWS (U. S. Fish and Wildlife Service). 2007. Flow-habitat Relationships for Spring Chinook Salmon and steelhead/Rainbow Trout Spawning in Clear Creek between Whiskeytown Dam and Clear Creek Road.

USFWS (U. S. Fish and Wildlife Service). 2008a. Biological Opinion on the Coordinated Operations of the Central Valley Project and State Water Project in California.

USFWS (U. S. Fish and Wildlife Service). 2008b. Juvenile Salmonid Monitoring in Clear Creek, California from July 2002 through September 2003.

USFWS (U. S. Fish and Wildlife Service). 2010. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List the Sacramento Splittail as Endangered or Threatened. Federal Register 75: 62070-62095.

USFWS (U.S. Fish and Wildlife Service). 2011a. Flow-habitat Relationships for fall-run Chinook Salmon and steelhead/Rainbow Trout Spawning in Clear Creek between Clear Creek Road and the Sacramento River.

USFWS (U.S. Fish and Wildlife Service). 2011b. Flow-habitat Relationships for spring-run Chinook Salmon and steelhead/Rainbow Trout Rearing in Clear Creek between Whiskeytown Dam and Clear Creek Road.

USFWS (U. S. Fish and Wildlife Service). 2011a. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project. First Draft Biological Opinion. Reference No. 81410-2011-F-0043.

USFWS (U. S. Fish and Wildlife Service). 2011b. Biological Assessment of Artificial Propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: Program Description and Incidental Take of Chinook Salmon and steelhead. July.

USFWS (U. S. Fish and Wildlife Service). 2012. California Hatchery Review Project, Appendix VIII. Coleman National Fish Hatchery Steelhead Program Report.

USFWS (U.S. Fish and Wildlife Service). 2013a. Flow-habitat Relationships for spring-run and fall-run Chinook Salmon and steelhead/Rainbow Trout Rearing in Clear Creek Clear Creek Road and the Sacramento River.

USFWS (U.S. Fish and Wildlife Service). 2015. Clear Creek Habitat Synthesis Report.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report. October.

USFWS et al. (U.S. Fish and Wildlife Service), Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County. 2004. Trinity River Fishery Restoration. Supplemental Environmental Impact Statement/Environmental Impact Report. April.

USFWS et al. (U.S. Fish and Wildlife Service and Bureau of Reclamation). 2008. Implementation of the Central Valley Project Improvement Act, Annual Report for Fiscal Year 2006. January.

Van Eenennaam, J. P., M. A. H. Webb, X. Deng, S. I. Doroshov, R. B. Mayfield, J. J. Cech, D. C. Hillemeier, and T. E. Willson. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transactions of the American Fisheries Society 130: 159-165.

Van Eenennaam, J. P., J. Linares-Casenave, X. Deng, and S. I. Doroshov. 2005. Effect of Incubation Temperature on Green Sturgeon Embryos, Acipenser medirostris. Environmental Biology of Fishes 72: 145-154.

Van Eenennaam et al. (Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson, and A. A. Nova). 2006. Reproductive Conditions of the Klamath River Green Sturgeon. Transactions of the American Fisheries Society 135: 151-163.

Van Nieuwenhuyse, E. E. 2007. Response of Summer Chlorophyll Concentration to Reduced Total Phosphorus Concentration in the Rhine River (Netherlands) and the Sacramento-San Joaquin Delta (California, USA). Can. J. Fish. Aquat. Sci. 64: 1529-1542.

Vincik, R. F., R. G. Titus, and B. Snider. 2006. Timing, Composition, and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing, September 1999-September 2000. California Department of Fish and Game, Sacramento Valley-Central Sierra Region, Lower Sacramento River Juvenile Salmonid Emigration Program.

Vogel, D. A. 2004. Juvenile Chinook Salmon Radio-telemetry Studies in the Northern and Central Sacramento-San Joaquin Delta, 2002-2003. Report to the National Fish and Wildlife Foundation, Southwest Region.

Vogel, D. A. 2008. Evaluation of Adult Sturgeon Migration at the Glenn-Colusa Irrigation District Gradient Facility on the Sacramento River.

Vogel, D. A. 2011. Insights into the Problems, Progress, and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration. Prepared for Northern California Water Association and Sacramento Valley Water Users.

Vogel, D. 2013. Evaluation of Fish Entrainment in 12 Unscreened Sacramento River Diversions. Final Report. Prepared for CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and NOAA Fisheries).

Vogel, D. A., and K. R. Marine. 1991. Guide to the Upper Sacramento River Chinook Salmon Life History. Bureau of Reclamation Central Valley Project.

Wagner, R. W., M. Stacey, L. R. Brown, and M. Dettinger. 2011. Statistical Models of Temperature in the Sacramento–San Joaquin Delta under Climate-Change Scenarios and Ecological Implications. Estuaries and Coasts (2011) 34:544–556. DOI 10.1007/s12237-010-9369-z.

Wallace, M. 2004. Natural vs. Hatchery Proportions of Juvenile Salmonids Migrating Through the Klamath River Estuary and Monitor Natural and Hatchery Juvenile Salmonid Emigration from the Klamath River Basin. July 1, 1998 through June 30, 2003. Final Performance Report. Federal Aid in Sport Fish Restoration Act, Project No. F-51-R-6.

Water Forum. 2004. Draft Policy Document: Lower American River Flow Management Standard.

Water Forum. 2005a. Impacts on Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations to Meet Delta Water Quality Objectives and Demands. Draft Report. January.

Water Forum. 2005b. Addendum to the Report Titled "Impacts on Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations to Meet Delta Water Quality Objectives and Demands."

Water Forum. 2005c. Lower American River, State of the River Report. April. Available online: http://www.waterforum.org./wp-content/uploads/2015/09/State-of-the-River-2005.pdf

Watry, C. B., A. Gray, R. Cuthbert, B. Pyper, and K. Arendt. 2007. Out-migrant Abundance Estimates and Coded Wire Tagging Pilot Study for Juvenile Chinook Salmon at Caswell Memorial State Park in the Lower Stanislaus River, California. 2007 Annual Data Report. Prepared for U.S. Fish and Wildlife Service Anadromous Fish Restoration Program.

Watry, C. B., A. Gray, K. Jones, K. Sellheim, and J. Merz. 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010-2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.

Wertheimer A.C., Heard, W.R., Maselko, J.M., and Smoker, W.W. 2004 Relationship of size at return with environmental variation, hatchery production, and productivity of wild pink salmon in Prince William Sound, Alaska: does size matter? Rev Fish Biol Fisheries 14: 321–334. doi: 10.1007/s11160-004-2942-4

Weston, D. P., J. You, and M. J. Lydy. 2004. Distribution and Toxicity of Sediment-Associated Pesticides in Agriculture-Dominated Water Bodies of California's Central Valley. Environmental Science and Technology 38: 2752-2759.

Whipple, A. A., R. M. Grossinger, D. Rankin, B. Stanford, and R. A. Askevold. 2012. Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process. Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. Historical Ecology Program Publication 672, San Francisco Estuary Institute-Aquatic Science Center, Richmond, California.

Wilkerson, F. P., R. C. Dugdale, V. E. Hogue, and A. Marchi. 2006. Phytoplankton Blooms and Nitrogen Productivity in San Francisco Bay. Estuaries and Coasts 29: 401-416.

Williams, J. G. 2001. Chinook Salmon in the Lower American River, California's Largest Urban Stream. Contributions to the biology of Central Valley salmonids, Volume 2. Edited by R. L. Brown. California Department of Fish and Game Fish Bulletin 179: 1-38.

Williams, J. G. 2006. Central Valley Salmon: a Perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4.

Williams, G. J. 2010. Life History Conceptual Model for Chinook Salmon and steelhead. DRERIP Delta Conceptual Model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Williams, J.G., S.G. Smith, R.W. Zabel, W.D. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R. McNatt, and S. Achord. 2004. Effects of the federal Columbia River power system on salmon populations. NOAA Technical Memorandum, NMFS-NWFSC 63 (2004).

Williams, T. H., J. C. Garza, N. Hetrick, S. T. Lindley, M. S. Mohr, J. M. Myers, M. R. O'Farrell, R. M. Quinones, and D. J. Teel. 2011. Upper Klamath and Trinity River Chinook Salmon Biological Review Team report. National Marine Fisheries Service, Southwest Region.

Winans, G. A., D. Viele, A. Grover, M. Palmer-Zwahlen, D. Teel, and D. Van Doornik. 2001. An update on genetic stock identification of Chinook salmon in the Pacific Northwest: test fisheries in California. Reviews in Fisheries Science 9:213–237.

Winder, M., and A. D. Jassby. 2011. Shifts in Zooplankton Community Structure: Implications for Food Web Processes in the Upper San Francisco Estuary. Estuaries and Coasts (2011) 34:675–690 DOI 10.1007/s12237-010-9342-x.

Wright, S. A., and D. H. Schoellhamer 2004. Trends in the Sediment Yield of the Sacramento River, California, 1957 – 2001. San Francisco Estuary and Watershed Science, 2(2).

YCWA (Yuba County Water Agency). 2009. Green Sturgeon Downstream of Englebright Dam. Preliminary Information Package, Public Information. Yuba River Development Project, FERC Project No. 2246.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California in Sierra Nevada Ecosystem Project. Final Report to Congress. Volume III: Assessments, commissioned reports, and background information. University of California, Davis, Centers for Water and Wildland Resources.

Yoshiyama, R. M, E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Contributions to the Biology of Central Valley Salmonids, Volume 1. Edited by R. L. Brown. California Department of Fish and Game Fish Bulletin 179: 71-177.

YTFP (Yurok Tribal Fisheries Program). 1998. Yurok Elder Interviews: Eulachon and Lamprey. Internal Report.

Zedonis, P. 2003. Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity River, CA, WY 2002. Report AFWO-F-04-03. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA 95521. 16 pp.

Zedonis, P. 2004. Lewiston Dam Releases and their Influence on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2003. Report AFWO-F01-04. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA 95521. 34 pp.

Zedonis, P. 2005. The influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2004. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR2005-03, Arcata, California. 31 pp.

Zedonis, P. 2009. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2008. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2009-15, Arcata, California. 24 pp.

Zedonis, P., and R. Turner. 2006. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2005. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS2006-08, Arcata, California. 29 pp.

Zedonis, P., and R. Turner. 2007. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2006. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2007-01, Arcata, California.

Zedonis, P., and R. Turner. 2008. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA, April to October, 2007. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2008-01, Arcata, California.

Zeug, S.C. and B.J. Cavallo. 2012. Influence of estuary conditions on the recovery rate of coded-wire-tagged Chinook salmon (*Oncorhynchus tshawytscha*) in an ocean fishery. Ecology of Freshwater Fish Vol. 22, Num. 1, Page(s): 157-168.

Zeug S.C., and B.J. Cavallo. 2014. Controls on the Entrainment of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) into Large Water Diversions and Estimates of Population-Level Loss. PLoS ONE 9(7): e101479. doi:10.1371/journal.pone.0101479.

Zeug, S. C., K. Sellheim, C. Watry, J. D. Wikert, and J. Merz. 2014. Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries Management and Ecology 21:155-168.

Zimmerman, C., G. Edwards, and K. Perry. 2008. Maternal Origin and Migratory History of Oncorhynchus mykiss Captured in Rivers of the Central Valley, California. Contract P0385300. Prepared for California Department of Fish and Game.

Zimmerman, C. E., G. W. Edwards, and K. Perry. 2009. Maternal Origin and Migratory History of steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California. Transactions of the American Fisheries Society 138: 280-291.

**Chapter 10**

# Terrestrial Biological Resources

## 10.1 Introduction

This chapter describes terrestrial biological resources in the study area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect terrestrial biological resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 10.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect terrestrial biological resources in areas: along the shorelines and in the waters of reservoirs that store CVP and SWP water supplies, along rivers and waterways (including bypasses) impacted by changes in the operations of CVP or SWP reservoirs, within agricultural areas served by CVP and SWP water supplies, and modified to provide wetland habitat. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 10.3 Affected Environment

This section describes terrestrial biological resources that could potentially be affected by implementing the alternatives considered in this EIS. Changes in terrestrial biological resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

Terrestrial biological resources occur throughout the study area. However, the analysis in this EIS is focused on terrestrial biological resources that could be directly or indirectly affected by the implementation of the alternatives analyzed in this EIS. The areas that could be affected are related to specific areas: 1) along the shorelines of reservoirs that store CVP and SWP water supplies, 2) along rivers downstream of CVP or SWP reservoirs, 3) areas with wetland habitat restoration in the Yolo Bypass and Suisun Marsh, 4) wildlife refuges that receive CVP water supplies, 5) riparian corridors within the Delta, and 6) within agricultural acreage that is irrigated with CVP and SWP water supplies.

Therefore, the following description of the affected environment is limited to these areas.

### 10.3.1 Overview of Species with Special Status

Species with special status are defined as species that are legally protected or otherwise considered sensitive by Federal, state, or local resource agencies, including:

- Species listed by the Federal government as threatened or endangered,
- Species listed by the State of California as threatened, endangered, or rare (rare status is for plants only),
- Species that are formally proposed for Federal listing or are candidates for Federal listing as threatened or endangered,
- Species that are candidates for State listing as threatened or endangered,
- Species that meet the definitions of rare, threatened, or endangered under California Environmental Quality Act,
- Species identified by the U.S. Fish and Wildlife Service (USFWS) as Birds of Conservation Concern,
- Species considered sensitive by the U.S. Bureau of Land Management (BLM) or U.S. Forest Service (USFS),
- Species identified by California Department of Fish and Wildlife (CDFW) as species of special concern, species designated by California statute as fully protected (e.g., California Fish and Game Code, sections 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians] and 5515 [fish]) or bird species on the CDFW Watch List, and
- Species, subspecies, and varieties of plants considered by CDFW and California Native Plant Society (CNPS) to be rare, threatened, or endangered in California. The CNPS Inventory of Rare and Endangered Plants of California assigns California Rare Plant Ranks (CRPR) categories for plant species of concern. Only plant species in CRPR categories 1 and 2 are considered special status plant species in this document:
  - CRPR 1A—Plants presumed to be extinct in California.
  - CRPR 1B—Plants that are rare, threatened, or endangered in California and elsewhere.
  - CRPR 2—Plants that are rare, threatened, or endangered in California but more common elsewhere.

A listing of wildlife and plant species with special status that occur or may occur in portions of the study area and are affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A. Relevant documents used to assemble these resource lists include the list of Federal endangered and threatened species that occur in or may be affected by projects in the counties within the study area generated on-line from the USFWS Sacramento Fish and Wildlife Office.

To supplement the U.S. Fish and Wildlife lists, the California Natural Diversity Database (CNDDB) was queried (DFG 2012) for regions where recent documentation was lacking. This included the Stanislaus River corridor between New Melones Dam and the San Joaquin River confluence, and the Trinity River Region, including Trinity Lake, Lewiston Reservoir, Whiskeytown Lake, and Clear Creek between Carr Powerhouse and the Sacramento River confluence.

#### *10.3.1.1 Critical Habitat*

Critical habitat refers to areas designated by the USFWS for the conservation of species listed as threatened or endangered under the Endangered Species Act of 1973, as amended through the 108th Congress (ESA). When a species is proposed for listing under the ESA, the USFWS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5 of the ESA as follows.

> *(5)(A) The term "critical habitat" for a threatened or endangered species means -*
>
> > *(i) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and*
> >
> > *(ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.*

Any Federal action (permit, license, or funding) in critical habitat requires that Federal agency to consult with the USFWS where the action has potential to adversely modify the habitat for terrestrial species.

The federally listed wildlife and plant species considered in this EIS that have designated critical habitat areas that could be affected by modification of CVP and SWP operations are presented in Table 10.1 below. There are occurrences of critical habitat of other species not included in Table 10.1 or other locations of critical habitat of the species listed in Table 10.1 which are not included below because those occurrences are not located within the CVP or SWP service areas or in areas that could be affected by modification of CVP and SWP operations, such as lands located at high elevations within national forests where CVP and SWP water is not delivered.

**Table 10.1 Terrestrial Species with Designated Critical Habitat in Portions of the Study Area that Could Be Affected by Changes in CVP and SWP Operations**

| Species | Regions* | Counties |
|---|---|---|
| Least Bell's Vireo | Central Coast and Southern California | Riverside, San Bernardino, San Diego, Santa Barbara, Ventura |
| Buena Vista Lake Shrew | Central Valley | Kern |
| Fresno Kangaroo Rat | Central Valley | Fresno |
| California Tiger Salamander | Central Valley | Alameda, Kern, Kings, Madera, Merced, San Benito, San Joaquin, Santa Barbara, Solano, Stanislaus, Tulare, Yolo |
| California Red-legged Frog | Central Valley, San Francisco Bay Area, Central Coast, Southern California | Alameda, Butte, Contra Costa, El Dorado, Kern, Kings, Los Angeles, Merced, Nevada, Placer, San Benito, San Joaquin, Santa Barbara, Santa Clara, Solano, Stanislaus, Ventura, Yuba |
| Alameda Whipsnake | Central Valley and San Francisco Bay Area | Alameda, San Joaquin, Santa Clara |
| Valley Elderberry Longhorn Beetle | Central Valley | Sacramento |
| Conservancy Fairy Shrimp | Central Valley | Butte, Merced, Solano, Stanislaus, Tehama, Ventura |
| Longhorn Fairy Shrimp | Central Valley | Alameda, Contra Costa, Merced |
| Vernal Pool Fairy Shrimp | Central Valley and San Francisco Bay Area | Alameda, Butte, Contra Costa, Fresno, Glenn, Madera, Merced, Placer, Sacramento, San Benito, San Joaquin, Santa Barbara, Shasta, Solano, Stanislaus, Tehama, Tulare, Ventura, Yuba |
| Vernal Pool Tadpole Shrimp | Central Valley | Alameda, Colusa, Kings, Madera, Merced, Sacramento, Shasta, Solano, Stanislaus, Tehama, Tulare, Yolo, Yuba |
| Butte County Meadowfoam | Central Valley | Butte, Tehama |
| Colusa Grass | Central Valley | Merced, Stanislaus, Yolo |
| Hairy Orcutt Grass | Central Valley | Butte, Fresno, Madera, Merced, Stanislaus, Tehama |
| San Joaquin Hairy Orcutt Grass | Central Valley | Fresno, Madera, Merced, Tulare |
| Slender Orcutt Grass | Central Valley | Plumas, Sacramento, Shasta, Tehama |

| Species | Regions* | Counties |
|---|---|---|
| Sacramento Orcutt Grass | Central Valley | Sacramento |
| Solano Grass | Central Valley | Yolo |
| Contra Costa Goldfields | Central Valley | Solano |
| Contra Costa Wallflower | Central Valley and San Francisco Bay Area | Contra Costa, Sacramento |
| Fleshy Owl's-Clover | Central Valley | Madera, Merced, Sacramento, San Joaquin, Stanislaus |
| Greene's Tuctoria | Central Valley | Madera, Merced, Shasta, Stanislaus, Tehama |
| Hoover's Spurge | Central Valley | Butte, Merced, Tehama, Tulare |
| Keck's Checker-Mallow | Central Valley | Fresno |
| Soft Bird's-Beak | Central Valley and San Francisco Bay Area | Contra Costa, Solano |
| Suisun Thistle | Central Valley | Solano |

Source: USFWS 2014a - 2014aj

Note:
*  Only includes critical habitat within lands served by CVP or SWP water or in areas that could be affected by modification of CVP and SWP operations.  Therefore, does not include lands where CVP and SWP water is not delivered or not affected by CVP and SWP operations.

### 10.3.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean.  The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 1999).  The mainstem of the Trinity River flows 170 miles to the west from the headwaters to the confluence with the Klamath River.  As described in Chapter 5, Surface Water Resources and Water Supplies, the CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of the Trinity River and the North Fork, South Fork, and New River.  Flows on the North Fork, South Fork, and New River are not affected by CVP facilities.  The Trinity River flows approximately 112 miles from Lewiston Reservoir to the Klamath River through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties.  The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low.

As described in subsection 10.3.2, Overview of Species with Special Status, a listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

#### *10.3.2.1 Trinity Lake and Lewiston Reservoir*

The dominant vegetation community in the Trinity River watershed upstream of Trinity Lake and Lewiston Reservoir includes mixed conifer, with ponderosa pine, sugar pine, and Douglas-fir as the dominant species. Some south-facing slopes are dominated by oak and brush. Mixed hardwood communities occur at lower elevations, and include species such as madrone, big-leaf maple, and a variety of oaks. The shrub community at lower elevations includes a number of chaparral species such as manzanita, bitterbrush, and deerbrush. South-facing slopes around Trinity Lake contain shrub fields that provide winter range for the Weaverville deer herd (USFS 2005; STNF 2014)

Along the margins of Trinity Lake and Lewiston Reservoir, vegetation is consistent with species associated with a reservoir environment and standing water, including floating species, rooted aquatic species, and emergent wetland species. Emergent wetland and riparian vegetation is constrained by fluctuating water levels and steep banks (NCRWQCB et al. 2009; USFWS et al. 1999).

The reservoirs attract resting and foraging waterfowl and other species that favor standing or slow moving water. Impounded water in the reservoirs also provides foraging habitat for eagles and other raptors that prey on fish (e.g., ospreys) and waterfowl.

Recently, ten pairs of mating bald eagles were observed at Trinity Lake and three pairs at Lewiston Lake (USFS 2012).

#### *10.3.2.2 Trinity River from Lewiston Reservoir to Klamath River*

Current terrestrial habitat along the Trinity River is different than habitat prior to construction of Trinity and Lewiston dams. The ongoing Trinity River Restoration Program is restoring portions of the habitat. The following description reflects recent habitat changes along the mainstem of the Trinity River between Lewiston Reservoir and the confluence of the Klamath River.

#### 10.3.2.2.1 Trinity River Restoration Program

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston dams changed the character of the river channel substantially and allowed riparian vegetation to encroach on areas that had previously been scoured by flood flows (USFWS et al. 1999). This resulted in the formation of a riparian berm that armored and anchored the river banks and prevented meandering of the river channel. The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel. In addition, the extent of wetlands probably declined following dam construction due, in part, to reduced flows and elimination of river meanders.

The ongoing Trinity River Restoration Program includes specific minimum instream flows, as described in Chapter 5, Surface Water Resources and Water Supplies; mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009; USFWS et al. 1999). The mechanical channel rehabilitation includes removal of fossilized riparian berms that had been anchored by extensive woody vegetation root systems and consolidated sand deposits, and thereby, had confined the river. Following removal of the berms, the areas had been re-vegetated to support native vegetation, re-establish alternate point bars, and re-establish complex fish habitat similar to conditions prior to construction of the dams. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages; and relocation of sand outside of the floodway. In areas closer to Lewiston Dam with limited gravel supply, gravel/cobble point bars are being rebuilt to increase gravel storage and improve channel dynamics. Riparian vegetation planted on the restored floodplains and flows will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Improvement projects have been completed and others are under construction or in the planning phases. The restoration actions are occurring between Lewiston Dam and the North Fork.

#### 10.3.2.2.2 Terrestrial Habitat

Between the North Fork and the South Fork, the Trinity River channel is restricted by steep canyon walls that limit riparian vegetation to a narrow band (NCRWQCB et al. 2009; USFWS et al. 1999). Between the South Fork and the confluence with the Klamath River, there are confined reaches with little riparian vegetation, alternating with vegetation similar to the pre-dam conditions in the upper reach below Lewiston dam.

Many wildlife species that inhabited river and riparian habitats prior to dam construction still occur along the Trinity River. Species that prefer early-successional stages or require greater riverine structural diversity are likely to be less abundant under current conditions (NCRWQCB et al. 2009; USFWS et al. 1999). For example, western pond turtle declined since completion of the dams in response to diminishing instream habitat. In contrast, species such as northern goshawk and black salamander that favor mature, late-successional riparian habitats increased with more upland habitat along the riparian corridor.

Current habitats along the Trinity River include annual grassland, fresh emergent wetland, montane riparian, valley-foothill riparian, and riverine habitats (NCRWQCB et al. 2009, 2013). The annual grassland species include grasses (e.g., wild oat, soft brome, ripgut brome, cheatgrass, and barley); forbs (e.g., broadleaf filaree, California poppy, true clover, and bur clover); and native perennial species (e.g., Creeping Wildrye). The annual grassland habitat supports Mourning Dove, Savannah Sparrow, White-Crowned Sparrow, American Kestrel, Red-Tailed Hawk, coyote, California Ground Squirrel, Botta's Pocket Gopher, California Kangaroo Rat, Deer Mouse, Gopher Snake, Western Fence Lizard, Western Skink, Western Rattlesnake, and Yellow-Bellied Racer. The fresh emergent wetland species occur along the backwater areas, depressions, and along the river edges, including American Tule, Narrow-Leaved Cattail, Dense Sedge, Perennial Ryegrass, Himalayan Blackberry, and Narrow-Leaved Willow. Wildlife species along the fresh emergent wetland include Western Toad, Pacific Chorus Frog, Bullfrog, Green Heron, Mallard, and Red-Winged Blackbird. The montane riparian habitat adjacent to the river include trees, including bigleaf maple, white alder, oregon ash, black cottonwood, and Goodding's black willow; and understory species, including mugwort, virgin's bower, American dogwood, oregon golden-aster, dalmatian toadflax, white sweet clover, musk monkeyflower, straggly gooseberry, California grape, and California blackberry. The valley-foothill riparian habitat occur along alluvial fans, slightly dissected terraces, and floodplains; and include cottonwood, California sycamore, valley oak, white alder, boxelder, Oregon ash, wild grape, wild rose, California blackberry, blue elderberry, poison oak, buttonbush, willow, sedge, rushes, grasses, and miner's lettuce. Riparian woodlands along the montane riparian habitat support breeding, foraging, and roosting habitat for tree swallow, bushtit, White-Breasted Nuthatch, Nuttall's Woodpecker, Downy Woodpecker, Spotted Towhee, and Song Sparrow; cover for amphibians, including Western Toad and Pacific Chorus Frog; and habitat for deer mouse, raccoon, and Virginia Opossum. The riverine habitat supports amphibians and reptiles, including Western Toad, Pacific Chorus Frog, bullfrog, and Western Pond Turtle; birds, including mallard, Great Blue Heron, Osprey, and Belted Kingfisher; and mammals, including river otter, beaver, Big Brown Bat, and Yuma Myotis (bat).

The lands upslope of the Trinity River are characterized by mixed chaparral, montane hardwood-conifer, blue oak-foothill pine, foothill pine, and Klamath mixed conifer (NCRWQCB et al. 2009, 2013). The trees include Pacific madrone, bigleaf maple, canyon live oak, black oak, blue oak, ponderosa pine, Douglas fir, and incense cedar. Shrubs include greenleaf manzanita, buckbrush, cascara, snowberry, and poison oak. Underlying herbaceous vegetation includes ripgut brome, blue wild rye, silver bush lupine, purple sanicle, false hedge-parsley, The habitats support numerous birds, including Northern Flicker, Stellar's Jay, Hairy Woodpecker, Acorn Woodpecker, Wrentit, Bewick's Wren, California Quail, Mountain Quail, Blue Grouse, Sharp-Shinned Hawk, Red-Tailed Hawk, and Great Horned Owl; mammals including Black-Tailed Deer, Gray Fox, coyote, Black-Tailed Jackrabbit, Raccoon, Virginia Opossum, Spotted Skunk, Gray Squirrel, Allen's Chipmunk, Deer Mouse, and Pallid Bat; and reptiles and amphibians, including California Kingsnake, Western Rattlesnake, Sharp-Tailed Snake, Western Fence Lizard, Southern Alligator Lizard, and Ensatina.

Inundation of lands by Trinity Lake, Lewiston Reservoir, and Whiskeytown Lake inundated approximately 20,500 acres of habitat for an estimated 8,500 black-tailed deer (USFWS 1975). The CDFW established a deer herd management plan for the Critical Winter Range for the Weaverville deer herd. A portion of the winter range is located along the Trinity River (NCRWQCB et al. 2009).

#### *10.3.2.3 Lower Klamath River Watershed from Trinity River to the Pacific Ocean*

The Klamath River from the confluence with the Trinity River to the Pacific Ocean is characterized by a forested river canyon with riparian vegetation occurring along the channel. There is a greater diversity of riparian vegetation along the lower Klamath River below the mouth of the Trinity River, partly as a result of a more natural hydrograph on the Klamath River than exists on the Trinity River. Plant species composition changes as the Klamath River nears the Pacific Ocean; because the river slows, temperatures increase, and the tides affect salinity.

Grazing, timber harvest, and roads have degraded riparian conditions along the lower Klamath River (Yurok Tribe 2000). Riparian areas are dominated by deciduous trees including red alder. Red alder is a typical hardwood in riparian zones, tanoak is a typical hardwood on mid to upper slopes, and Pacific madrone occurs in small stands on drier sites (Green Diamond Resource Company 2006).

The broad lower Klamath River meanders within the floodplain and supports wetland habitats similar to those that existed pre-dam along the Trinity River. Wetland habitats along the lower Klamath River are dominated by cattails, tules, and a variety of rushes and sedges. As the river nears the ocean, salt-tolerant plants such as cord grass and pickleweed increase in abundance as the salinity increases (USFWS et al. 1999). Wildlife species in the lower Klamath River watershed are similar to those found in the Trinity River watershed.

### 10.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

The Central Valley Region includes portions of the Sacramento Valley and San Joaquin Valley; including the Delta, Suisun Marsh, and the Yolo Bypass. The areas where terrestrial biological resources could potentially be affected include the fluctuation zones associated with reservoirs; river margins influenced by the magnitude, duration, and frequency of flows; and agricultural lands and refuges served by CVP and SWP water supplies.

The Central Valley Region is predominantly made up of lowlands and plains surrounded by foothills and tall mountains of the Coast Ranges to the west, the Cascade Range to the north, the Sierra Nevada Mountains to the east, and the Tehachapi Mountains to the south. Communities of various sizes and an extensive network of roadways are located throughout the valley.

Land use within the Sacramento Valley and San Joaquin Valley is dominated by agriculture and urban development. Grassland and oak woodland habitats occur in the foothills, particularly in the mid-elevation eastern margin of the Sacramento and San Joaquin valleys. Coniferous forests, mixed hardwood/coniferous forests, and oak woodlands generally represent the dominant vegetation surrounding CVP and SWP reservoirs. Riparian vegetation is generally constrained to narrow ribbons immediately adjacent to creeks and rivers. Many of the wetlands and riparian areas that once occurred in the Central Valley have been eliminated as a consequence of land use conversion to agriculture and urbanization.

#### *10.3.3.1 Overview of Terrestrial Communities*

This section describes the terrestrial communities in the Central Valley Region that could be affected directly or indirectly by operations of the CVP and SWP. These communities are broadly described for lakes/reservoirs (including open water and drawdown areas); rivers (including open water and riparian and floodplain areas); wetlands; and agricultural lands that could be affected by changes in water deliveries and ecosystem restoration activities. Other communities are described for areas that could be affected by restoration activities related to the proposed action and alternatives.

##### 10.3.3.1.1 Lake/Reservoir Communities

Reservoirs that store CVP and SWP water supplies provide habitat used by some terrestrial species, either within the open water area of the reservoirs or along the margins and in the drawdown areas.

*Open Water Areas*

As described in Chapter 5, Surface Water Resources and Water Supplies, water surface elevations in reservoirs that store CVP and SWP water supplies change seasonally and annually due to hydrologic and operational variables. The open water areas of these reservoirs are used as foraging and resting sites by waterfowl and other birds, and by semi-aquatic mammals such as river otter and beaver. Bald Eagles and Ospreys nest in forests at the margins of these reservoirs, and frequently use the reservoirs to forage for fish.

*Margin and Drawdown Areas*

The CVP and SWP reservoirs in the Central Valley are generally located in canyons where the surrounding slopes are dominated by upland vegetation such as woodland, forest, and chaparral. The water surface elevations in these reservoirs fluctuate within the inundation area, as described in Chapter 5, Surface Water Resources and Water Supplies, between maximum allowed storage elevations and minimum elevations defined by the lowest elevation on the intake structure. Along the water surface edge of the inundation area, the soils are usually shallow. Soil is frequently lost to wave action and periodic inundation, followed by severe desiccation when the water elevation declines, which generally results in a barren drawdown zone around the perimeter of the reservoirs. Natural regeneration of vegetation within the drawdown zone is generally prevented by the timing of seed release when reservoir levels are high in the spring, lack of sediment replenishment necessary for seedling establishment in the spring, and high temperatures combined with low soil moisture levels of exposed soils in the summer.

Lack of vegetative cover within the drawdown zone can limit wildlife use of this area. Rapidly rising reservoir levels can potentially result in direct mortality of some sedentary wildlife species or life stages within the drawdown zone of reservoirs. As reservoir levels drop, energy expenditures can increase for piscivorous (fish-eating) birds foraging in the reservoirs as these species must travel greater distances to forage (DWR 2004a).

#### 10.3.3.1.2 Riverine Communities

The rivers and streams influenced by the long-term coordinated operation of the CVP and SWP support habitats for plants and wildlife. The primary components of the riverine environment that support plants and wildlife, including open water areas and adjacent riparian and floodplain communities (including bypasses that are inundated at high flows), are described below.

*Open Water Areas*

The riverine environment downstream of reservoirs is managed generally for water supply and flood control purposes. As such, the extent of open water in the rivers varies somewhat predictably, although not substantially, within and among years. In the wetter years when bypasses and floodplains are inundated, vast areas of open water become available during the flood season, generally in the late winter and early spring. Open water portions of riverine systems provide foraging habitat for fish eating birds and waterfowl. Gull, Tern, Osprey, and Bald Eagle forage over open water. Near shore and shoreline areas provide foraging habitat for birds such as waterfowl, heron, egret, shorebirds, and belted kingfisher. Many species of insectivorous birds such as swallows, swifts, and flycatchers forage over open water areas of lakes and streams. Mammals known to associate with open water and shoreline habitats include river otter, American mink, muskrat, and beaver.

*Riparian and Floodplain Areas*

The riparian and floodplain communities that could be affected by CVP and SWP operations refers primarily to the vegetation and associated wildlife community supported and influenced by proximity to the waterway, including areas frequently flooded by rising water levels in the rivers (floodplains). The extent of riparian vegetation within the Central Valley has been reduced over time due to a variety of actions, including local, state, and Federal construction and operation of flood control facilities isolated historic floodplains; agricultural and land use development that occurred following development of flood control projects; regulation of flows from dams that has reduced the magnitude and frequency of larger flow events, increased recession rates, and increased summertime flows; and construction and maintenance of active ship channels by the U.S. Army Corps of Engineers (USACE) (DWR 2012). Currently, levee and bank protection structures associated with the flood protection system are present along more than 2,600 miles of rivers in the Central Valley, including the Delta (DWR 2009a).

Characteristic riparian tree species in the Central Valley include willows, cottonwoods, California sycamore, and valley oaks. Typical understory plants include elderberry, blackberries, and poison oak. On the valley floor in the deep alluvial soils, the structure and species composition of the plant communities change with distance from the river, with the denser stands of willow and cottonwood at the water's edge transitioning into stands of valley oaks on the less frequently inundated terraces. In other areas, the riparian zone does not support a canopy of large trees and instead is dominated by shrub species (sometime referred to as riparian scrub).

Riparian and floodplain vegetation supports wildlife habitats because of its high floristic and structural diversity, high biomass and high food abundance, and proximity to water. In addition to providing breeding, foraging, and roosting habitat for an array of animals, riparian and floodplain vegetation also provides movement corridors for some species, connecting a variety of habitats throughout the region. The Sacramento and San Joaquin valleys lack substantial areas of natural habitat that support native biodiversity or corridors between the areas of natural habitat; therefore, riparian and floodplain corridors play a critical role in connecting wildlife among the few remaining natural areas (CalTrans and DFG 2010).

Typical wildlife species associated with the riparian and floodplain communities include mammals such as striped skunk, raccoon, and gray fox. Riparian bird species include Red-Shouldered Hawk, Wood Duck, Great Blue Heron, Black-Crowned Night Heron, and many neotropical migratory birds, including Yellow Warbler and Western Yellow-Billed Cuckoo. Amphibians and reptiles include Pacific Tree Frog, Pacific Gopher Snake, Garter Snake, and Western Pond Turtle. Special status species that associate with riparian and floodplain habitats include Bank Swallow (state listed), Western Yellow-Billed Cuckoo (Federally and state listed), and the Valley Elderberry Longhorn Beetle (Federally listed).

River flows and associated hydrologic and geomorphic processes are important for maintaining riparian and floodplain ecosystems. Most aspects of a flow regime (e.g., the magnitude, frequency, timing, duration, and sediment load) affect a variety of riparian and floodplain habitat processes. Two processes that create riparian and floodplain ecosystems are disturbance and plant recruitment. The interaction of these processes across the landscape is primarily responsible for the pattern and distribution of riparian and floodplain habitat structure and condition, and for the composition and abundance of riparian-associated species.

High flow events and associated scour, deposition, and prolonged inundation can create exposed substrate for plant establishment or openings in existing riparian and floodplain communities. Early successional species, like cottonwoods and willows that recruit into these openings, become more abundant in the landscape as vegetation grows within disturbed areas. As a result, structural and species diversity within riparian and floodplain vegetation could increase, as could overall wildlife habitat values. Without disturbance, larger trees and species less tolerant of frequent disturbance begin to dominate riparian woodlands.

The recruitment of cottonwoods and willows especially depends on geomorphic processes that create bare mineral soil through erosion and deposition of sediment along river channels and on floodplains, and on flow events that result in floodplain inundation. Receding flood flows that expose moist mineral soil create ideal conditions for germination of cottonwood and willow seedlings. After germination occurs, the water surface must decline gradually to enable seedling establishment. Riparian and floodplain communities also undergo natural disturbance cycles when flood flows remove streamside vegetation and redistribute sediments and seeds, thereby maintaining habitat diversity for terrestrial species that associate with riparian and floodplain corridors.

Both prolonged drought and prolonged inundation, however, can lead to plant death and loss of riparian plants (Kozlowski and Pallardy 2002). Riparian plants have high moisture requirements during the active growing season (spring through fall), and dry soil conditions can reduce growth and injure or kill plants. On the other hand, prolonged inundation creates anaerobic conditions that, during the active growing season, also can reduce growth, injure, or kill plants.

The continuation of riparian and floodplain communities is anticipated to change along levees within the federally authorized levee systems that have maintenance agreements with the USACE (including Delta levees along the Sacramento and San Joaquin rivers) and other levees that are eligible for the federal Rehabilitation and Inspection Program (Public Law 84-99). As described in Section 3.3.2.2 of Chapter 3, Description of Alternatives, the vegetation management policies of the USACE were changed in 2009 and 2010. Historically, the USACE allowed brush and small trees to be located on the waterside of federal flood management project levees if the vegetation would preserve, protect, and/or enhance natural resources, and/or protect rights of Native Americans, while maintaining the safety, structural integrity, and functionality of the levee (DWR 2011). After Hurricane Katrina in 2005, the USACE issued a policy and draft policy guidance to remove substantial vegetation from these levees throughout the nation (USACE 2009). In 2010, the USACE issued a draft policy guidance letter, *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls—75 Federal Register 6364-68* (USACE 2010) that included procedures for State and local agencies to request variances on a site-specific basis. DWR has been in negotiations with USACE to remove vegetation on the upper third of the waterside slope, top, and landside of the levees, and continue to allow vegetation on the lower two-thirds of the waterside slope of the levee and along benches above the water surface (DSC 2011). The effects of these changes have not become widespread at this time. Future conditions under these requirements are further described under the description of the No Action

Alternative in this chapter (see Section 10.4.2.1.3, Changes in River and Delta Floodplains).

#### 10.3.3.1.3 Wetlands, Marshes, and Wet Meadows

Wetlands in the Central Valley can be characterized as perennial or seasonal with perennial wetlands further classified as tidal or non-tidal. Natural, non-tidal perennial wetlands are scattered along the Sacramento and San Joaquin rivers, typically in areas with slow moving backwaters. Management of wetlands, marshes, and wet meadows can include irrigation of open areas to support native herbaceous plants or cultivated species; periodic or continuous flooding to provide feeding and roosting sites for many wetland-associated birds; and either limited or no tilling or disturbance of the managed areas.

Managed seasonal wetlands on the west side of the Sacramento River generally occur between Willows and Dunnigan along the Colusa Basin Drain. Substantial portions of these managed wetland habitats occur at the flood bypasses, including the Yolo Bypass Wildlife Area and Fremont Weir, as a part of the Sacramento National Wildlife Refuge Complex, and around the Thermalito Afterbay (Reclamation 2010a). Both tidal and nontidal, perennial wetlands are found in the Delta and Suisun Marsh.

*Perennial Non-tidal (Freshwater) Wetlands and Marshes*

In the Sacramento and San Joaquin valleys and foothills, perennial non-tidal wetland habitats include freshwater emergent wetlands and wet meadows. Freshwater emergent wetlands, or marshes, are dominated by large, perennial herbaceous plants, particularly tules and cattails, which are generally restricted to shallow water. In marshes, vegetation structure and the number of species are strongly influenced by disturbance, changes in water levels, and the range of elevations present at a site. Wet meadows are similar to perennial freshwater wetlands in many regards; however, they are dominated by a greater variety of perennial plants such as rushes, sedges, and grasses than are found in freshwater wetlands. Perennial freshwater wetlands also provide ecological functions related to water quality and hydrology. These areas generally qualify as jurisdictional wetlands subject to U.S. Army Corps of Engineers jurisdiction under Sections 401 and 404 of the federal Clean Water Act.

Perennial freshwater wetlands are among the most productive wildlife habitat in California (CDFW 1988a). In the Sacramento and San Joaquin valleys and foothills, these wetlands support several sensitive amphibians, reptiles, birds, and mammals. Perennial freshwater wetlands also provide food, cover, and water for numerous species of wildlife. Wetlands in the Sacramento and San Joaquin valleys and foothills are especially important to migratory birds and wintering waterfowl.

*Seasonal Wetlands*

Natural seasonal wetlands occur in topographic depressions and swales that are seasonally saturated and exhibit hydric soils that support hydrophytic plant species. Natural seasonal wetlands are generally dominated by hydrophytic plants during the winter and spring months. Characteristic plant species in seasonal wetlands consist of both native and nonnative species. Native species include coyote thistle, toad rush, hyssop loosestrife, and foothill meadowfoam. Natural seasonal wetlands provide food, cover, and water for numerous common and special status species of wildlife that rely on wetlands for all or part of their life cycle. Like perennial wetlands, seasonal wetlands have been substantially reduced from their historical extent.

Numerous managed seasonal wetlands occur within the Sacramento Colusa, Sutter, Tisdale, and Yolo Bypasses and around the Thermalito Afterbay (Reclamation 2010a).

Managed marsh areas are intentionally flooded and managed during specific seasonal periods to enhance habitat values for specific wildlife species (CALFED 2000). Managed marsh areas are distributed largely in the northern, central, and western portions of the Delta, as well as in Suisun Marsh and the Yolo Bypass, Stone Lakes National Wildlife Refuge, Cosumnes River Preserve, and Suisun Marsh.

*Perennial Tidal Wetlands and Open Water*

In the Central Valley, tidal wetlands and open water are primarily found in the Delta and Suisun Marsh. Tidal wetlands are influenced by tidal movement of salt water from San Francisco Bay and inflow of freshwater from the Delta and smaller local watersheds. Tidal open water in the Delta is mainly freshwater habitat, with brackish and saline conditions occurring in the western Delta at times of high tides and low flows into the western Delta. It is freshwater in the Yolo Bypass and mainly brackish and saline in Suisun Marsh. Tidal mudflats occur as mostly unvegetated sediment deposits in the intertidal zone between the tidal wetland communities at its upper edge and the tidal perennial aquatic community at its lower edge. Tidal brackish wetlands exist from near Collinsville westward to the Carquinez Strait. Suisun Marsh is the largest contiguous brackish water marsh remaining on the North America west coast (Reclamation et al. 2011). Tidal freshwater marshes occur at the shallow, slow-moving or stagnant edges of freshwater waterways in the intertidal zone and are subject to frequent long duration flooding.

Salinity levels vary throughout the year and are influenced largely by inflow from the Delta (Reclamation et al. 2011). Tidal water in the Delta is mainly freshwater, with brackish and saline conditions occurring in the western Delta at times of high tides and low flows into the western Delta. Tidal marshes associated with the lower Yolo Bypass are freshwater, whereas they are mainly brackish and saline in Suisun Marsh where tidal brackish marshes exist from near Collinsville westward to the Carquinez Strait.

#### 10.3.3.1.4 Agricultural Lands

Agricultural land uses and farming practices in the Central Valley provide habitats and resources for a variety of terrestrial species, including several Federal and state special status species. Agricultural lands are primarily found within the

Sacramento and San Joaquin valleys on the rich alluvial soils of the riverine floodplains. The distribution of seasonal crops varies annually and seasonally, depending on market forces and crop-rotation patterns. Some of the principal crop types and their value to wildlife are described below.

Crops in the Sacramento and San Joaquin valleys include grain and seed crops (e.g., barley and wheat), forage crops (e.g., hay and alfalfa), row crops (e.g., tomatoes, lettuce, sugar beets), cotton, orchards (e.g., almonds, walnuts, peaches, plums), and vineyards. There are also areas of irrigated pastureland throughout the Sacramento and San Joaquin valleys.

Grain and seed crops include wheat, barley, corn, and other annual grasses that are grown in dense stands. Most of the value for wildlife occurs during the early growing period because the later dense growth makes it difficult for wildlife to move through these fields. Following harvesting, waste grain is available to waterfowl and other birds, such as sandhill crane. Row crop and silage fields generally provide lesser value to wildlife than native cover types, but can support abundant populations of small mammals, such as California vole and western harvest mouse. These species attract predators such as snakes and raptors. Other reptile and bird species prey on the abundant insect populations found in row crop and silage fields.

Species generally associated with field and row crops include the Red-Winged Blackbird, Western Meadowlark, California Vole, Black-Tailed Jackrabbit, Western Harvest Mouse, Botta’s Pocket Gopher, Raccoon, Striped Skunk, and Virginia Opossum. Croplands also provide foraging habitat for many raptors including Swainson’s Hawk, Northern Harrier, Red-Tailed Hawk, and White-Tailed Kite.

Alfalfa is irrigated and intensively mowed such that vegetation structure varies with the growing, harvesting, and fallowing cycle. As a result, alfalfa supports some of the highest biodiversity amongst crops in California, second only to rice in agricultural habitat biodiversity (Hartman and Kyle 2010), with many species using alfalfa to forage, nest, rest, and hide. A wide range of species, including songbirds, swallows, bats, and many types of waterfowl and migratory birds feed on insects in alfalfa fields. Mammals such as gophers, mice, and rabbits feed directly on alfalfa. Larger herbivorous mammals, such as deer, antelope, and elk, frequent alfalfa fields, especially during dry or cold seasons. Hawks, eagles, migratory birds, coyotes, and mountain lions feed on the birds and rodents that feed on the alfalfa. Scavengers such as coyotes and vultures feed on carrion (Putnam et al. 2001).

Rice cultivation is also widespread in the Sacramento Valley. Rice fields provide surrogate wetland habitats and many wetland wildlife species use rice fields, especially waterfowl and shorebirds, and wading birds that forage on aquatic invertebrates and vertebrates such as crayfish and small fish. Foraging opportunities are provided by fish that become entrained in the irrigation canals that supply water to the rice fields and the crayfish that are found along canal banks and berms of the rice fields. Other wildlife species that use flooded rice fields include Giant Garter Snake and bullfrog. Ring-necked pheasant and Sandhill Cranes among others forage on post-harvest waste grain. The practice of flooding rice fields in winter to allow for decomposition of rice stubble, as opposed to burning, enhances the wildlife value of rice fields. Winter flooding provides loafing and foraging opportunities for a variety of birds, including waterfowl, cranes, herons, and egrets.

Orchards and vineyards, typically dominated by a single tree species, are grown in fertile areas that once supported diverse and productive habitats for wildlife. Orchards and vineyards generally provide relatively low wildlife value; however, some species of birds and mammals have adapted to orchard and vineyard habitats. Many have become "agricultural pests" which result in crop losses. Deer and rabbits browse on the trees while other wildlife such as squirrels and numerous birds feed on fruit or nuts. Cover crops grown under the trees provide a food source for wildlife that feed on seeds or herbaceous vegetation. Wildlife species reported to feed on nuts (almonds and walnuts) include Northern Flicker, Western Scrub-Jay, American Crow, Plain Titmouse, Brewer's Blackbird, House Finch, Gray Squirrel and California Ground Squirrel (DFG 1999a, 1999b, 1999c). Other fruit crops such as apples, cherries, figs, pears and prunes are also eaten by these same species and others such as Band-Tailed Pigeon, Yellow-Billed Magpie, Western Bluebird, American Robin, Varied Thrush, Northern Mockingbird, Cedar Waxwing, Yellow-Rumped Warbler, Black-Headed Grosbeak, Bullock's Oriole, Desert Cottontail, Gray Squirrel, coyote, black bear, raccoon, and Mule Deer. Evergreen orchards (citrus, olives, avocado) do not provide the food for wildlife that many of the deciduous fruit and nut trees provide. Mourning Dove and California Quail use orchard habitats for cover and nesting sites. Carnivores such as fox, bobcat, and coyote frequently use avocado orchards (Nogeire et al. 2013). Irrigated pastures are managed grasslands with a low structure of native herbaceous plants, cultivated species, or a mixture of both. Pastures are not typically tilled or disturbed frequently and provide breeding opportunities for ground-nesting birds, including waterfowl, Ring-Necked Pheasant, and Sandhill Crane if adequate residual vegetation is present. Flood irrigation of pastures provides feeding and roosting sites for many wetland-associated birds, including shorebirds, wading birds, gulls, waterfowl, and raptors. Large mammals such as deer, and elk graze in pastures when there is adequate escape cover adjacent to the open pasture. Burrowing species using irrigated pastures include California Ground Squirrel, Pocket Gophers, and Burrowing Owls. Pastures provide foraging habitat for grassland-foraging wildlife, such as coyote and fox, and raptors like the Northern Harrier, American Kestrel, and Red-Tailed Hawk.

In addition to the crop lands, the network of irrigation canals, drains, and reservoirs that convey water in the agricultural areas provide habitat for many species of wildlife, including species with special status. These conveyance features, particularly those that contain water throughout the growing season, typically support some of the plants and animals characteristic of riverine systems and riparian areas. While water flows through many of these facilities intermittently, these features can provide habitat for species, such as Giant Garter

Snake. Giant Garter Snake is frequently associated with the water conveyance systems that support rice cultivation.

#### 10.3.3.1.5 Invasive Species

Invasive plants and wildlife are species that are not native to the region, persist without human assistance, and have serious impacts on the environment. They are termed "invasive" because they displace native species and alter habitat functions and values. Many invasive plant species are considered "noxious weeds" by governmental agencies such as the U.S. Department of Agriculture and California Department of Food and Agriculture. Numerous invasive plants have been introduced into the study area, and many have become established. The California Invasive Plant Council maintains a list of species that have been designated as invasive in California (CalIPC 2006).

According to the California Department of Fish and Wildlife's aquatic invasive species management plan (DFG 2008), invasive species threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Unlike the native riparian flora, many invasive riparian species do not provide the food, shelter, and other habitat components on which many native fish and wildlife species depend. In addition to the ability to degrade wildlife habitat, many of these invasive trees and shrubs have the potential to harm human health and the economy by adversely affecting the ecosystem, flood protection systems, water delivery, recreation, and agriculture.

Changes in CVP and SWP operations would affect the wetted edges at CVP and SWP reservoirs, reservoirs that store CVP and SWP water supplies, and along the rivers downstream of the CVP and SWP reservoirs. Therefore, only those invasive plant species that are associated with the margins at these waterways would be likely to cause adverse effects on terrestrial biological resources. Examples of these species include tree-of-heaven, giant reed, purple loosestrife, perennial pepperweed, tamarisk, and red sesbania. In addition to the potential effects caused by changed water operations, invasive species have the potential to be introduced as part of construction of habitat restoration, or to colonize areas disturbed by restoration construction activities (e.g., yellow star thistle, perennial pepperweed, Spanish broom, Himalaya blackberry).

### *10.3.3.2 Sacramento Valley*

The Sacramento Valley portion of the Central Valley Region considered in this EIS includes Shasta Lake, Keswick Reservoir, and the Sacramento River from Keswick Reservoir to the Delta. The Sacramento Valley also includes the lower Yuba River and the middle and lower portions of the Feather River and American River watersheds that are influenced by CVP and SWP operations, respectively.

Historically, the Sacramento Valley contained a mosaic of riverine, wetland, and riparian communities with terrestrial habitats consisting of perennial grassland and oak woodlands. With development of the Sacramento Valley, native habitats were converted to cultivated fields, pastures, residences, water impoundments, and flood-control structures. As a result, native habitats generally are restricted in their distribution and size and are highly fragmented.

A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved a habitat conservation plan for the Natomas Basin/Metropolitan Air Park near Sacramento. Six other habitat conservation plans are being prepared in the Sacramento Valley, including programs for Butte County, Yuba-Sutter counties, Placer County, Yolo County, South Sacramento County, and Solano County.

#### 10.3.3.2.1 Shasta Lake and Keswick Reservoir

The area in which Shasta Lake is situated is characterized by a variety of vegetation and wildlife habitats typical of transitional mixed woodland and low-elevation forest habitats (Reclamation 2013a). The majority of vegetation communities and wildlife habitats around Shasta Lake are tree-dominated, and include upland forests with associated mixed chaparral, riparian forests, and woodlands. Other wildlife habitats around the lake include annual grasslands and barren areas. Montane riparian, the dominant riparian vegetation type at and near Shasta Lake, also occurs as thin stringers and patches along most stream corridors tributary to Shasta Lake.

Wildlife species around Shasta Lake are those typically associated with tree-dominated habitats and chaparral (Reclamation 2013a). Mammals in these habitats include deer, rabbits, chipmunks, and squirrels. Mature trees provide nesting habitat for raptors such as the bald eagle and osprey. Hollow trees and logs provide denning sites for mammals such as the coyote and skunks, and cavities in mature trees are used by cavity-dwelling species such as the Acorn Woodpecker and California Myotis. Many amphibians and reptiles, including Ensatina, Western Skink, and Western Fence Lizard, inhabit the detrital layer of moist areas. Snakes, including the Western Rattlesnake and Sharp-Tailed Snake, also are found in these habitats.

Recently, 38 pairs of mating Bald Eagles were observed at Shasta Lake (USFS 2012).

Terrestrial resources around Keswick Reservoir are similar to those found at lower elevations around Shasta Lake. Otters, Gray Fox, coyote, bobcat, Osprey, and turtles occur along the Keswick Reservoir reach of the Sacramento River (BLM 2006). Historically, vegetation in this area of the watershed was harvested to provide fuel for mining smelters. Chaparral habitat, dominated by manzanita with intermittent oak, pine, and fir trees occur on the foothills above the reservoir. As described in Chapter 5, Surface Water Resources and Water Supplies, water elevations in Keswick Reservoir are relatively stable throughout the year.

#### 10.3.3.2.2 Whiskeytown Lake and Clear Creek

Riparian communities within the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area, which includes Whiskeytown Reservoir, include the following species: grey pine, willow, white alder, dogwoods, Oregon ash, bigleaf maple, and Fremont and black cottonwood. Wild grape is also very common; other riparian shrubs include snowberry, California blackberry, toyon, buckeye, and button willow. Flowering herbaceous plants, cattails, sedges, rushes, and ferns make up the riparian understory. The riparian habitats are generally vigorous and well-vegetated, especially in the most favorable locations, such as canyons and stream bottoms (NPS 1999).

Riparian vegetation is limited to a narrow band along the channel margins in the confined canyon reaches of Clear Creek between Whiskeytown Dam and Clear Creek Bridge, where the alluvial section of the creek begins. Downstream of Clear Creek Bridge, where the valley widens, the channel becomes predominately alluvial, and floodplains and terraces allow riparian vegetation to be more extensive (CBDA 2004).

Fresh emergent wetlands occur throughout the entire reach of lower Clear Creek from Whiskeytown Dam to the Sacramento River. These wetlands are more prominent in the reach below Clear Creek Road Bridge where soils are deeper and the valley becomes wider and is subject to periodic flooding. Valley-foothill riparian is found primarily in the lower reaches of lower Clear Creek from Clear Creek Road Bridge to the Sacramento River. In addition, smaller linear patches occur scattered throughout the system up to Whiskeytown Dam (BLM and NPS 2008).

Due to the diversity of habitats present within the watershed, the areas adjacent to Whiskeytown Lake and lower Clear Creek support a diverse assemblage of wildlife species. More than 200 vertebrate species are known to occur within the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area, including at least 35 mammal species, 150 bird species, and 25 reptile and amphibian species (NPS 2014).

#### 10.3.3.2.3 Sacramento River: Keswick Reservoir to the Delta

Release of flows from Shasta Dam changed the pre-dam flow patterns from high flows in the mid-spring during snow melt to high flows in the summer months, as described in Chapter 5, Surface Water Resources and Water Supplies. Consequently, in most years, the current flow regime precludes or substantially reduces opportunities for establishment of cottonwoods and willows; and the structure and composition of riparian vegetation has undergone change (Roberts et al. 2002). The extent of early-successional riparian communities (e.g., cottonwood forest) has been decreasing, while the extent of mid-successional communities (e.g., mixed riparian forest) has been increasing. Generally, these effects diminish with distance downstream because of the influence of inflows from tributaries, diversions, and flood bypasses (Reclamation 2013a).

Much of the Sacramento River from Shasta Dam to Redding is deeply entrenched in bedrock, which precludes development of extensive areas of riparian vegetation (Reclamation 2013a). The upper banks along these steep-sided, bedrock-constrained segments of the upper Sacramento River are characterized primarily by upland communities, including woodlands and chaparral. Outside the river corridor, other vegetation communities along the upper Sacramento River include riparian scrub, annual grassland, and agricultural lands.

The river corridor between Redding and Red Bluff once supported extensive areas of riparian vegetation (Reclamation 2013a). Agricultural and residential development has permanently removed much of the native and natural habitat. Riparian vegetation now occupies only a small portion of floodplains. Willow and blackberry scrub and cottonwood- and willow-dominated riparian communities are still present along active channels and on the lower flood terraces, whereas valley oak–dominated communities occur on higher flood terraces. Although riparian woodlands along the upper Sacramento River typically occur in narrow or discontinuous patches, they provide value for wildlife and support both common and special status species of birds, mammals, reptiles, amphibians, and invertebrates.

Portions of the adjacent land along the Sacramento River from Red Bluff to Hamilton City include substantial remnants of the pre-European Sacramento Valley historical riparian forest (Reclamation 2013a). Along the Sacramento River below Red Bluff, riparian vegetation is characterized by narrow linear stands of trees and shrubs, in single- to multiple-story canopies. These patches of riparian vegetation may be on or at the toe of levees. Riparian communities in this region include woodlands and riparian scrub.

From Red Bluff to Colusa, the Sacramento River contains point bars, islands, high and low terraces, instream woody cover, and early-successional riparian plant growth, reflecting river meander and erosional processes (Reclamation 2013a). Major physiographic features include floodplains, basins, terraces, active and remnant channels, and oxbow sloughs. These features sustain a diverse riparian community and support a wide range of wildlife species including raptors, waterfowl, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats.

Downstream of Colusa, the Sacramento River channel changes from a dynamic and active meandering one to a confined, narrow channel (Reclamation 2013a). Surrounding agricultural lands encroach directly adjacent to the levees, which have cut the river off from most of its riparian corridor, especially on the eastern side of the river. Most of the levees in this reach are lined with riprap, allowing the river no erodible substrate and limiting the extent of riparian vegetation and riparian wildlife habitat.

#### 10.3.3.2.4 Feather River

Antelope Lake, Lake Davis, and Frenchman Lake located in the Upper Feather River; Lake Oroville and Thermalito Forebay and Afterbay; and the lower Feather River are located within areas in the Feather River watershed that could be affected by changes in CVP and/or SWP operations. Downstream of Lake Oroville, the basin extends south and includes the drainage of the Yuba and Bear Rivers.

*Upper Feather River Lakes*

The Upper Feather River Lakes, including Antelope Lake, Lake Davis, and Frenchman Lake, are SWP facilities on the upper Feather River upstream of Lake Oroville. These lakes are part of the Plumas National Forest and provide habitat for raptor nesting and wintering areas, waterfowl nesting area, and deer movement area (DWR 2013a; Plumas County 2012). Deer movement and fawning areas also occur around Lake Davis.

*Lake Oroville and Thermalito Complex*

Lake Oroville is situated in the foothills on the western slope of the Sierra Nevada Mountains, about a mile downstream of the confluence of its major tributaries. Below the dam, a portion of the river flow is diverted at the Thermalito Diversion Dam and routed to the Thermalito Forebay, which is an offstream reservoir with a surface area up to 630 acres (DWR 2007a, 2007b). Downstream of the forebay, water is stored in Thermalito Afterbay (up to 4,300 surface acres), which among other purposes serves as a warming basin for agricultural water.

The majority of vegetation around Lake Oroville consists of a variety of native vegetation associations, including mixed oak woodlands, foothill pine/mixed oak woodlands, and oak/pine woodlands with a mosaic of chaparral (DWR 2004a, 2007a). Open areas within the woodlands consist of annual grassland species. Native riparian habitats are restricted to narrow strips along tributaries, consisting mostly of alder, willow, and occasional cottonwood and sycamore. There is minimum wetland vegetation around Lake Oroville, and most is associated with seeps and springs that are a natural part of the landscape above the high water line. Emergent wetlands are generally absent within the drawdown zone of Lake Oroville.

Lack of vegetative cover within the drawdown zone severely limits wildlife use of this area. Thirty-six wildlife species were detected using habitats within the drawdown zone on at least one occasion during field surveys (DWR 2004a). Several of these species may use habitats within the drawdown zone for reproduction including Belted Kingfisher, Canada Goose, Canyon Wren, American Dipper, killdeer, mallard, Common Merganser, and Northern Rough-Winged Swallow.

Riparian vegetation occurs around the north shore of Thermalito Forebay as a thin strip of mixed riparian species (mostly willows), with an understory of emergent wetland vegetation. Cottonwoods and willows occur in scattered areas around the high water surface elevation of Thermalito Afterbay shoreline (FERC 2007). Emergent wetlands ranging from thin strips to more extensive areas are found around Thermalito Forebay and Thermalito Afterbay. Waterfowl brood ponds constructed in inlets of Thermalito Afterbay support emergent vegetation along much of their shores.

Species observed within the wetland margin of Thermalito Afterbay include Barn Swallow, Black Phoebe, White-Tailed Kite, Black-Tailed Jackrabbit, Brown-Headed Cowbird, bullfrog, Common Garter Snake, Common Yellowthroat, Gopher Snake, Northern Harrier, Pacific tree Frog, raccoon, red-Winged Blackbird, Ring-Necked Pheasant, Short-Eared Owl, Striped Skunk, Tree Swallow, Virginia Opossum, and Violet-Green Swallow (DWR 2004a).

In contrast to the drawdown area around the margin of Lake Oroville, the drawdown zone of Thermalito Afterbay supports a richer wildlife community and greater habitat diversity. Survey data collected as part of the relicensing process indicate that exposed mudflats seasonally provide habitat for a variety of migratory waterbirds including Black-Necked Stilt, Black Tern, California Gull, Caspian Tern, Forster’s Tern, Greater Yellowlegs, Least Sandpiper, Long-Billed Dowitcher, Ring-Billed Gull, Semipalmated Sandpiper, Spotted Sandpiper, and White-Faced Ibis. Wading birds and other waterfowl have been observed on the mudflats as well as shallow flooded areas (DWR 2004a). Potentially suitable Giant Garter Snake habitat is present along portions of the afterbay and forebay margins. The existing waterfowl brood ponds provide a refuge for Giant Garter Snakes during periods of afterbay drawdown.

Several invasive plant species are found around Lake Oroville and downstream in and around the Thermalito Complex. Invasive species associated with riparian and wetland areas include purple loosestrife, giant reed, tree-of-heaven, and red sesbania. About 85 of the roughly 900 acres of wetlands and riparian areas along the margin of Thermalito Afterbay contain varying densities of purple loosestrife (DWR 2007a). Purple loosestrife adversely affects native vegetation.

*Feather River from Oroville Complex to the Sacramento River*

The Feather River from Oroville Dam to the confluence with the Sacramento River supports stands of riparian vegetation, which have been restricted over time by flood control levees and land clearing for agriculture and urbanization. As a consequence, the vegetation generally occurs in a narrow zone along much of the river in this reach. However, remnant riparian forest exist in areas where wide meander bends persist, such as at Abbott Lake and O’Connor Lake near the Lake of the Woods State Recreation Area (DWR 2004b). This area contains mixed riparian forests, including Fremont cottonwood, willow, boxelder, alder, and Oregon ash. The riparian strip along the river is bordered mostly by agricultural fields. Downstream of Yuba City near the confluence with the Sacramento River, valley oak and cottonwood riparian stands becomes more common.

As described above for the Sacramento River, riparian areas provide value for wildlife and support a wide range of species of birds, mammals, reptiles, amphibians, and invertebrates.

#### 10.3.3.2.5 Yuba River

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007b).

New Bullards Bar Dam and Reservoir are owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation. The Harry L. Englebright Dam and Reservoir were constructed by the California Debris Commission downstream of New Bullards Bar Reservoir to trap and store sediment from historical hydraulic mining sites in the upper watershed, and to provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Reservoir (Lake) was assumed by the USACE. Portions of the watershed along the Middle Yuba River between New Bullards Bar Reservoir and Englebright Reservoir are within the Plumas and Tahoe national forests.

Vegetation communities adjacent to New Bullards Bar Reservoir include oak woodlands, mixed conifer, and montane hardwood habitats which include live oak, blue oak, foothill pine, California wild rose, and lupine (DWR et al. 2007). The shoreline is generally barren. Bald Eagles have been observed near New Bullards Bar Reservoir; and California Red-legged Frogs have been reported in a tributary to the reservoir, Oregon Creek.

Vegetation communities at Englebright Reservoir are generally blue oak woodland and montane chaparral with small areas of mixed chaparral and live oak woodland (Yuba County 2011).

Vegetation along the lower Yuba River downstream of Englebright Dam is characterized by a number of vegetation types including grasslands, woodlands, and chaparral (USACE 2014). Within the Narrows, a steep gorge in the Yuba River immediately below Englebright Dam, there is little vegetation; small, isolated clumps of willow, mulefat, and other riparian species are widely scattered along the mostly barren, rocky banks. Downstream of the Narrows, there are extensive piles of cobble and gravel left from past gold and gravel mining operations. Here there are narrow strips of riparian vegetation consisting of Fremont cottonwood, willow, boxelder, and elderberry shrub. As described above for the Sacramento River, these communities support a wide range of similar wildlife species including raptors, waterfowl, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats.

#### 10.3.3.2.6 Bear River

The Bear River flows into the Feather River downstream of the confluence with the Yuba River. As described in Chapter 5, Surface Water Resources and Water Supplies, the Bear River includes Nevada Irrigation District’s Rollins and Combie reservoirs along the upper and middle reaches of the Bear River, and South Sutter Water District’s Camp Far West Reservoir along the lower reach of the Bear River (FERC 2013; NID 2005).

Vegetation communities near the reservoirs and along the Bear River from Rollins Reservoir to the confluence with the Feather River occur in bands based on elevations (FERC 2013; NID 2005). Gray pine, ponderosa pine, hardwoods, and chaparral shrubs occur at the higher elevations with black cottonwood, white alder, and valley oak in the riparian zones. Incense cedar, Douglas fir, white fir, madrone, sugar pine, Brewer’s oak, whiteleaf manzanita, greenleaf manzanita, wedgeleaf ceanothus, deerbrush, and poison oak at mid-elevations with white alders, maple, and willow along the riparian areas.

#### 10.3.3.2.7 American River

The American River watershed encompasses approximately 2,100 square miles (Reclamation et al. 2006). The North, Middle, and South forks of the American River converge upstream of Folsom Lake. Lake Natoma is located downstream of Folsom Lake. Water continues to flow between Nimbus Dam and the confluence with the Sacramento River, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Folsom Lake and Lake Natoma*

Folsom Lake, formed by Folsom Dam, has a surface area of about 11,500 acres, and 75 miles of shoreline (Reclamation 2005a). Lake Natoma, which serves as an afterbay downstream of Folsom Dam, has about 540 acres of surface area.

Vegetation communities associated with Folsom Lake include oak woodland and annual grassland. The oak woodland habitat is located on the upland banks and slopes of the reservoir, and is dominated by live oak, blue oak, and foothill pine with several species of understory shrubs and forbs. Annual grasslands occur around the reservoir, primarily at the southern end.

The oak woodlands and annual grasslands around the reservoir support a variety of birds. A number of raptors, including red-tailed hawk, Cooper’s hawk, great horned owl, and long-eared owl use oak woodlands for nesting, foraging, and roosting. Mammal species likely to occur in woodland habitats include deer, coyote, bobcat, fox, Virginia Opossum, raccoon, rabbits, squirrels, and a variety of rodents. Amphibians and reptiles that may be found in oak woodlands include California Newt, Pacific Tree Frog, Western Fence Lizard, Gopher Snake, Common Kingsnake, and Western Rattlesnake. The adjacent grasslands are used by various bird species for foraging, including White-Crowned Sparrow, Lesser Goldfinch, Western Meadowlark, and several raptor species. Migratory waterfowl also are known to feed and rest in the grasslands associated with the north fork of Folsom Reservoir.

Seasonal wetland communities occur both inside and outside of the area influenced by the reservoir. These communities are exposed to wetland hydrology for a limited period of time and may not meet all criteria for wetlands. Within the reservoir drawdown zone, this seasonal vegetation is frequently inundated and may receive overland flow from upland areas. Outside of the drawdown zone, seasonally wet areas receive water from seeps, drainages, and precipitation (Reclamation et al. 2006). Small areas of permanent freshwater marsh are found at the toe of the Mormon Island Auxiliary Dam. Water birds and other wildlife depend on the freshwater marshes in these areas for foraging and/or rearing habitat. These species include Pacific Tree Frog, Western Toad, Common Garter Snake, beaver, raccoon, and muskrat.

Folsom Lake is surrounded by a relatively barren drawdown zone due to annual fluctuations in water elevations. The majority of this zone is devoid of vegetation, although scattered stands of woody vegetation occur in some areas of the drawdown zone (Reclamation et al. 2006). The only contiguous riparian vegetation occurs along Sweetwater Creek at the southern end of the reservoir.

Between Folsom Dam and Lake Natoma, the river channel is narrower and flanked by steep, rocky cliffs (Reclamation 2005a). The land along the river includes wooded canyon areas, sheer bluffs, and dredge tailings from the gold mining era. Within Lake Natoma, the open water is bordered by narrow bands of riparian woodland. Patches of permanent freshwater marsh exist in shallow coves that are inundated when water rises in Lake Natoma (Reclamation 2005a).

*Lower American River between Lake Natoma and Confluence with the Sacramento River*

Downstream of Lake Natoma, the lower American River flows to the confluence with the Sacramento River. In the upper reaches of the lower American River, the river channel is controlled by natural bluffs and terraces. Levees have been constructed along the northern and southern banks for approximately 13 miles upstream of the confluence with the Sacramento River (Reclamation et al. 2006).

Most of the lower American River is encompassed by the American River Parkway, which preserves what remains of the historic riparian zone (Reclamation et al. 2006). Vegetation communities along the lower American River downstream of Nimbus Dam include freshwater emergent wetland, riparian forest and scrub. Oak woodland and annual grassland are present in the upper, drier areas farther away from the river. The current distribution and structure of riparian communities along the river reflects the human-induced changes caused by activities such as gravel extraction, dam construction and operations, and levee construction and maintenance, as well as by both historical and ongoing streamflow and sediment regimes, and channel dynamics.

In general, willow and alder tend to occupy areas within the active channel of the river that are repeatedly disturbed by river flows, with cottonwood-willow thickets occupying the narrow belts along the active river channel (Reclamation et al. 2006). Typical species in these thickets include Fremont cottonwood, willow, poison oak, wild grape, blackberry, northern California black walnut, and white alder.

Cottonwood forest is found on the steep, moist banks along much of the river corridor (Reclamation et al. 2006). Valley oak woodlands occur on upper terraces where fine sediment and adequate soil moisture provide a long growing season. Live oak woodland occurs on the more arid and gravelly terraces that are isolated from the fluvial dynamics and moisture of the river. Annual grassland occurs in areas that have been disturbed by human activity and can be found in many areas within the river corridor.

The cottonwood-dominated riparian forest and areas associated with backwater and off-river ponds are highest in wildlife diversity and species richness relative to other river corridor habitats (Reclamation et al. 2006). More than 220 species of birds have been recorded along the lower American River and more than 60 species are known to nest in the riparian habitats. Typical species that can be found along the river include Great Blue Heron, Mallard, Red-Tailed Hawk, American Kestrel, California Quail, Killdeer, Belted Kingfisher, Western Scrub-Jay, Swallows, and American Robin. Additionally, more than 30 species of mammals reside along the river, including skunk, rabbit, raccoon, squirrel, vole, muskrat, deer, fox, and coyote. Reptiles and amphibians that occupy riparian habitats along the river include Western Toad, Pacific Tree Frog, bullfrog, Western Pond Turtle, Western Fence Lizard, Common Garter Snake, and Gopher Snake (Reclamation 2005a).

Backwater areas and off-river ponds are located throughout the length of the river, but occur predominantly at the Sacramento Bar, Arden Bar, Rossmoor Bar, and between Watt Avenue and Howe Avenue (Reclamation 2005a; Reclamation et al. 2006). Plant species that dominate these backwater areas include various species of willow, sedge, cattail, bulrush, and rush. Riparian vegetation around these ponded areas is composed of mixed-age willow, alder, and cottonwood. These backwater ponds may be connected to the river by surface water during high winter flood flows and by groundwater during other times of the year. Wildlife species typical of these areas include: Pied-Billed Grebe, American Bittern, Green Heron, Common Merganser, White-Tailed Kite, Wood Duck, Yellow Warbler, Warbling Vireo, Dusky-Footed Woodrat, Western Gray Squirrel, Pacific Tree Frog, and Western Toad.

Several non-native weed populations are rapidly expanding in the riparian vegetation of the lower American River (County of Sacramento 2008). In particular, red sesbania is expanding along shorelines of streams and ponds, along with other invasive species such as Chinese tallowtree, giant reed, pampasgrass, Spanish broom, Himalayan blackberry, and tamarisk, which can rapidly colonize exposed bar surfaces and stream banks.

#### 10.3.3.2.8 Agricultural Lands in the Sacramento Valley

The study area in the Sacramento Valley includes Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, and Solano counties. As described in Chapter 12, Agricultural Resources, field and forage crops dominate the irrigated acreage in Sacramento Valley with over 1.4 million acres irrigated. Rice, irrigated pasture, and hay are the largest acreages. Second to field and forage crops are orchard and vine crops, making up roughly 21 percent of the total acreage. Almonds and walnuts are the largest acreages in this category. In total, the Sacramento Valley contains nearly two million agricultural acres. Typical terrestrial resources of these crops are described in subsection 10.3.4.1.4, Agricultural Lands.

#### 10.3.3.2.9 Wildlife Refuges in the Sacramento Valley

The Sacramento Valley supported three major landscape types: wetlands, grassland-prairies, and riparian woodlands (Reclamation et al 2001a). These habitats were hydrologically and biologically linked to the river systems. Prior to their containment by the construction of dams and levees, the major rivers meandered, forming oxbows and riparian habitat. Winter floods would inundate and scour areas along these rivers, creating marshes and early-succession riparian scrub. Expanses of seasonal wetlands were also created by winter flooding. These seasonal wetlands formed habitat for overwintering and migrating waterfowl. Habitat areas such as wetlands are now intensively managed to support a wide range of birds and other wildlife within small and fragmented areas. Remnant wetlands and agricultural lands in the Central Valley support approximately 60 percent of the waterfowl wintering in the Pacific Flyway region (includes Alaska, Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and portions of Colorado, Montana, New Mexico, and Wyoming west of the Continental Divide [PFC 2014]). In addition, another 20 percent of the Pacific Flyway population passes through the Central Valley, using the wetlands for foraging and resting on their migratory passage through the region. The Sacramento Valley provides winter habitat for 44 percent of the Pacific Flyway waterfowl. The wetland and associated habitat are also important to several federally listed and proposed species, and other special status species such as the American Peregrine Falcon, Bald Eagle, Aleutian Canada Goose, Giant Garter Snake, and California Tiger Salamander.

The Sacramento National Wildlife Refuge (NWR) Complex is composed of five national wildlife refuges (Sacramento, Delevan, Colusa, Sutter and Sacramento River NWRs) and three state wildlife management areas (Willow Creek-Lurline, Butte Sink and North Central Valley Wildlife Management Areas) (USFWS 2013a). The refuges of the Sacramento NWR Complex contain permanent ponds, seasonal wetlands, irrigated moist soil impoundments, and uplands (Reclamation et al 2001). Gray Lodge Wildlife Area is located adjacent to the Butte Sink, an overflow area of Butte Creek and the Sacramento River. It consists of seasonal wetlands and upland areas with permanent wetland and riparian habitats (DFG 2011a). The Gray Lodge Wildlife Area supports permanent and seasonal wetlands, crops, and pasture (Reclamation et al. 2001).

Seasonally flooded marsh is the most prevalent and diverse of the wetland habitat types (Reclamation et al 2001). Wetland units managed as seasonally flooded marsh are typically flooded from early September through mid-April. Their diversity is the product of a variety of water depths that result in an array of vegetative species that, in combination, provide habitat for the greatest number of wildlife species throughout the course of a year. Through the fall and winter, seasonally flooded marshes are used by a wide range of waterfowl and smaller numbers of egret, heron, ibis, and grebe, to name a few. In addition, raptors take advantage of the water bird prey base. Water is removed in the spring; therefore, shorebirds use the shallow depth and exposed mudflats on their northern migration.

Moist soil impoundments, or seasonally flooded impoundments, are similar to seasonally flooded marshes (Reclamation et al 2001). Moist soil impoundments are typically irrigated during the summer to bolster plant growth and to enhance seed production. Irrigation is usually performed in mid-summer to increase plant biomass and seed production of watergrass, sprangletop, and smartweed plants. During these irrigation periods, these units are often used by locally nesting colonial water birds (egrets, herons).

Permanent ponds and summer water provide wetland habitat for year-round and summer resident species (Reclamation et al 2001). Permanent ponds remain flooded throughout the year, while units managed for summer water are flooded through June or July. Characterized by both emergent and submergent aquatic plants, permanent ponds and summer water units provide brood and molting areas for waterfowl, secure roosting and nesting sites for wading birds and other over-water nesters, and feeding areas for species like cormorants and pelicans. Permanent wetland habitats are also important to a number of special status species, such as the Giant Garter Snake, White-Faced Ibis, and Tricolored Blackbird.

Valley-foothill riparian habitats are found along low- to mid-elevation streams and waterways (Reclamation et al. 2001). Riparian habitats provide nesting, roosting, and feeding areas for passerines, raptors, herons, egrets, waterfowl, and small mammals. These areas also provide corridors for resident and migratory wildlife. Riparian woodland habitats are characterized by even-aged, broad-leafed, deciduous trees with open canopies that reflect flood-mediated episodic events. Cottonwood, willow, alder, and oak are typical trees found in riparian woodlands. Riparian scrub habitats are described as streamside thickets dominated by one or more willow species, as well as other fast-growing shrubs and vines.

#### ***10.3.3.3 San Joaquin Valley***

The San Joaquin Valley portion of the Central Valley Region considered in this EIS includes the San Joaquin River from Millerton Lake to the Delta; lower Stanislaus River from New Melones Reservoir to the confluence with the San Joaquin River; San Luis Reservoir; and agricultural areas and wildlife refuges that use CVP and SWP water supplies.

Historically, the San Joaquin Valley was a large floodplain that supported vast expanses of permanent and seasonal marshes, lakes, and riparian areas. Almost 70 percent of the valley has been converted to irrigated agriculture (Reclamation 2005b). Relict stands of alkali desert scrub are widely scattered throughout the San Joaquin Valley, but are generally found in the Tulare Basin in the southern San Joaquin Valley. Annual and perennial grasslands occur throughout the San Joaquin Valley, mostly on level plains and the gently rolling foothills at elevations immediately higher than the patches of alkali desert scrub. Ruderal vegetation is typically associated with road and utility rights-of-way, borders of fields, ditches, and abandoned fields.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved a habitat conservation plan for San Joaquin County Multi-species Habitat Conservation and Open Space Plan, Kern Water Bank, and the Metropolitan Bakersfield.

**10.3.3.3.1 San Joaquin River**

Potential changes in CVP and SWP operations could affect terrestrial resources associated with the San Joaquin River from Millerton Lake to the Delta.

*Millerton Lake*

Millerton Lake on the San Joaquin River is located in the western foothills of the Sierra Nevada Mountains in an area that ranges from grasslands and rolling hills near Friant Dam, to steep, craggy slopes in the upper reaches of the lake. Vegetation around Millerton Lake consists of a number of terrestrial communities, including annual grassland, oak woodland, foothill pine oak woodland, and chaparral (Reclamation 2011; Reclamation and State Parks 2010).

The most dominant vegetation community near the water edge is the nonnative grassland with blue oak woodland on the slopes above the lake and mixed riparian woodlands along drainages to the lake (Reclamation 2011; Reclamation and State Parks 2010). The dominant grassland species include broad-leaf filaree, fiddleneck, Heermann tarweed, vinegar weed, and ripgut brome, soft chess, zorro grass. The blue oak woodland also includes gray pine, buck brush, bush lupine, holly-leaf redberry, and hoary coffeeberry. The mixed riparian woodland species include interior live oak and gray pine with red willow, Fremont cottonwood, California buckeye, edible fig, and Oregon ash with an understory of California grape, button bush, Himalayan blackberry, sedges, and nonnative spearmint. Aquatic plants occur along the drainages where the water is relatively stagnant including mosquito fern, common duckweed, dotted duckmeat, punctuate smartweed, tall flat sedge, and broad-leaf cattail. Much of the shoreline is barren or characterized by nonnative grasslands with weedy species, such as Bermuda grass and cocklebur, and sporadic Goodding’s black willow.

Mule Deer, California Quail, wild turkey, and feral pig, all of which are game species, occur in the area around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). The region provides winter range and migratory routes for the San Joaquin deer herd. A number of special status bat species have potential to occur in the area, and suitable roost sites may be found throughout the area. Other special status species that may occur in the area include the ringtail, American badger, and San Joaquin pocket mouse.

A relatively diverse community of reptile and amphibian species exists in and around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). The presence of the nonnative bullfrog has changed, and continues to dramatically alter, the extant reptile and amphibian community through predation and because of its ability to out-compete native species. The Western Pond Turtle is known to occur around the lake. The California Tiger Salamander has also been reported. Limited areas of potential breeding habitat for California tiger salamander, primarily stock ponds dominated by nonnative species, have been identified in the San Joaquin River gorge upstream of the lake.

Bald eagles use roost trees near open water for foraging and are known to winter around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). Several species associated with riparian habitats, including the least Bell's vireo and willow flycatcher, occurred historically around the lake, but have not been recently documented. A number of nonnative birds, including European Starling and Brown-Headed Cowbird, influence the native bird community through competition and nest parasitism.

A number of rare and listed plant species are known to occur around Millerton Lake and the upper San Joaquin River (Reclamation 2011; Reclamation and State Parks 2010). These include Ewan's larkspur, Michael's piperia, tree anemone, and Madera leptosiphon. Two plant species which serve as hosts for special status invertebrates, the elderberry and California pipevine, are also known to occur in the area. California pipevine is the obligate host plant for the pipevine swallowtail, a butterfly species and the elderberry shrub is the host plant of the Valley Elderberry Longhorn Beetle.

*San Joaquin River from Friant Dam to the Confluence with the Merced River*

A multilayered riparian forest dominated by cottonwoods occurs on the active low floodplain of the San Joaquin River along with older stands of cottonwood-dominated riparian forest in areas that were formerly active floodplains prior to the completion of Friant Dam and associated diversion channels, and the resulting reduction in river flow (DWR and Reclamation 2002; Reclamation and DWR 2011). Other areas on the low floodplain are dominated by willow, with occasional scattered cottonwood, ash, or white alder. California buttonbush is often present and may even dominate the riverbank for stretches.

The intermediate terrace of the floodplain of the San Joaquin River is primarily a mixed-species riparian forest (DWR and Reclamation 2002; Reclamation and DWR 2011). Species dominance in this mixed riparian forest depends on site conditions, such as availability of groundwater and frequency of flooding. Typical dominant trees in the overstory and midstory include Fremont cottonwood, boxelder, Goodding's black willow, Oregon ash, and California sycamore. Immediately along the water's edge, white alder occurs in the upper reaches of the San Joaquin River. Typical shrubs include red willow, arroyo willow, and California buttonbush.

Tree-dominated habitats with an open-to-closed canopy are typically found on the higher portions of the floodplain (DWR and Reclamation 2002; Reclamation and DWR 2011). These areas are exposed to less flood-related disturbance than areas lower on the floodplain. Valley oak is the dominant tree species while California sycamore, Oregon ash, and Fremont cottonwood are present in small numbers.

Typical understory species include creeping wild rye, California wild rose, Himalayan blackberry, California wild grape, and California blackberry.

Dense stands of willow shrubs frequently occur within the active floodplain of the river in areas subject to more frequent scouring flows and often occupy stable sand and gravel point bars immediately above the active channel (DWR and Reclamation 2002; Reclamation and DWR 2011). Dominant species include sandbar willow, arroyo willow, and red willow. Occasional emergent Fremont cottonwood may also be present.

Other areas have vegetation consisting of woody shrubs and herbaceous species dominated by different species depending on river reach. Some areas are dominated by mugwort, together with stinging nettle and various tall weedy herbs. Other areas are dominated either by blackberry (usually the introduced Himalayan blackberry) or wild rose in dense thickets, with or without scattered small emergent willows.

Areas with fine-textured, rich alluvium located outside the active channels but in areas that are subject to periodic flooding contain a shrub-dominated community characterized by widely spaced blue elderberry shrubs (DWR and Reclamation 2002; Reclamation and DWR 2011). The herbaceous understory is typically dominated by nonnative grasses and forbs that are characteristic of annual grassland communities, including ripgut brome, foxtail fescue, foxtail barley, red-stemmed filaree, and horseweed.

Emergent wetlands typically occur in the river bottom immediately adjacent to the low-flow channel (DWR and Reclamation 2002; Reclamation and DWR 2011). Backwaters and sloughs where water is present through much of the year support emergent marsh vegetation, such as tule and cattails. More ephemeral wetlands, especially along the margins of the river and in swales adjacent to the river, support native and nonnative herbaceous species.

Prevalent invasive species found in this portion of the San Joaquin River corridor include red sesbania, tamarisk, giant reed, Chinese tallow, Tree-of-heaven, and perennial pepperweed (Reclamation and DWR 2011). Water hyacinth, water milfoil, Parrot’s feather, curly-leaf pondweed, and sponge plant occur within the streams, especially in areas with slow or ponded water.

The riparian forest trees and understory provide habitat for raptors, cavity-nesting birds, and songbirds, including Red-Tailed Hawk, Red-Shouldered Hawk, Swainson’s Hawk, White-Tailed Hawk, Downy Woodpecker, Wood Duck, Northern Flicker, Ash-Throated Flycatcher, Pacific-Slope Flycatcher, Olive Sided Flycatcher, Tree Swallow, Oak Titmouse, White-Breasted Nuthatch, Western Wood-Pewee, Warbling Vireo, Orange-Crowned Warbler, Yellow Warbler, Bullock’s Oriole, and Spotted Towhee (DWR and Reclamation 2002; Reclamation and DWR 2011). Western Wood-Pewee, Bushtit, Bewick’s Wren, Lazuli Bunting, Blue Grosbeak, and American Goldfinch inhabit the riparian scrub vegetation. Song Sparrow, Common Yellowthroat, Marsh Wren, and Red-Winged Blackbird inhabit the emergent wetlands. Coyote, River Otter, raccoon, Desert Cottontail, and Striped Skunk occur in the riparian forest and shrub communities. Shorebirds, such as Killdeer; Mallard Duck; California Vole; Common Muskrat; Norway Rat; Pacific Chorus Frog; Western Pond Turtle; and Western Terrestrial Garter Snake occur near the river.

*San Joaquin River from Merced River to the Delta*

Downstream of the Merced River confluence, vegetation and wildlife resources along the San Joaquin River are similar to the upstream reaches described above (DWR and Reclamation 2002; Reclamation and DWR 2011). The reach of the San Joaquin River immediately downstream of the Merced River is more incised than areas further downstream and has a less developed riparian area with less understory vegetation. Between the Merced River and the Delta, agricultural land use has encroached on the riparian areas, leaving only a narrow band of riparian habitat. Near the confluence with tributary rivers, in cutoff oxbows, and in the San Joaquin River NWR, there are more extensive riparian habitat areas. Remnant cattail-dominated marshes and tules occur in these areas.

Wildlife species are similar to those found in the reaches upstream of the Merced River described above (DWR and Reclamation 2002; Reclamation and DWR 2011).

**10.3.3.3.2 Stanislaus River**

The upper Stanislaus River watershed has a drainage area of approximately 980 square miles (Reclamation 2010b). The North, Middle, and South forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. Water from New Melones Reservoir flows into Tulloch Reservoir. Downstream of Tulloch Reservoir, the Stanislaus River flows to Goodwin Dam and then approximately 40 miles to the confluence with the San Joaquin River.

*New Melones Reservoir*

Several broad categories of vegetation have been described in other studies around the New Melones Reservoir, including blue oak woodland and blue oak-foothill pine woodland, grasslands, chaparral, wetlands, and serpentine-based communities (Reclamation 2010b). The montane hardwood and montane hardwood-conifer woodlands occur at higher elevations substantially above the reservoir open water, especially along the eastern portion of the New Melones Reservoir; and are not anticipated to be affected by changes in CVP and SWP operations.

Blue oak woodland vegetation occurs in the western and southwestern portion of New Melones Reservoir, especially on rocky slopes and along riparian corridors (Reclamation 2010b). Oak trees that are established along the shoreline during drier periods are frequently killed when the reservoir fills to the maximum elevation. The blue oak woodland community also includes ponderosa pine, California buckeye, manzanita, ceanothus, yerba santa, foothill pine, scrub oak, black oak, valley oak, interior live oak, coffeeberry, redberry, holly-leaved cherry, and needlegrass. The blue oak-foothill pine woodland occurs at higher elevations along the western and southern areas of the New Melones Reservoir, and includes understory species, including poison oak, woodland star, sugar cup, shooting star, Chinese house, and gooseberry. The oak woodland supports woodpecker, mourning doves, wild turkey, California quail, mule deer, black-tailed deer, western grey squirrel, gray fox, raccoon, feral pig, striped skunk, mountain lion, and bobcat. The transition chaparral zones between the oak woodlands and grasslands support California Thrasher, quail, wrentit, bobcat, Deer Mouse, feral pig, and Fence Lizard.

Annual grasslands occur along adjacent plains and foothills on the western and southern portions of New Melones Reservoir (Reclamation 2010b). The annual plant species, including wild oats, soft chess, ripgut, fiddleneck, longbeak stork's bill, and redstem stork's bill. Perennial grass species include triple-awned grass, wheat grass, bent grass, wild-rye, melic grass, needle-grass, and muhly. The area also includes foothill pine, blue oak, California poppy, and lupines. Grasslands support Meadowlark, Horned Lark, sparrow, quail, mouse, and vole. Raptors that forage in the grasslands include White-Tailed Kite, Northern Harrier, Great Horned Owl, Red-Tailed Hawk, and Swainson's Hawk.

Little riparian vegetation exists along the shoreline of New Melones Reservoir because fluctuating water levels limit the establishment of riparian vegetation (Reclamation 2010b). Riparian vegetation is generally found in the upstream reaches of some of the perennial drainages that flow into the reservoir. Wetland vegetation is found in some locations along the edges of the lake and in moist canyons. There are many riparian communities, seeps, and wet meadows in the upper reaches of streams that are tributaries of the lake. Species in the valley and foothill riparian woodlands include boxelder, Fremont cottonwood, willows, white alder, and big-leaf maple. The wet meadow species include short-hair sedge, gentian-aster, few-flowered spikerush, carpet clover, bentgrass, pull-up muhly, beaked sedge, Nebraska sedge, Kentucky bluegrass, longstalk clover, and tufted hairgrass.

The open water of New Melones Lake, along with associated shoreline vegetation, provides foraging and resting habitat for a variety of waterfowl and shorebirds (Reclamation 2010b). Several fish-eating bird species, such as grebe, forage in the open water; other species, such as ducks, herons, and egrets, dabble along the shoreline foraging on seeds and small fish in shallow areas. Trees along the shoreline provide nesting areas for osprey. Riparian areas along larger tributaries to New Melones Reservoir provide food, cover, water, and nesting habitat for a variety of wildlife species and serve as travel corridors for species such as black-tailed deer.

Limestone caves are located in portions of the upper reaches of New Melones Reservoir, especially along the Stanislaus River (Reclamation 2010b). Bats use the caves for roosting and breeding. A type of rare spider, New Melones harvestman, was transplanted from caves that were to be inundated through the filling of New Melones Reservoir into neighboring caves.

*Tulloch Reservoir*

Many vegetation community types characteristic of the New Melones Reservoir and other portions of the Sierra foothills are found around Tulloch Reservoir, including blue oak woodland, chaparral, grassland, various tree-shrub communities dominated by pines, and grasslands (Tri-Dam Project 2008). The elderberry shrub (*Sambucus* species) occurs at multiple locations around the reservoir and may provide habitat for the Valley Elderberry Longhorn Beetle. A number of nonnative weedy species have been documented around the reservoir including Himalayan blackberry, red brome, tree-of-heaven, slenderflower thistle, yellow star thistle, pampas grass, Bermuda grass, and the aquatic parrot's feather. The vegetation along the water edge is affected by daily and seasonal water elevation variability. Wildlife supported by the vegetative community are similar to wildlife communities near New Melones Reservoir as well as Western Pond Turtle, bat, river otter, and mink (Goodwin Power 2013).

*Goodwin Dam*

Downstream of Tulloch Dam, the Stanislaus River flows to Goodwin Dam, and then continues approximately 40 miles to the confluence with the San Joaquin River. Goodwin Dam serves as a diversion dam for Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District, as described in Chapter 5, Surface Water Resources and Water Supplies (Tri-Dam Project 2003, 2007). The Goodwin Dam impounds 502 acre-feet of water along the Stanislaus River approximately 1.6 miles downstream of Tulloch Dam and 8.3 miles downstream of New Melones Dam. Water surface elevations are relatively constant upstream of Goodwin Dam.

The vegetation communities in this area of the Stanislaus River are similar to the vegetation near Tulloch Dam, including hardwood and oak woodlands with blue oak, interior live oak, gray pine, California buckeye, toyon, tree of heaven, and California black walnut (Tri-Dam 2003). Near the Stanislaus River, the vegetation is characterized by riparian woodland with cottonwood, willows, white alder, blue elderberry, and Himalayan berry. Some low-gradient areas along the shoreline of Goodwin Lake, especially in coves, support small patches of emergent aquatic vegetation such as bulrush and cattail (Goodwin Power 2013). Wildlife occurrences are similar to conditions near Tulloch Reservoir.

*Stanislaus River from Goodwin Dam to the Confluence with the San Joaquin River*

From Goodwin Dam to Knight's Ferry, the Stanislaus River flows through a bedrock canyon with nearly vertical walls and rock outcrops (DFG 1995). The riparian edge includes valley foothill riparian vegetation in a very narrow band for the entire length of this reach. This habitat is characterized by a canopy layer of cottonwood, California sycamore, and valley oak. Subcanopy cover trees are white alder, boxelder, and Oregon ash. Typical understory shrub layer plants include wild grape, wild rose, California blackberry, elderberry, button brush, and willow. The herbaceous layer consists of sedges, rushes, grasses, miner's lettuce, poison-hemlock, and stinging nettle.

From Knights Ferry to the Orange Blossom Bridge, located to the east of the City of Oakdale, the valley foothill riparian habitat continues along the river (DFG 1995). Further away from the river, vegetation is dominated by blue oak-digger pine woodland and shrub, including California redbud, California buckeye, ceanothus, manzanita, poison oak, and grasslands. Vernal pools and vernal pool complexes are found within adjacent grasslands.

Downstream of the Orange Blossom Bridge, the riparian corridor is virtually nonexistent in some areas with agricultural land uses extending into the riparian corridor (DFG 1995). In a few areas the riparian corridor is wide, such as within Caswell Memorial State Park. The major habitats include valley foothill riparian along the Stanislaus River with annual grasslands and fresh emergent wetlands amount the agricultural and urban developments.

#### 10.3.3.3.3 San Luis Reservoir Complex

The San Luis Reservoir complex, consisting of San Luis Reservoir, O'Neill Forebay, and Los Banos Creek Reservoir, is located in northwestern San Joaquin Valley and is part of the water storage and delivery system for the CVP and SWP. The area is located within several vegetative communities (Reclamation and State Parks 2013). The northern and western portion of the San Luis Reservoir is located within the coastal foothills with blue oak-foothill pine woodlands. The O'Neill Forebay and parts of Los Banos Creek Reservoir are located within the San Joaquin Valley with valley oak habitat.

The vegetation around the San Luis Reservoir complex and wildlife management areas consists of riparian woodlands, blue oak woodlands and savanna, coast live oak woodland, ornamental trees, California sagebrush scrub, grasslands, wetlands, alkali sink scrub, and nonnative and weedy plant communities (Reclamation and State Parks 2013). The riparian woodland and wetland communities occur at the edge of the reservoirs and along watercourses. The San Luis Wildlife Area also contains blue oak woodland, blue oak savanna, coast live oak woodland, and California sycamore riparian woodland. California sagebrush scrub occurs on hillsides above and to the west of Los Banos Creek Reservoir. Iodine bush scrub occurs at Salt Spring, a tributary to Los Banos Creek Reservoir. Native purple needlegrass occurs throughout the complex.

Along the shorelines, riparian vegetation remains in an early successional stage because either the extreme fluctuation of the water level inundates the vegetation or the vegetation does not receive enough water during the dry season (Reclamation and State Parks 2013). Areas at the edges of O'Neill Forebay and Los Banos Creek Reservoir appear to be slowly changing to riparian vegetation.

A herd of more than 200 tule elk occurs towards the western shoreline of San Luis Reservoir within and near Pacheco State Park (Reclamation and State Park 2013). The herd moves down towards the water edge within the reservoir inundation area when the water elevation is low. Another herd of approximately 60 individuals occur around B.F. Sisk Dam which forms San Luis Reservoir; and approximately 70 tule elk occur throughout other areas in the complex.

#### 10.3.3.3.4 Agricultural Lands in the San Joaquin Valley

The study area in the San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. As described in Chapter 12, Agricultural Resources, field and forage crops dominate the irrigated acreage in the San Joaquin Valley with over 5.5 million agricultural acres. Hay, cotton, and silage are the largest acreages. Second to field and forage crops are orchards and vineyards, making up roughly 35 percent of total acreage. Almonds and grapes are the largest acreages in this category.

Typical terrestrial resources of these crops are described in subsection 10.3.4.1.4, Agricultural Lands. In the grassland and pasture areas, areas not dominated by crops include nonnative grasses, foxtail barley, and forbs (Reclamation and DWR 2011). The grassland and pasture support Northern Harrier, Ring-Necked Pheasant, Mourning Dove, Burrowing Owl, Loggerhead Shrike, Deer Mouse, California Vole, California Ground Squirrel, Botta's Pocket Gopher, American Badger, coyote, Western Toad, Western Fence Lizard, Western Racer, and Gopher Snake. The cropland provides foraging areas for raptors and supports Ground Squirrel, American Crow, Brewer's Blackbird, and European Starling.

#### 10.3.3.3.5 Wildlife Refuges in the San Joaquin Valley

The San Joaquin Valley historically supported three major landscape types: wetlands, grassland-prairies, and riparian woodlands (Reclamation et al 2001b). These habitats were hydrologically and biologically linked to the river systems. Prior to their containment by the construction of dams and levees, the major rivers meandered, forming oxbows and riparian habitat. Winter floods would inundate and scour areas along these rivers, creating marshes and early-succession riparian scrub. Expanses of seasonal wetlands were also created by winter flooding. These seasonal wetlands formed habitat for overwintering and migrating waterfowl. Habitat areas such as wetlands are now intensively managed to support a wide range of birds and other wildlife within small and fragmented areas. Remnant wetlands and agricultural lands in the Central Valley support approximately 60 percent of the waterfowl wintering in the Pacific Flyway region. In addition, another 20 percent of the Pacific Flyway population passes through the Central Valley, using the wetlands for foraging and resting on their migratory passage through the region. The Sacramento Valley provides winter habitat for 44 percent of the Pacific Flyway waterfowl. The wetland and associated habitat are also important to several federally listed and proposed species, and other special status species such as the American Peregrine Falcon, Bald Eagle, Aleutian Canada Goose, Giant Garter Snake, and California Tiger Salamander.

CVP water supplies are provided to the San Luis NWR Complex which includes the Merced NWR, San Luis NWR (including the San Luis Unit, West Bear Creek Unit, East Bear Creek Unit, Freitas Unit, Blue Goose Unit, and Kesterson Unit), and Grasslands Wildlife Management Area (Reclamation 2012; USFWS 2012b, 2013b). The San Luis NWR Complex also includes the San Joaquin River NWR which is influenced by CVP operations; however, this refuge does not specifically receive CVP water under a contract. CVP water supplies are also provided to the Los Banos Wildlife Area; Volta Wildlife Area; Mendota Wildlife Area; and North Grasslands Wildlife Area (including China Island Unit and Salt Slough Unit) (Reclamation 2012b). In the southern San Joaquin Valley, the Kern and Pixley NWRs provide wildlife viewing opportunities.

*San Luis National Wildlife Refuge Complex*

The San Luis NWR Complex includes wetlands, riparian forests, native grasslands, and vernal pools (USFWS 2012a, 2012b). The refuge is a major wintering ground and migratory stopover point for a wide range of waterfowl, shorebirds, and other waterbirds. The refuge is host to significant assemblages of birds, mammals, reptiles, amphibians, insects, and plants, some of which, such as the California Tiger Salamander and San Joaquin Kit Fox, are endangered species. Riparian woodlands occur along rivers and sloughs with willow, cottonwood, and oak to support egrets, herons, cormorants, raptors, and songbirds (USFWS 2012b). Wetlands occur on over 25 percent of the San Luis NWR Complex lands and provide nesting habitat for coots, grebes, blackbirds, bitterns, ibis, and marsh wrens; and seasonal wetlands for ducks, geese, shorebirds, and other waterbirds. Grasslands occur on over 70 percent of the lands, including the native creeping wild Rye and alkali sacaton, to support elk, Black-Tailed Deer, Desert Cottontail Rabbit, Black-Tailed Jackrabbit, voles, and songbirds. Vernal pools occur in some areas during the spring, especially in the Kesterson NWR and West Bear Creek Unit. Artificial dens and other habitat structures have been constructed on the refuge, including nest boxes for songbirds, owls, and wood ducks; and dens for kit foxes (USFWS 2012a).

*San Luis National Wildlife Refuge*

The San Luis NWR contains approximately 26,800 acres of wetlands, riparian forests, native grasslands, and vernal pools (USFWS 2012c). Saline and alkaline conditions on portions of the upland habitat support a rich botanical community of native bunchgrasses, native and nonnative annual grasses, forbs, and native shrubs. Wintering habitat is provided for numerous waterbirds, including green-winged teal, northern shoveler, mallard, gadwall, wigeon, cinnamon teal, northern pintail, ring-necked, canvasback, and ruddy ducks; snow, Ross', and white-fronted geese. Shorebirds include sandpipers and plovers. Tule elk occur in the upland habitats.

*Merced National Wildlife Refuge*

The Merced NWR contains approximately 10,250 acres of wetlands, native grasslands, vernal pools and riparian areas (USFWS 2012d). In addition to providing breeding habitat for Swainson's Hawk, Tricolored Blackbird, Marsh Wren, and Burrowing Owl; the refuge is host to the largest wintering populations along the Pacific flyway of Lesser Sandhill Crane and Ross' Goose. Mammals such as coyote, Ground Squirrel, rabbit, and beaver are found year-round. Vernal pools are a component of the refuge and are home to many species of vernal pool plants and invertebrates as well as the California Tiger Salamander. Merced NWR also includes approximately 300 acres of cultivated corn and winter wheat crops and more than 500 acres of irrigated pasture for wildlife.

*San Joaquin River National Wildlife Refuge*

The San Joaquin River NWR encompasses approximately 7,000 acres located where Tuolumne, Stanislaus, and San Joaquin rivers join, creating a mix of habitats for terrestrial wildlife and plan species. Initially established to protect and manage habitat for the Aleutian Cackling Goose, the refuge is currently managed to provide habitat for migratory birds and endangered wildlife species (USFWS 2012e, 2012f). The refuge includes a mosaic of valley oak riparian forest, riverine and slough habitats, seasonal and permanent wetlands, vernal pools, natural uplands, and agricultural fields. Over 500,000 native trees and shrubs such as willow, cottonwood, oak, blackberry, and rose have been planted across 2,200 acres of river floodplain within the refuge, creating the largest block of contiguous riparian woodland in the San Joaquin Valley. Endangered riparian brush rabbits have been re-introduced to this restored habitat from captive-reared populations. These woodlands also support a diversity of breeding songbirds including grosbeak, oriole, flycatcher, warbler, and Least Bell's Vireo; and a heron/egret rookery. The refuge also provides winter and migration habitat for Lesser Sandhill Cranes, Greater Sandhill Cranes, Snow Geese, Ross' Geese, and White-Fronted Goose.

Several nonnative invasive plants influence the quality of wildlife habitat on the refuge including yellow star thistle, perennial pepperweed, poison hemlock, Russian thistle, milk thistle, and bull thistle. According to the Comprehensive Conservation Plan for the refuge (USFWS 2006), infestations are greatest in fallow agricultural fields, roadsides, canal banks, and undergrazed pastures, as well as other disturbed sites. Perennial pepperweed is established throughout the riparian areas of the refuge and stands of giant reed are scattered along the banks of the San Joaquin River. Infestations of water hyacinth seasonally disrupt water delivery and create impenetrable surfaces in the streams, sloughs, oxbows, and canals.

*Grasslands Wildlife Management Area*

The Grasslands Wildlife Management Area is composed entirely of privately owned lands with perpetual conservation easements to preserve wetland and grassland habitats, and wildlife-friendly agricultural lands along the San Joaquin River (GRCD 2014; USFWS 2013c). The Grassland Resource Conservation District, located within the western portion of the Wildlife Management Area, contains approximately 75,000 acres of private wetlands and associated grasslands, and over 30,000 acres of federal National Wildlife Refuges and State Wildlife Management Area. The area constitutes 30 percent of the remaining wetland habitat in the Central Valley and is a major wintering ground for migratory waterfowl and shorebirds of the Pacific Flyway.

Grassland Resource Conservation District provides habitat for waterfowl, shorebirds, wading birds, songbirds, raptors, and other wildlife species (GRCD 2014; USFWS 2013c). The Grassland Resource Conservation District specifically manages a program to encourage production of natural food plants (such as swamp grass, smartweed, and watergrass). Habitats include seasonally flooded wetlands, moist soil impoundments, permanent wetland, irrigated pasture, and croplands.

*Los Banos Wildlife Area*

The Los Banos Wildlife Area, located approximately 4 miles northeast of Los Banos, contains more than 6,200 acres in the San Joaquin River floodplain and is dominated by seasonal wetlands (CDFW 2014a; Reclamation 2001b). Permanent and semi-permanent wetlands are also present, along with areas of riparian vegetation. The Los Banos Wildlife Area also supports native and nonnative grasslands. Irrigated pasture and croplands are maintained to provide food, resting, and nesting habitat for waterfowl and other wildlife. Western Pond Turtle, raccoon, Striped Skunk, beaver, muskrat, and mink; as well as over 200 species of waterfowl, shore birds, upland game birds, and song birds occur seasonally throughout the area. Seasonal marshes provide habitat for a wide range of waterbirds, upland birds, and seasonal migrants, including American bittern, snowy egret, killdeer, American avocet, wood duck, and mallard.

*Volta Wildlife Area*

The Volta Wildlife Area consists of approximately 2,900 acres. The Wildlife Area is partially in the Grassland Resource Conservation District (CDFW 2014b; Reclamation et al. 2001b). The Wildlife Area supports permanent and seasonal wetlands and valley alkali shrub. Irrigated pasture and crops are grown to provide food and nesting cover for migratory waterfowl. Beaver, coyote, cottontail, and 150 species of birds, including a wide range of waterfowl and shorebirds, are found on the Volta Wildlife Area.

*Mendota Wildlife Area*

The Mendota Wildlife Area contains more than 12,000 acres of flatlands and floodplain (Huddleston 2001; Reclamation et al. 2001b). The Mendota Wildlife Area has been managed primarily to provide seasonal wetland habitat. Water is used to irrigate natural food crops, such as swamp grass, alkali bulrush, smartweed, and millet, and to flood seasonal and semi-permanent wetlands. Small grains, corn, and pasture are also irrigated in the upland areas. The Wildlife Area has significant white-faced ibis and great-blue heron rookeries. Shorebirds, songbirds, raptors, waterfowl, and wading birds use the wetlands habitat. Mammals that use the refuge include coyote, muskrat, beaver, mink, raccoon, weasel, Black-Tailed jackrabbit, Cottontail Rabbit, Spotted Skunk, Striped Skunks, and Ground Squirrel.

*North Grasslands Wildlife Area*

The North Grasslands Wildlife Area includes the China Island, Salt Slough, and Galdwall units which encompass 7,069 acres of wetlands, riparian habitat, and uplands (CDFW 2014c). Restoration and enhancement actions have focused on increasing seasonal wetlands, permanent and semi-permanent wetlands, and riparian habitat on the unit, including habitat for the Swainson’s hawk and sandhill crane.

The China Island Unit of the North Grasslands Wildlife Area borders the San Joaquin River southwest of the confluence with the Merced River (DFG 2011b). The Salt Slough Unit is located on the west side of Salt Slough, adjacent to the San Luis NWR Complex and Los Banos Wildlife Area. Before its acquisition, the unit consisted mainly of irrigated pasture and was managed as a cattle ranch (DFG 2011c). Habitat on both units includes permanent wetlands that are flooded continuously; semi-permanent wetlands that are flooded in the spring and summer; moist soil vegetation to produce seeds and sustain invertebrates, including swamp timothy, watergrass, and smartweed; seasonal wetlands to provided flooded areas in the fall for waterfowl; riparian habitat, nesting habitat for resident breeding birds, including Short-Eared Owl, Northern Harrier, ducks, and pheasants; upland foraging areas; and pasture which provides late winter and early spring habitat for geese, and other habitat areas for sandhill crane, pheasants, and raptors.

*Kern National Wildlife Refuge Complex*

The Kern NWR Complex consists of the Kern NWR and Pixley NWR (USFWS 2013d). The Kern NWR contains approximately 11,249 acres including seasonal marsh; moist soil units; and uplands (e.g., grasslands, alkali playa, and valley sink scrub) (USFWS 2013e). Wetlands on the refuge are seasonal in nature. Fall flooding begins in mid-August, with a peak in flooded marsh habitat by January. This habitat is maintained through February, after which the wetland areas are slowly drained. Selected units are irrigated during late spring and early summer to encourage plants to grow, to provide food for wintering and migrating birds the following fall (USFWS 2013e). The refuge is the largest wetland area in the Southern San Joaquin Valley and plays a vital role in the Pacific Flyway for migrating waterfowl, shorebirds, and songbirds. Uplands occupy the northeastern and northwestern portions of the refuge, used by threatened and endangered species, such as San Joaquin Kit Fox, Tipton Kangaroo Rat, and Blunt-Nosed Leopard Lizard. Artificial dens have been built for endangered San Joaquin Kit Foxes and artificial burrows have been provided for Burrowing Owls.

The Pixley NWR contains 6,389 acres of grasslands, vernal pools, and playas along the historic Tulare Lake boundaries (USFWS 2014ak). The refuge includes approximately 300 acres of managed wetlands for waterfowl and shorebirds. San Joaquin Kit Fox, Blunt-Nosed Leopard Lizard, and Tipton Kangaroo rat use the upland areas. Vernal pools also occur on the refuge.

#### *10.3.3.4 Delta, Suisun Marsh, and Yolo Bypass*

Historically, the natural Delta system was formed by water inflows from upstream tributaries in the Delta watershed and outflow to Suisun Bay and San Francisco Bay (SFEI 2012). Upstream of the Delta, during high Sacramento River flows, water spilled into the geologic formation known as the Yolo Basin which extends from Knights Landing Ridge upstream of the confluence between the Sacramento and Feather rivers to the confluence of Cache Slough and the Sacramento River in the Delta upstream of Rio Vista and Suisun Marsh. The Delta and Suisun Marsh have a complex web of channels and islands and is located at the confluence of the Sacramento and San Joaquin rivers. As described below in subsection 10.3.4.4.1, Yolo Bypass, is a 59,280-acre floodway through the Yolo Basin that was constructed as part of the Sacramento River Flood Control Project to protect the cities of Sacramento and West Sacramento and the north Delta from extreme flood events.

The Delta (as legally defined in the Johnston-Baker-Andal-Boatwright Delta Protection Act of 1992 [California Water Code section 12220]) covers 737,358 acres, including 4,278 acres of the Suisun Marsh and 16,762 acres of the Yolo Bypass. Individually, the overall Delta, Suisun Marsh, and Yolo Bypass extend over 737,358 acres, 106,511 acres, and 59,280 acres, respectively. In total, the Delta, Suisun Marsh, and Yolo Bypass constitute a natural floodplain that covers approximately 882,200 acres and drains approximately 40 percent of the state (DWR 2009a).

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

#### 10.3.3.4.1 Delta and Suisun Marsh

The Delta overlies the western portions of the Sacramento River and San Joaquin River watersheds. The Delta is a network of islands, channels, and marshland at the confluence of the Sacramento and San Joaquin rivers. Major rivers entering the Delta are the Sacramento River flowing from the north, the San Joaquin River flowing from the south, and eastside tributaries (Cosumnes, Mokelumne, and Calaveras rivers). Suisun Marsh is a tidally influenced brackish marsh located about 35 miles northeast of San Francisco in southern Solano County It is a critical part of the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) estuary ecosystem. The Delta, together with Suisun Marsh and greater San Francisco Bay, make up the largest estuary on the west coast of North and South America (DWR 2009a).

The Delta was once composed of extensive freshwater and brackish marshes, with tules and cattails, broad riparian thickets of scrub willows, buttonwillow, and native brambles. In addition, there were extensive riparian forests of Fremont cottonwood, valley oak, Oregon ash, boxelder, white alder, and Goodding’s black willow. Upland, non-riparian stands of valley oak and coast live oak occurred in a mosaic with seasonally flooded herbaceous vegetation, including vernal pools and alkali wetlands (SFEI 2012).

Substantial areas of the Delta and Suisun Marsh have been modified by agricultural, urban and suburban, and recreational land uses (Reclamation et al. 2011; SFEI 2012). Over the past 150 years, levees were constructed in the Delta and Suisun Marsh to provide lands for agricultural, municipal, industrial, and recreational land uses. The remaining natural vegetation is fragmented, and largely restricted to the edges of waterways, flooded islands, and small protected areas such as parks, wildlife areas, and nature reserves (Hickson and Keeler-Wolf 2007). A substantial portion of the emergent wetlands exists as thin strips along the margins of constructed levees (SFEI 2012). Current habitat along the Delta waterways includes seasonal wetlands, tidal wetlands, managed wetlands, riparian forests, and riparian scrub.

Seasonal wetlands historically had occurred along the riparian corridor at elevations that were inundated during high flow events. Many of the levees were constructed along the riparian corridor edges; and therefore, historic seasonal wetlands were substantially modified (SFEI 2012). Adjacent areas of perennial wetlands on the water-side of the riparian corridor were modified as levees were constructed and channels enlarged. In many of these areas the perennial wetlands were replaced by seasonal wetlands. The vegetation of seasonal wetlands is typically composed of wetland generalist species that occur in frequently disturbed sites such as hyssop loosestrife, cocklebur, dallis grass, Bermuda grass, barnyard grass, and Italian ryegrass.

Alkali-related habitats occur near salt-influenced seasonal and perennial wetlands. Alkali seasonal wetlands occur on fine-textured soils that contain relatively high concentrations of dissolved salts. These types of soils are typically found at the historical locations of seasonal ponds in the Yolo Basin in and around the CDFW Tule Ranch Preserve, and upland in seasonal drainages that receive salts in runoff from upslope salt-bearing bedrock such as areas near Suisun Marsh and the Clifton Court Forebay. Alkali wetlands include saltgrass, alkali weed, saltbush, alkali heath, and iodine bush. Small stands of alkali sink scrub (also known as valley sink scrub) are characterized by iodine bush.

Tidal wetlands consist of tidal brackish wetlands that occur either as relatively substantial tracts of complex tidal wetlands, or in narrow bands of fringing tidal wetlands (Siegel et al. 2010a). Fringing tidal marsh exists along the outboard side exterior levees and generally has formed since diking for managed wetlands began. Fringing tidal wetlands vary in size and vegetation composition, exhibit less geomorphic complexity, and have a low area-to-edge ratio. Fringing marshes lack connection with the upland transition, are often found in small, discontinuous segments, and can limit movement of terrestrial marsh species.

Plant zones in complex tidal wetlands are influenced by inundation regime and salinity. Tidal wetlands can be divided into three zones: low marsh, middle marsh, and high marsh (Reclamation et al. 2011). The low tidal wetland zone is tidally inundated once or twice per day. At the lowest elevations, vegetation is inhibited by frequent, prolonged, often deep inundation and by disturbance by waves or currents. The dominant plant species are bulrushes. Other species occurring in the low tidal wetland zone are pickleweed, lowclub rush, common reed, and cattails. The low tidal wetland zone provides foraging habitat for waterfowl and shorebirds, California Ridgway's Rail, California Black Rail, and other wading birds.

The middle tidal wetland zone is tidally inundated at least once per day; there is relatively little cover and no refuge from higher tides, which completely flood the vegetation of the middle marsh. The dominant plant species are pickleweed, saltgrass, and bulrush. Other species occurring in the middle tidal marsh are fleshy jaumea, sea milkwort, rushes, salt marsh dodder, alkali heath, cattail, sneezeweed, and marsh gumplant (Siegel et al. 2010b). The middle tidal wetland zone provides foraging habitat for salt marsh harvest mouse and Suisun shrew, as well as common and special status bird species, including waterfowl and shorebirds, California Ridgway's Rail, California Black Rail, and other wading birds. This zone also provides nesting and foraging habitat for Suisun Song Sparrow and Salt Marsh Common Yellowthroat (Reclamation et al. 2011).

The high tidal wetland zone receives intermittent inundation during the monthly tidal cycle, with the higher elevations being inundated during only the highest tides. Historically, the high marsh was an expansive transitional zone between the tidal wetlands and adjacent uplands. The high marsh and associated upland transition zone have been significantly affected by land use changes (e.g., managed wetlands, agriculture). The dominant plants are native species, such as saltgrass, pickleweed, and Baltic rush, and nonnative species, including perennial pepperweed, poison hemlock, and fennel. Other species occurring in the high tidal marsh are saltmarsh dodder, fleshy jaumea, seaside arrowgrass, alkali heath, brass button, and rabbitsfoot grass.

The high tidal marsh provides habitat for special status plants, including Suisun Marsh aster, Soft bird’s beak, and Suisun thistle (Siegel et al. 2010b). The high marsh zone provides foraging and nesting habitat for waterfowl, shorebirds, California Ridgway's Rail, California Black Rail, and other birds. It also provides foraging and nesting habitat for special status species such as Salt Marsh Harvest Mouse and Suisun Shrew and provides escape cover for Salt Marsh Harvest Mouse, and Suisun Shrew during periods when the middle and lower portions of the high tidal wetland zone are inundated (Reclamation et al. 2011).

Managed wetlands are primarily located within the Suisun Marsh, Cache Slough, and near the confluence of the Mokelumne and Sacramento rivers within the historical limits of the high tidal marsh and adjacent uplands that were diked and leveled for agricultural purposes and later managed to enhance habitat values for specific wildlife species (CALFED 2000). Diked managed wetlands and uplands are the most typical land cover type in the Suisun Marsh area. Managed wetlands are considered seasonal wetlands because they may be flooded and drained several times throughout the year. Watergrass and smartweed are typically the dominant species in managed wetlands that use fresher water. Bulrush, cattail, and tule are the dominant species in managed wetlands that employ late drawdown management. Pickleweed, fat hen, and brass buttons are typical in the higher elevations of the managed wetlands. In marshes with higher soil salinity, pickleweed, saltgrass, and other salt-tolerant species are dominant. Managed wetlands are managed specifically as habitat for wintering waterfowl species, including Northern Pintail, Mallard, American Wigeon, Green-Winged Teal, Northern Shoveler, Gadwall, Cinnamon Teal, Ruddy, and Canvasback ducks; White-Fronted Goose, and Canada Goose. Some wetlands are also managed for breeding waterfowl, especially mallard.

Riparian forest areas (excluding willow-dominated riparian habitats) are still present in some portions of the Delta along many of the major and minor waterways, oxbows, and levees (CALFED 2000). Riparian forest and woodland communities dominated by tree species are mostly limited to narrow bands along sloughs, channels, rivers, and other freshwater features throughout the Delta. Isolated patches of riparian vegetation are also found on the interior of reclaimed Delta islands, along drainage channels, along pond margins, and in abandoned, low-lying fields. Cottonwoods and willows, Oregon ash, boxelder, and California sycamore, are the most typical riparian trees in central California. Valley oak and black walnut are typical in riparian areas in the Delta. Riparian trees are used for nesting, foraging, and protective cover by many bird species and riparian canopies provide nesting and foraging habitat for a variety of mammals. Understory shrubs provide cover for ground-nesting birds that forage among the vegetation and leaf litter.

Riparian scrub in the Delta and Suisun Marsh consists of woody riparian shrubs in dense thickets (SFEI 2012). Riparian scrub thickets are usually associated with higher, sloping, better drained edges of marshes or topographic high areas, such as levee remnants and elevated flood deposits; and along shorelines of ponds or banks of channels in tidal or non-tidal freshwater habitats. Plant species may include willow, blackberry, buttonbush, mulefat, and other shrub species. Willow-dominated habitat types appear to be increasing in extent in recent years; and willows line many miles of artificial levees where waterways historically had flowed into freshwater emergent wetland. Nonnative Himalayan blackberry thickets are a typical element of riparian scrub communities along levees and throughout pastures in the levees. Willow thickets provide habitat for a wide range of wildlife species, including the Song Sparrow, Lazuli Bunting, and Valley Elderberry Longhorn Beetle.

#### 10.3.3.4.2 Yolo Bypass

The Yolo Bypass is a 59,280-acre floodway through the natural-overflow of the Yolo Basin on the west side of the Sacramento River (DWR 2012). As described in Chapter 5, Surface Water Resources and Water Supplies, the Yolo Bypass generally extends north to south from Fremont Weir along the Sacramento River (near Verona) to upstream of Rio Vista along the Sacramento River in the Delta. The bypass, part of the Sacramento River Flood Control Project, conveys floodwaters around the Sacramento River near the cities of Sacramento and West Sacramento. The bypass is utilized as a flood bypass approximately once every 3 years, generally during the period from November to April. Land use in the Yolo Bypass is generally restricted to specific agriculture, managed wetlands, and vegetation communities to ensure that floodway function is maintained (CALFED et al. 2001; USFWS 2002). Agricultural crops include corn, tomatoes, melons, safflower, and rice within the northern bypass; and corn, milo, safflower, beans, tomatoes, and sudan grass in the southern bypass. Waterfowl hunting areas are generally located in the southern bypass, and include rice fields, permanent open water, or a mixture of water and upland habitat. The USACE has developed criteria for managing emergent vegetation (e.g., cattails and bulrushes) in the Yolo Bypass to maintain flood capacity, including no more than 5 percent of the vegetation in seasonal wetlands can be emergent wetlands; no more than 50 percent of the vegetation in permanent wetlands can be emergent wetlands; and riparian vegetation can only occur in specified areas to maintain flood capacity (DFG and Yolo Basin Foundation 2008).

The Yolo Bypass supports several major terrestrial vegetation types, including riparian woodland, valley oak woodland, open water, and wetland. Historically, riparian woodland and freshwater wetland were the dominant habitat types in the Yolo Basin (CALFED et al. 2001; USFWS 2002). Currently, riparian woodland and associated riparian scrub habitats are primarily found adjacent to Green's Lake, Putah Creek, and along the East Toe Drain within the Yolo Bypass Wildlife Area. Riparian woodland is a tree-dominated community found adjacent to riparian scrub on older river terraces where flooding frequency and duration is less. Riparian woodlands include Fremont cottonwood, valley oak, sycamore, willow, eucalyptus, giant reed, and black oak. The understory is typically sparse in this community with limited areas of California grape, blackberry, poison oak, mugwort, grasses, and forbs. The woodland canopy provides habitat for hawks, owls, American Crow, Great Egret, Great Blue Heron, Red-Tailed Kite, Yellow-Rumped Warbler, Black Phoebe, woodpecker, Wood Duck, bat, and raccoon.

Riparian scrub is a shrub-dominated community typically found along stream margins and in the streambed, on gravel bars and similar formations (CALFED et al. 2001; USFWS 2002). This community is typically dominated by phreatophytes (i.e., deep-rooted plants that obtain their water from the water table or the layer of soil just above it), such as willows, and other plants representative of early- to mid-successional stage vegetation communities within riparian areas in the Central Valley. The species include alder, elderberry, cottonwood, wild rose, blackberry, and boxelder. This habitat supports Black-Crowned Night Heron, Snowy Egret, Belted Kingfisher, Black Phoebe, Swallow, and bat. Riparian scrub habitat frequently occurs adjacent to nonwoody riparian habitat, including false bamboo, cocklebur, weedy annual grasses, sedges, rushes, mustard, sweet clover, thistle, and other weedy species. The nonwoody riparian habitat supports Savannah Sparrow, House Finch, American Goldfinch, California Ground Squirrel, Gopher Snake, and pond turtle.

Remnants of valley oak woodlands and savanna occur on floodplain terraces in fragmented areas, including downstream of Fremont Weir and along the southern portion of the Toe Drain (CALFED et al. 2001). The habitat also includes sycamore, black walnut, wild grape, poison oak, elderberry, blackberry, grass, and sedge.

Depending on the duration of inundation, local soil factors, site history, and other characteristics, seasonal wetlands typically are dominated by species characteristic of one of three natural wetland communities: freshwater marshes, alkali marshes, or freshwater seasonal (often disturbed) wetlands (CALFED et al. 2001). Freshwater marsh communities are typically found in areas subjected to prolonged flooding during the winter months, and frequently do not dry down until early summer. Permanent open water is found throughout the Yolo Bypass, including Gray's Bend near Fremont Weir, Green's Lake near Interstate 80, ponds in the Yolo Bypass Wildlife Area, along Cache and Prospect sloughs, and within canals and drainage ditches. The wetlands support duck breeding habitat; and habitat for many lifestages of grebe, ibis, heron, egret, bittern, coot, rails, raptors, muskrat, raccoon, opossum, beaver, Ring-Necked Pheasant, garter snake, Pacific Tree Frog, and bullfrog.

Managed wetlands in the Yolo Bypass occur near Fremont Weir, in the 16,770-acre Yolo Bypass Wildlife Area, and within and near Cache Slough. The managed wetlands are generally flooded in the fall, with standing water maintained continuously throughout the winter until drawdown occurs in the following spring (CALFED et al. 2001; DFG and Yolo Basin Foundation 2008). A primary objective of seasonal wetland management is to provide an abundance and diversity of seeds, aquatic invertebrates, and other foods for wintering waterfowl and other wildlife. The wetlands also are managed to control the extent of tules and cattails; and more recently, water hyacinth. A portion of the managed wetlands occur within rice fields which are flooded in the winter to provide waterfowl habitat for feeding and resting habitats. A variety of annual plants germinate on the exposed mudflats of seasonal wetlands during the spring draw down, including swamp timothy, watergrass, smartweed, and cocklebur. These plants are then managed through the timing, duration or absence of summer irrigation. The mudflats support sandpiper, plover, avocet, stilt, and other shorebirds.

Managed semi-permanent wetlands, commonly referred to as “brood ponds,” are flooded during the spring and summer, but may experience a 2 to 6 month dry period each year. These semi-permanent wetlands provide breeding ducks, ducklings, and other wetland wildlife with protection from predators and abundant invertebrate food supplies (DFG and Yolo Basin Foundation 2008). Permanent wetlands remain flooded throughout the year. Due to year-round flooding, permanent wetlands support a diverse, but usually not abundant, population of invertebrates. Permanent managed wetlands provide deep water habitat for diving ducks, such as Ruddy Duck, Scaup, and Goldeneye; and other water birds, including Pied-Billed Grebe, coot, and moorhen. They often have dense emergent cover on their edges that is the preferred breeding habitat for Marsh Wren and Red-Winged Blackbird; and roosting habitat for Black-Crowned Night Heron, White-Faced Ibis, and egret.

The managed wetlands are operated by private hunting clubs; private conservation entities, including conservation banks; and the Federal and state governments (CALFED et al. 2001). Some of the hunting clubs have implemented wetland management agreements with CDFW under the State Presley Program or Wetland Easement Program to coordinate the timing and patterns of flooding, drawdowns, irrigation, soil disturbance, and maintenance of brood habitat. The patterns may be adjusted annually to respond to specific wildlife and hydrologic needs. A similar program focused on providing spring habitat for breeding is provided by the Federal Waterbank Program.

Habitat in the Yolo Bypass is affected by periodic flooding (CALFED et al. 2001). Following a flood, roads, canals, and ditches may need to be excavated; debris needs to be removed from habitat, and water delivery facilities may need to be repaired. Flooding also disrupts nesting and resting activities of birds. During floods, hunting activities are diminished or ceased.

#### 10.3.3.4.3 Agricultural Lands in the Delta, Suisun Marsh, and Yolo Bypass

Major crops and cover types in agricultural production in the Delta and Suisun Marsh include small grains (wheat and barley), field crops (corn, sorghum, and safflower), truck crops (tomato and sugar beet), forage crops (hay and alfalfa), pastures, orchards, and vineyards. The distribution of seasonal crops varies annually, depending on crop rotation patterns and market forces. In many areas, cropping practices result in monotypic stands of vegetation for the growing season and bare ground in fall and winter. Some farmland is more intensively managed to provide wildlife habitat in addition to crops. Regular maintenance of fallow fields, roads, ditches, and levee slopes can reduce the establishment of ruderal vegetation or native plant communities.

Agriculture has been present in the Yolo Bypass since the seasonal wetlands and perennial marsh and riparian areas were first converted to farms in the mid-1800s. For many years, grazing was the primary use of agricultural lands in the Yolo Bypass. In the latter part of the 20th century, irrigation systems were developed and fields were engineered for the production of row crops (DFG and Yolo Basin Foundation 2008). Periodic flooding of the bypass limits the types of crops that can be grown. The Yolo Bypass Wildlife Area utilizes agriculture to manage habitats while providing income for the management and operation of the property. Working with local farmers, the Yolo Bypass Wildlife Area provides fields of milo, corn, and Sudan grass specifically for wildlife forage. Rice is grown, harvested, and flooded to provide food for thousands of waterfowl. Corn fields are harvested to provide forage for geese and cranes. Crops such as safflower are cultivated and mowed to provide seed for upland species such as Ring-Necked Pheasant and Mourning Dove. Row and truck crops are grown across the northern half of the Yolo Bypass Wildlife Area. The primary crops grown include rice, corn, millet, milo, safflower, sunflower, and tomatoes. These crops are cultivated during the summer months. From fall to spring, some farmed areas are fallowed and flooded to provide forage for wildlife as well as seasonal wetland habitat. An extensive area at the southern end of the wildlife area is used for grazing cattle. Cattle are brought onto the Yolo Bypass Wildlife Area in mid-spring or early summer after the threat of flooding has passed and are removed by January. Forage is provided in irrigated pasture, uplands within the bypass and the annual grassland-vernal pool complex. Alfalfa is only grown in the western portion of the bypass south of Interstate 80, along with a variety of row crops that are grown in this region (Yolo County 2013).

#### 10.3.3.4.4 Wildlife Refuges in the Delta, Suisun Marsh, and Yolo Bypass

A number of wildlife areas that could be affected by changes in long-term operations of CVP and SWP are located in the Delta, Suisun Marsh, and Yolo Bypass. Conditions in the Yolo Bypass, including the Yolo Bypass Wildlife Area, are described above and not repeated in this subsection.

*Stone Lakes National Wildlife Refuge*

The Stone Lakes NWR is located in the Beach-Stone Lakes Basin about 10 miles south of the city of Sacramento. It was established in 1994 and the refuge area is approximately 18,000 acres, of which about 9,000 acres is in a core refuge area owned by the USFWS and an approximately 9,000-acres “Cooperative Wildlife Management Area” where the USFWS seeks to enter into cooperative agreements or purchase conservation easements from willing landowners. The USFWS actively manages around 6,000 acres on the refuge (USFWS 2007).

The refuge vegetative communities include agricultural lands, open water, perennial freshwater wetlands, cottonwood-willow riparian, irrigated pasture and wet meadow, managed permanent and seasonal wetland, orchards, riparian scrub, upland forest, valley oak riparian woodland, vernal pool, and grasslands that facilitate wildlife movement and help compensate for habitat fragmentation and buffers the effects of urbanization on agricultural lands in the Delta region (USFWS 2007).

The diverse vegetation provides habitat for a wide ranges of mammals, birds, reptiles, and amphibians similar to those described for other sections of the Sacramento Valley (USFWS 2007). The grasslands, pastures, woodlands support White-Faced Ibis, Geese, Black-Bellied Plover, Great Blue Heron, Great Egret, Greater Sand Hill Crane, Northern Harrier, White-Tailed Kite, Red-Shouldered Hawk, Swainson’s Hawk, Great Horned Owl, Barn Owl, Bald Eagle, Golden Eagle, American Kestrel, Prairie Falcon, Tree Swallow, Barn Swallow, Cliff Swallow, songbirds, and birds that use the grasslands, including killdeer, Ring-Necked Pheasant, Burrowing Owl, Mourning Dove, Brewer’s Blackbird, and Turkey Vulture. The waterfowl species include Tundra Swan, White-Fronted Goose, Snow Goose, Canada Goose, Mallard, Northern Pintail, Northern Shoveler, Cinnamon Teal, Green-Winged Teal, Wood, and Ruddy ducks. The wetland areas also support Common Yellowthroat, Red-Winged Blackbird, Marsh Wren, coot, Cormorant, and American White Pelican. Other wildlife species on this refuge include coyote, Deer Mouse, Pocket Gopher, Black Tailed Hare, California Vole, California Ground Squirrel, Pacific Tree Frog, bullfrog, pond turtle, Pond Slider Turtle, Western Fence Lizard, Western Terrestrial Garter Snake, Gopher Snake, Common Garter Snake, California King Snake, and Western Toad.

The riparian cottonwood forests include Fremont cottonwood, Gooding’s willow, California grape, California boxelder, California blackberry, white-stemmed raspberry, buttonbush, and blue elderberry. The mixed riparian forest includes valley oak with vegetation similar to the riparian cottonwood forest but at lower densities. The valley oak riparian forest is dominated by valley oak, Oregon ash, California sycamore, and California black walnut with an understory of grasses, vines, and shrubs, including California blackberry and wild rose. The perennial wetlands include cattails, tules, cottonwood, willows, sedges, and rushes with areas of watergrass, smartweed, and swamp timothy that also occur in seasonal wetlands. The riparian vegetation provides vast amounts of insects, perches, and cover to support the wide range of bird species, the valley oak woodlands provide acorns, insects, and perch and nesting sites. The wetland sites provide foraging opportunities for waterbirds and upland species.

*Miner Slough Wildlife Area*

The Miner Slough Wildlife Area within the Delta is about 10 miles north of Rio Vista at the junction of Miner and Cache sloughs and is accessed by boat (CDFW 2014d). The 37-acre Wildlife Area includes approximately 10 acres of tidal wetlands which become a narrow peninsula extending from Prospect Island at low tide. The riparian vegetation of willow, cottonwood, tules, and blackberry support a wide range of wildlife species including beaver, black-crowned night heron, and waterfowl.

*Decker Island Wildlife Area*

Decker Island is a 648-acre island located about 20 feet above sea level surrounded by the Sacramento River and Horseshoe Bend in the Delta just south of Rio Vista (DWR 2003; Philipp 2005). The island was created between 1917 and 1937 as part of the actions to implement the Sacramento Deep Water Ship Channel, as described in Chapter 5, Surface Water Resources and Water Supplies. CDFW owns the northernmost 33 acres of Decker Island and has been working with the California Department of Water Resources (DWR) to reestablish and enhance wetland and upland habitats. The vegetation includes shallow water channels lined with thick stands of tules, sedges, willow, and alder. Many mammal species have been observed, including river otter, mink, beaver, coyote, mice, and voles. Various species of raptors, waterfowl, songbirds, and shorebirds have also been observed. Amphibians and reptiles such as Pacific Tree Frog, Western Fence Lizard, and Gopher Snake have been seen. Invasive plants such as perennial pepperweed, yellow star thistle, water hyacinth, Brazilian water weed and Egeria continue to pose a threat to restoration efforts.

*Lower Sherman Island Wildlife Area*

The Lower Sherman Island Wildlife Area occupies roughly 3,100 acres, primarily marsh and open water, at the confluence of the Sacramento and San Joaquin Rivers in the western Delta (DFG 2007). Riparian vegetation is characterized by narrow linear strips of trees and shrubs, in single-to multiple story canopies. Riparian vegetation primarily occurs along the historic levees above elevations that support tidal marsh. Native woody plant species occurring in the riparian strip include Fremont cottonwood, willow, red alder, and California wild rose. The invasive nonnative, Himalayan blackberry infests many of these areas. Marsh vegetation includes both emergent marsh and areas of floating aquatic vegetation. Most emergent marsh is dominated by bulrush, cattail, and common reed. In the northwestern portion of Lower Sherman Island, there is also upper elevation marsh dominated by pickleweed and saltgrass. Grasslands are dominated by annual grasses, but also include many perennial species that are also typical in seasonal wetlands. Pampas grass and perennial pepperweed, two invasive nonnative species are also found in the grassland areas.

At the Lower Sherman Island Wildlife Area, habitat exists for a wide variety of wildlife species, including numerous bird species, mammals, reptiles, and amphibians (DFG 2007). Many of the bird species that occur in the wildlife area are migratory and are there only, or primarily, during the fall and winter months. Wintering birds include waterfowl, shorebirds, wading birds, and raptors. Other groups that utilize the wildlife area seasonally include upland game species, cavity-nesting birds, and neotropical migratory birds. Typical mammal species found in the upland grassland and disturbed areas of the wildlife area include Striped Skunk, raccoon, squirrel, voles, Pocket Gopher, feral cats, fox, and coyote. Muskrat and beaver may be found in the marsh vegetation. Typical reptiles and amphibians include Western Fence Lizard, snake, frog, and toad.

*Rhode Island Wildlife Area*

Rhode Island Wildlife Area is a 67-acre island, located in Contra Costa County that is managed by CDFW (CDFW 2014e). The vegetation along the perimeter of the island includes alder, willow, blackberry, and tule. The interior open water areas include marsh vegetation of tule and cattail. The island provides habitat for river otters, beaver, muskrat, and many species of birds including Great Blue Heron; Black-Crowned Night Heron; egrets; and Mallard, Cinnamon Teal, and Wood ducks.

*White Slough Wildlife Area*

The White Slough Wildlife Area, west of Lodi and north of Stockton, is an 880-acre area refuge with open water, freshwater marsh, grassland/upland area, and riparian habitats (CDFW 2014f). The area supports upland game birds such as Ring-Necked Pheasant, California Quail, Mourning Dove, and a range of waterfowl species similar to those described for the Delta and Yolo Bypass.

*Hill Slough Wildlife Area*

Hill Slough Wildlife Area, located in the northern part of Suisun Marsh, is operated by CDFW and contains 1,723 acres of saltwater tidal marsh, managed marshes, slough, and upland grassland (CDFW 2014g). The area supports a wide variety of waterfowl, including Northern Pintail, Mallard, Northern Shoveler, and Green-Winged Teal ducks; and American wigeon. Ferruginous Hawks and Rough-Legged Hawks winter in the area while year-round residents such as Golden Eagle, Northern Harrier, and Red-Tailed Hawk which forage over the ponds and upland areas. Mammals including raccoon, jackrabbit, and voles are found here and are preyed upon by the coyotes that hunt and live in the wildlife area.

*Grizzly Island Wildlife Area*

Grizzly Island Wildlife Area is administered by CDFW and consists approximately 15,300 acres of tidal wetlands and managed marshes within Suisun Marsh (CDFW 2014h, 2014i). The CDFW manages waterways to create more than 8,500 acres of seasonal ponds containing alkali bulrush and fat-hen. Grizzly Island Wildlife Area includes habitats that support Northern Pintail Duck, Green-Winged Teal Duck, American Widgeon, Tule Goose, egret, Great Blue Heron, Snowy Egret, Black-Crowned Night Heron, Yellowthroat, Marsh Wren, Suisun Song Sparrow, American White Pelican, Ferruginous Hawk, Sharp-Shinned Hawk, white Tailed Kite, Red-Tailed Hawk, Prairie Falcon, Peregrine Falcon, Northern Harrier, and Short-Eared Owl. The Grizzly Island Wildlife Area also supports mammals, including Plush River Otter and Tule Elk.

*Point Edith Wildlife Area*

Point Edith Wildlife Area is located in Contra Costa County, approximately 2.5 miles east of Martinez. The Point Edith Wildlife Area includes approximately 760 acres of marshes which is accessed by boat. The habitat includes open water and tidal wetlands that support waterfowl, including coot and moorhen (CDFW 2014j).

*Fremont Weir Wildlife Area*

The Fremont Weir Wildlife Area is located within the Yolo Bypass from the Sacramento River to downstream of the Fremont Weir. During high flows, water from the Sacramento River flows into the Yolo Bypass over the Fremont Weir as part of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies. The 1,461-acre refuge includes valley oak, willow, cottonwood, brush, and weedy vegetation (CDFW 2014k). The area supports pheasant, Valley Quail, Mourning Dove, a range of waterfowl species similar to those described for the Yolo Bypass, Cottontail Rabbit, and jackrabbit.

*Sacramento Bypass Wildlife Area*

The Sacramento Bypass Wildlife Area is located along a channel that connects the Sacramento River to the Yolo Bypass. During high flows, water from the Sacramento River flows into the Yolo Bypass through the Sacramento Bypass as part of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies. The 360-acre refuge includes valley oak, willow, cottonwood, and weedy vegetation (CDFW 2014l). The area supports raptors, songbirds, pheasant, Mourning Dove, and a range of mammal species similar to those described for the Yolo Bypass.

*Calhoun Cut Ecological Reserve*

The Calhoun Cut Ecological Reserve is located within the Cache Slough area and is only accessed by boat through Lindsay Slough (CDFW 2014m). Vegetation in Calhoun Cut includes grasslands, marshes, and riparian vegetation (Witham and Karacfelas 1994). The grasslands include native purple needlegrass grasslands and vernal pools.

### 10.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, San Benito, and Napa counties that are within the CVP and SWP service areas. The CVP and SWP water supplies are used in the San Francisco Bay Region by Contra Costa Water District, East Bay Municipal Utility District, Zone 7 Water Agency, Alameda County Water District, Santa Clara Valley Water District, San Benito County Flood Control and Water Conservation District, and Napa County Flood Control and Water Conservation District. The majority of the CVP and SWP water uses in the San Francisco Bay Area Region are for municipal and industrial land uses. Agricultural areas that use CVP and SWP water are located within coastal valleys, especially within the Livermore-Amador valleys of Alameda County, southern Santa Clara County, and northern San Benito County.

Many of these agencies store the CVP and/or SWP water supplies in surface water reservoirs, including CVP Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. CVP and SWP are generally not stored in reservoirs within Santa Clara County (SCVWD 2010). Operation of the reservoirs is dependent upon the volume of CVP and/or SWP water blended with other water supplies used by these agencies. Surface water streams are not used to convey the water from the CVP and/or SWP facilities to the reservoirs. As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved two habitat conservation plans in the areas served by CVP and SWP water supplies, including the East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan and the Santa Clara Valley Habitat Plan (ECCCHCPA 2006; Reclamation et al. 2009; Santa Clara County et al. 2012).

#### *10.3.4.1 Central Valley Project Reservoirs*

The CVP reservoirs in the San Francisco Bay Area Region include Contra Loma and San Justo reservoirs.

##### 10.3.4.1.1 Contra Loma Reservoir

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal, as described in Chapter 5, Surface Water Resources and Water Supplies. The 80-acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014a). The Contra Loma Reservoir area includes open space and recreation facilities. In the open space, vegetative communities include grasslands, blue oak woodland, valley foothill riparian, fresh emergent wetlands, riverine, and open water communities. The annual grasslands include smooth brome, slender wild oats, Italian ryegrass, yellow star thistle, white-stem filaree, and mouse-ear chickweed. Valley foothill riparian occurs along intermittent streams and includes valley oaks, cottonwoods, red willows, Himalayan blackberry, poison oak, and mulefat. The riverine and fresh emergent wetland communities include ryegrass, curly dock, hyssop, loosestrife, Baltic rush, flowering quillwort, cattails, rushes, dallis grass, nutsedge, and cocklebur. Watermilfoil occurs along portions of the shoreline. Recreation areas include urban trees with Oregon ash, black walnut, Fremont cottonwood, blue oak, valley oak, interior live oak, fig, and eucalyptus. East Bay Regional Parks District has initiated restoration actions to improve native grasslands and riparian and provide habitat for quail.

Wildlife in the grasslands areas include Burrowing Owl, Horned Lark, Western Meadowlark, Turkey Vulture, Northern Harrier, American Kestrel, White-Tailed Kite, Red-Tailed Hawk, Brewer's Blackbird, Mourning Dove, Western Fence Lizard, Common Garter Snake, Western Rattlesnake, Black-Tailed Jackrabbit, California Ground Squirrel, Botta's Pocket Gopher, Western Harvest Mouse, California Vole, American Badger, Mule Deer, and coyote (Reclamation 2014a). The valley foothill riparian and blue oak woodland vegetation support a wide range of birds including Northern Flicker, Yellow Warbler, Acorn Woodpeckers, Western Scrub Jay, White-Tailed kite, Cooper's Hawk, Red-Shouldered Hawk, American Kestrel, Great Horned Owl, Song Sparrow, Black Phoebe, European Starling, Western Bluebird, and Tree Swallow. The valley foothill riparian and blue oak woodland vegetation also support Pacific Tree Frog, Red-legged Frog, Sharp-Tailed Snake, California Alligator Lizard, Common Garter Snake, Mule Deer, Raccoon, Coyote, Striped Skunk, Deer Mouse, Harvest Mouse, Dusky-Footed Woodrat, and Gray Fox. Riverine and wetlands, and open water support Brewer's Blackbird, Red-Winged Blackbird, Brown-Headed Cowbird, Great Blue Heron, Great Egret, ducks, American Coot, Common Merganser, Double-Crested Cormorant, American Wigeon, Canada Goose, Western Grebe, and gull; Pacific Tree Frog, Red-legged Frog, Bullfrog, California Tiger Salamander, Western Pond Turtle, Western Toad, and Garter Snake; Deer Mouse, California Vole, Long-Tailed Weasel, and other mammals that use the adjacent woodlands and grasslands.

##### 10.3.4.1.2 San Justo Reservoir

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. The reservoir is surrounded by steep hills with recreational facilities on the northeast side reservoir and intermittent streams, wetlands, and open water downslope of the reservoir (SBCWD 2012). Adjacent land uses are dominated by irrigated row crops, orchards, and rangeland. Vegetation and wildlife resources of the reservoir area are consistent with grasslands vegetation on uplands.

#### *10.3.4.2 State Water Project Reservoirs*

Bethany Reservoir, Patterson Reservoir, and Lake Del Valle are SWP facilities associated with the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies.

Vegetative communities around Bethany Reservoir are characterized by nonnative grasses with several areas of woodland habitat (DWR 2014). The grassland habitat includes slender oat, ripgut brome, soft chess, wild barley, Italian ryegrass, black mustard, bull thistle, redstem filaree, dissected geranium, English plantain, and tumble mustard; and forbs, including sweet fennel, Great Valley gumweed, Mediterranean linseed, and Ithuriel's spear. The woodland habitat includes white ironbark, Casuarina, and Bishop pine. Coyote bush occurs along the water edge. The grasslands provide habitat for Mourning Dove, Western Scrub-Jay, Finches, Sparrows, Owls, Hawks, California Ground Squirrel, Black-Tailed Jackrabbit, Audubon's Cottontail, Botta's Pocket Gopher, California vole, mice, frogs, toads, salamanders, snakes, lizards, and turtles. The woodlands support Red-Tailed Hawk, Osprey, Owls, Black Phoebe, Bullock's Oriole, Yellow Warbler, amphibians and reptiles, and coyote. Emergent vegetation does not occur along the shoreline at Bethany Reservoir (DWR 2005).

Patterson Reservoir is a small, 100-acre-foot, SWP reservoir located along the South Bay Aqueduct between Bethany Reservoir and Lake Del Valle. Vegetation around Patterson Reservoir is characterized by grasslands and upland habitat. Red-legged Frog has been observed in the vicinity of Patterson Reservoir (DWR 2014).

Lake Del Valle is a 77,100 acre-foot SWP facility located along the South Bay Aqueduct (DWR 2001). Vegetation around Lake Del Valle includes grasslands, chaparral, shrub, oak woodland, and riparian and freshwater habitats (EBRPD 1996, 2001, 2012, 2013). The grasslands include nonnative grasses and native perennial bunchgrass. The nonnative grasslands include grasses such as wild oats, bromes, ryegrass, wild barley, silver hairgrass, and dogtail grass; forbs, including filaree, clover, and plantain; and lupine, yarrow, and soap plant. Native grasses include annual and perennial fescues, needlegrass, wild ryes, junegrass, and California bromegrass. The coastal scrub and chaparral vegetation includes coyote brush-scrub, California sagebrush, manzanita, black sage, cream bush, California coffeeberry, yerba santa, blackberry, bush monkeyflower, and poison oak. The oak woodlands and riparian woodlands include coast live oak, black oak, valley oak, scrub oak, California bay, and California buckeye. Mixed deciduous riparian woodlands occur along perennial streams, including white alder, big-leaf maple, western sycamore, willow, and Fremont cottonwood. Along springs and seeps, the vegetation includes rabbitsfoot grass, saltgrass, bentgrasses, rushes, tules, sedges, horsetails, and cattail, buttercup, brass-button, mint, duckweed, pondweed, and ferns.

#### *10.3.4.3 Contra Costa Water District Los Vaqueros Reservoir*

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. The area around the Los Vaqueros reservoir includes grasslands, upland scrub, valley and foothill woodlands, freshwater wetlands, and open water habitats (Reclamation et al. 2009). The grasslands include perennial and alkali habitats with wild oats, ripgut brome, yellow star thistle, fescue, filaree, mustard, fiddleneck, lupine, popcorn flower, and California poppy. The grasslands support Northern Harrier, Burrowing Owl, Western Meadowlark, California Horned Lark, Turkey Vulture, Red-Tailed Hawk, American Kestrel, White-Tailed Kite, Western Fence Lizard, Common Garter Snake, Western Rattlesnake, California Tiger Salamander, Western Harvest Mouse, California Ground Squirrel, Black-Tailed Jackrabbit, Black-Tailed Deer, and San Joaquin Kit Fox.

The upland scrub habitat is dominated by evergreen chaparral species and coastal scrub, including chamise, California sagebrush, black sage, poison oak, bush monkeyflower, and California buckwheat underlain by annual grasses and purple needlegrass (Reclamation et al. 2009). This habitat supports California Quail, Western Scrub-Jay, Bushtit, California Thrasher, Spotted Towhee, Sage Sparrow, Western Fence Lizard, Common Garter Snake, Common King Snake, Western Rattlesnake, California Mouse, Deer Mouse, and feral pig.

The valley and foothill woodlands and riparian woodlands includes willow, Fremont cottonwood, valley oak, sycamore, black walnut, California buckeye, Mexican elderberry, and Himalayan blackberry which occur along much of Kellogg Creek (Reclamation et al. 2009). This habitat supports many birds, reptiles, amphibians, and mammals, including red-legged frog. The freshwater emergent habitat includes meadows with wetland species and stream channels. The vegetation includes tules, bulrushes, and cattail. Wildlife that occurs in this area include Marsh Wren, Common Yellowthroat, Red-Winged Blackbird, Red-legged Frog, and Western Pond Turtle. The open water habitat of the Los Vaqueros Reservoir provides forage, winter, and brood habitat for Canada Goose; American Wigeon; Wood,, Gadwall, Mallard, Northern Shoveler, Northern Pintail, Green-Winged Teal, Canvasback, Redhead, Ring-Necked, Greater Scaup, Lesser Scaup, Bufflehead, Common Goldeneye, Hooded Merganser, Common Merganser, and Ruddy ducks; and other habitat values for grebe, sandpiper, pelican, cormorant, egret, heron, and gull.

#### *10.3.4.4 East Bay Municipal Utility District Reservoirs*

The East Bay Municipal Utility District reservoirs in Alameda and Contra Costa County used to store water within and near the East Bay Municipal Utility District service area include Briones Reservoir, San Pablo Reservoir, Lafayette Reservoir, Upper San Leandro Reservoir, and Lake Chabot. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies.

The Briones Reservoir watershed is characterized by grasslands, chaparral, coastal scrub, oak and bay woodlands, riparian, and freshwater wetlands (EBMUD 1999; EBRPD 1996, 2001, 2013). The San Pablo Reservoir watershed is characterized by grasslands, hardwood forest, coastal scrub, Monterey pine planted along the reservoir shoreline, riparian woodland, and eucalyptus. The Lafayette Reservoir watershed is characterized by grasslands, oak and bay woodland, and coastal scrub. The Upper San Leandro Reservoir watershed includes grasslands, chamise-black sage chaparral, coastal scrub, oak and bay woodland, redwood forest, knobcone forest with a dense manzanita understory, and an 18-acre freshwater marsh. The Lake Chabot watershed includes grasslands, coastal scrub, oak and bay woodland, and riparian and freshwater vegetation.

The grasslands vegetative communities generally include nonnative grasses and native perennial bunchgrass (EBMUD 1999; EBRPD 1996, 2001). The nonnative grasslands include grasses such as wild oat, bromegrass, ryegrass, wild barley, bluegrass, silver hairgrass, and dogtail grass; forbs, including filaree, bur clover, clovers, owls clover, cat's ear, and English plantain; and brodiaeas, lupine, mariposa lilies, mule's ear, yarrow, farewell to spring, and soap plant. Native grasses include annual and perennial fescues, needlegrass, wild rye, California oatgrass, junegrass, bluegrass, squirreltail, meadow barley, and California bromegrass. Grasslands are used by wildlife similar to those described for other San Francisco Bay Area reservoirs, including hawks, owls, shrikes, swallows, turkey vulture, reptiles, coyote, fox, bobcat, and mice.

The coastal scrub and chaparral vegetation includes coyote brush-scrub, California sagebrush, bitter cherry scrub, manzanita, chamise-black sage, cream bush, California coffeeberry, wild lilac, yerba santa, blackberry, bush monkeyflower, and poison oak (EBMUD 1999; EBRPD 1996, 2001). The woodlands include native and nonnative plants. The native redwood and knobcone pine forests are located at Upper San Leandro Reservoir and provide unique habitat. Nonnative eucalyptus and Monterey pine forests occur at San Pablo Reservoir and Lake Chabot. The eucalyptus trees provide specific habitat for hummingbird, Bald Eagle, Great Blue Heron, and Great Egret. The oak and bay woodlands and oak savannas include coast live oak, black oak, valley oak, blue oak, interior live oak, canyon live oak, California bay, California buckeye, and madrone.

Mixed deciduous riparian woodland occur along perennial streams, including white alder, big-leaf maple, western sycamore, Fremont cottonwood, and black cottonwood that supports frogs, newts, and other amphibians; coast live oak, California bay, and willow woodlands on steep slopes along intermittent streams; and willow riparian scrub along perennial and intermittent streams (EBMUD 1999; EBRPD 1996, 2001). Along springs and seeps, the vegetation includes grasses, includes rabbitsfoot grass, saltgrass, bentgrasses, rushes, tules, sedges, horsetails, and cattail; and forbs includes buttercup, watercress, stinging nettle, brass-buttons, mints, duckweed, and pondweed.

### 10.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The SWP water is provided to the Central Coast Region by the Central Coast Water Authority (CCWA 2013). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to a water treatment plant at Polonto Pass. The treated water is conveyed to municipal water users in San Luis Obispo and Santa Barbara counties to reduce groundwater overdraft in these areas. Water is delivered to southern Santa Barbara County communities through Cachuma Lake.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

#### 10.3.5.1 Cachuma Lake

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County, as described in Chapter 5, Surface Water Resources and Water Supplies. The Cachuma Lake watershed is located in the Coast Range and extends into the Los Padres National Forest. The primary habitats include hardwood woodland, chaparral, coastal sage scrub, nonnative grassland, and riparian woodland and scrub (Reclamation 2010c). The hardwood woodlands includes oak woodland, oak savannah, and pine woodland with blue oak, coast live oak, gray pine, skunk brush, and poison oak. The chaparral and coastal sage scrub includes mountain mahogany, greenbark ceonothus, blue oak, interior live oak, scrub oak, holly leaf redberry, buck brush, toyon, chaparral mallow, chamise, California sage brush, purple sage, deer weed, and coyote brush-scrub with understory of grasses and forbs. Birds that use the hardwood woodlands and savannah include Turkey Vulture; raptors including Red-Tailed Hawk and Bald Eagle; woodpecker, California Quail, Rufous-Crowned Sparrow, wrentit, California Thrasher, and Spotted Towhee. Nonnative grasslands are dominated by rip-gut brome and dove weed. Native grasses include purple needlegrass, blue-eyed grass, Johnny-jump-up, Chinese houses, rusty popcorn flower, slender cottonseed, forget-me-not, lupine, mountain dandelion, checkerbloom, narrow-leaved milkweed, fleabane, vinegar weed, California milkweed, and verbena.

Riparian habitat along streams and stream terraces include arroyo willow, red willow, yellow willow, black willow, sycamore, oak, cottonwood, Pacific blackberry, California rose, poison oak, elderberry, mulefat, California goldenrod, California brome, black mustard, mugwort, clover, stinging nettle, red brome, and California buckwheat (Reclamation 2010c). Habitat near the shoreline of Cachuma Lake includes willows, tamarisk, cattail, mulefat, and mugwort. Disturbed lands around the lake are characterized by weedy species, including yellow star thistle, Spanish broom, tamarisk, giant reed, pampas grass, scotch broom, veldt grass, perennial pepperweed, red brome, fennel, and cheatgrass. Marginal vegetation, reedy marshes, and riparian woodland support killdeer, spotted Sandpiper, Red-Winged Blackbird, Common Yellowthroat, Song Sparrow, Marsh Wren, Warbling Vireo, Yellow Warbler, Yellow-Breasted Chat, and Brown-Headed Cowbird. The open water of Cachuma Lake supports diving birds, including diving duck, American Coot, Pied-Billed Grebe, Western Grebe, Clark’s Grebe, Double-Crested Cormorant, Heron, Egret, pelican, Osprey, and Bald Eagle. Amphibians and reptiles that occur near Cachuma Lake include Monterey Salamander, California Slender Salamander, Western Spadefoot, California Toad, Pacific Tree Frog, Bullfrog, Red-legged Frog, Yellow-Legged Frog, Southwestern Pond Turtle, Western Skink, and Southern Alligator Lizard. Mammals which depend upon habitat near Cachuma Lake include bat, hare, rabbit, pika, bear, coyote, fox, weasel, raccoon, cats, chipmunk, squirrel, marmot, shrew, mice, rat, mule deer, and feral pig.

### 10.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

The SWP water supplies generally are conveyed to Southern California municipal, industrial, and agricultural water users in canals and pipelines. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs store SWP water, including United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente Reservoir and Lower Otay Reservoir; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved several habitat conservation plans in the Southern California Region within areas served by CVP and SWP water, including the following plans (County of Orange 1996; Riverside County 2003; Riverside County Habitat Conservation Agency 2014; SDCWA and USFWS 2010; San Diego County 2014a, 2014b, 2015; SANDAG 2003; CVAG 2007).

- County of Orange Central and Coastal Subregion Natural Community Conservation Plan and Habitat Conservation Plan.
- Western Riverside County Multiple Species Conservation Plan.
- Habitat Conservation Plan for the Stephen's Kangaroo Rat in Western Riverside County which is administered by the Riverside County Habitat Conservation Agency for Riverside County and the cities of Corona, Hemet, Lake Elsinore, Menifee, Moreno Valley, Murrieta, Perris, Riverside, Temecula, and Vail Lake, and which includes areas around Diamond Valley Lake and Lake Skinner.
- San Diego County Water Authority Subregional Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP).
- San Diego County Multiple Species Conservation Plan including the initial area which includes the lands served by the City of San Diego Wastewater Sewer System; future North County Plan expansion (extends from the areas near the cities of Oceanside, Encinitas, San Marcos, Vista, and Escondido to the Cleveland National Forest and Riverside County boundary), and remaining land within the county (including lands from Alpine east to the Imperial and Riverside counties boundaries).
- Multiple Habitat Conservation Program for the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista.
- Coachella Valley Multiple Species Habitat Conservation Plan.

#### *10.3.6.1 State Water Project Reservoirs*

The SWP reservoirs include Quail Lake, Pyramid Lake, and Castaic Lake in Los Angeles County; Silverwood Lake and Crafton Hills Reservoir in San Bernardino County; and Lake Perris in Riverside County, as described in Chapter 5, Surface Water Resources and Water Supplies.

Quail Lake was formed by seismic activity on the San Andres Fault and enlarged by the Department of Water Resources (DWR) as part of the West Branch of the SWP (DWR 1997). Quail Lake is bordered by the Tehachapi and Liebre Mountains. The area is characterized by cottonwood and oak woodlands that support Crested Sparrow, Red-Winged Blackbird, Golden Eagle, Red-Tailed Hawk, fox, coyote, deer, squirrel, and Pronghorn Antelope. The open water habitat support Canada Geese, egrets and Blue Herons

Pyramid Lake is located in the Angeles and Los Padres National Forests, as described in Chapter 15, Recreation Resources. Upland areas around Pyramid Lake are assumed to be similar to upland areas around Middle Piru Creek downstream of Pyramid Dam (DWR 2004c). The vegetative communities include coastal sage scrub and chaparral with oak woodlands and nonnative grasslands. Water is released from Pyramid Lake to provide habitat flows in Piru Creek, including flows to support habitat for the Arroyo Toad.

Terrestrial resources for Castaic Lake include coastal scrub, red shank-chamise chaparral, and chaparral scrub (DWR 2007b). Castaic Lagoon is located immediately downstream of Castaic Dam and is surrounded by coastal scrub. Vegetation includes pines, eucalyptus, and nonnative and native grasses. The habitat is used by Western Grebe, Canada Goose, Mallard Duck, gull, American Coot, Bald Eagle, and Western Mastiff Bat.

Silverwood Lake is located in the San Bernardino National Forest and surrounded by the Silverwood Lake State Recreation Area at the edge of the Mojave Desert and at the base of the San Bernardino Mountains. The area contains a wide variety of vegetative communities including live oak and scrub oak woodlands, ponderosa pine and Douglas-fir forests, mixed scrub, chaparral, and riparian hardwood (State Parks 2006, 2009). Chamise, interior live oak, manzanita, mountain mahogany, and ceanothus are found along the shoreline and willow, alders, and sycamores grow along area streams. The forest, chaparral, and riparian woodland habitats support a wide variety of small mammals, reptiles, and amphibians including rabbit, squirrel, woodrat, Western Fence Lizard, Rattlesnake, Pacific Tree Frog, California Toad, coyote, Mule Deer, bobcat, beaver, and skunk. The open water supports Great Blue Heron, Western Grebe, Avocet, Egret, Canada Goose, and ducks. A number of raptors are found around the lake including Bald Eagle, Osprey, owls, Cooper’s Hawk, and Red-Tailed hawk.

The Crafton Hills Reservoir area includes 4.5 acres of open water and 1.9 acres of open space (DWR 2009b). The open space is characterized by chaparral scrub and grass species, including chamise, golden yarrow, hoaryleaf ceanothus, brittlebush, California sagebush, California buckwheat, deerweed, black sage, purple needlegrass, heartleaf penstemon, ripgut grass, soft chess, foxtail chess, wild oat, Italian thistle, tocalote, short-pod mustard, and wild oat. The area is used by Mallard Duck, Killdeer, Red-Tailed Hawk, Cassin's Kingbird, and Wrentit; California Toad, Pacific Tree Frog, Western Fence Lizard, Common Side-Blotched Lizard, and California Kingsnake; and Desert Cottontail, Desert Woodrat, coyote, raccoon, and bobcat.

Lake Perris is located adjacent to the cities of Moreno Valley and Perris and the Perris Fairgrounds which includes a motor sports complex (DWR 2010a). Lake Perris is located within the Lake Perris State Recreation Area which provides extensive recreational opportunities, as described in Chapter 15, Recreation Resources. The open space areas are characterized by willow and sage scrub, willow and eucalyptus woodland, and nonnative grassland. The scrub areas include California sagebrush, lemonadeberry, sugarbush, yellow bush penstemon, coyote brush, Mexican elderberry, sweetbush, boxthorn, tall prickly-pear, California buckwheat, red brome, bur ragweed, California aster, ripgut brome, sticky monkeyflower, prickly sow thistle, and Russian thistle. The willow woodland includes Goodding's black willow, red willow, narrow leaved willow, Fremont's cottonwood, California sycamore, gooseberry, mulefat, tarragon, curley dock, ragweed, southwestern spinyrush, and bromes. Eucalyptus woodland includes eucalyptus underlain by nonnative grassland. Nonnative grasslands includes soft chess, wild oat, foxtail barley, mustard, sweet fennel, California sagebrush, and California buckwheat. Habitat has been restored within the grasslands to provide habitat for the Stephen's Kangaroo Rat. Mourning Dove, Anna's Hummingbird, raven, California Kingsnake, Raccoon, Black-Tailed Deer, Striped Skunk, coyote, and bobcat use the shoreline. The woodland is used by Ash-Throated Flycatcher, Western Kingbird, Least Bell's Vireo, House Wren, California Towhee, Spotted Towhee, Black-Headed Grosbeak, Blue Grosbeak, Song Sparrow, Bullock's Oriole, House Finch, Lesser Goldfinch, Nuttal's Woodpecker, Red-Tailed Hawk, Red-Shouldered Hawk, Cooper's Hawk, Cottontail Rabbit, Black-Tailed Jackrabbit, raccoon, and Long-Tailed Weasel. The scrub supports California Quail, Greater Roadrunner, White-Throated Swift, Rock Wren, California Towhee, Western Fence Lizard, Gopher Snake, Red Diamond Rattlesnake, Southern Pacific Rattlesnake, Side Blotched Lizard, Granite Spiny Lizard, Coastal Western Whiptail, Black-Tailed Jackrabbit, bobcat, coyote, and rodents.

#### *10.3.6.2 Non-SWP Reservoirs in Riverside County*

Non-SWP reservoirs in Riverside County that store SWP water include Diamond Valley Lake and Lake Skinner that are owned and operated by Metropolitan Water District of Southern California, and Vail Lake that is owned and operated by Rancho California Water District, as described in Chapter 5, Surface Water Resources and Water Supplies.

Diamond Valley Lake is located adjacent to the City of Hemet along the northern boundary, and adjacent to pasture and dairies along the eastern and western boundaries (City of Hemet 2012). Sage scrub and nonnative grasslands occur between the lake and the City of Hemet. Chaparral with sage scrub occur along the southern boundary of the lake. Riversidean sage scrub includes California sagebrush, flat top buckwheat, black sage, and California encelia. Wildlife movement corridors occur around Diamond Valley Lake. Open space around Lake Skinner is also characterized by grassland and sage scrub vegetation (USFWS 2004).

Diamond Valley Lake and Lake Skinner are located within the Southwestern Riverside County Multi-Species Reserve, an area of 11,000 acres surrounding and connecting Diamond Valley Lake and Lake Skinner through the Dr. Roy Shipley Reserve (MWD 2014). At least eight types of habitat are found in the reserve, but coastal sage scrub, nonnative grassland, and chaparral are dominant. There are smaller areas of coast live oak woodland, willow scrub with live oak, and cottonwood-willow riparian forests. The reserve is home to the California Gnatcatcher, Bell's Sage Sparrow, San Diego Horned Lizard, Payson's Jewelflower, and Parry's Spineflower.

Areas around Vail Lake support habitat for Bald Eagle, Golden Eagle, and Great Blue Heron (RCWD 2015).

#### *10.3.6.3 Non-SWP Reservoir in Ventura County*

Lake Piru, located in Ventura County, is used to store SWP water by United Water Conservation District, as described in Chapter 5, Surface Water Resources and Water Supplies (UWCD 1999, 2014). The area surrounding the lake is characterized by chaparral on the hills and coast live oak woodlands along the stream channels.

#### *10.3.6.4 Non-SWP Reservoirs in San Diego County*

Reservoirs in San Diego County that are used to store SWP water include the City of Escondido Dixon Lake; City of San Diego San Vicente, El Capitan, Lower Otay, and Lake Hodges reservoirs; Lake Jennings owned by Helix Water District; and Sweetwater Reservoir owned by Sweetwater Authority.

Dixon Lake is located in the hills above the City of Escondido within the Escondido Multiple Habitat Conservation Plan area (City of Escondido 2012). Habitat around Lake Dixon is characterized by coastal sage scrub and chaparral. The coastal sage scrub includes California sagebrush, flat-top buckwheat, white sage, laurel sumac, black sage, California encelia, San Diego County viguiera, goldenbush, coast prickly-pear, and lemonadeberry and sugarbush. Chaparral includes chamise, scrub oak, toyon, thick-leaf ceanothus, black sage, wild cucumber, morning glory, saw-toothed goldenbush, and nonnative grasses.

The San Vicente Reservoir is characterized by rocky or coarse sand, with occasional willow trees and mulefat (SDCWA and USACE 2008). The constantly fluctuating water levels make it difficult for wetland or riparian vegetation to become established. Much of the shoreline around San Vicente Reservoir, therefore, is a non-vegetated fringe. Outside of the fringe, the area around the reservoir is primarily sage scrub with nonnative grassland and coast live oak woodland. Along the stream channel, vegetation includes southern willow scrub and live oak riparian forest with chaparral. Submerged aquatic vegetation occurs in an intermittent band surrounding almost the entire reservoir. Freshwater marsh vegetation of cattail, bulrush, and sedges occurs between the open water and lakeshore fringe. Birds associated with the open water include grebe, cormorant, heron, egret, ducks and geese, coot, plover, sandpiper, gull, and tern. Other birds associated with open water and riparian habitats include the bald eagle, osprey, and kingfisher. The uplands support rabbit, snakes, lizards, ground squirrel, pocket gopher, raccoon, mule deer, bats, mice, fox, skunk, bobcat, and mountain lion.

El Capitan Reservoir is located within Diegan coastal sage scrub with areas of oak woodlands and chaparral (San Diego County 2011; SDRWWG 2005; SDRP 2015). The Lower Otay Reservoir, Lake Hodges, and Lake Jennings are located within coastal sage scrub. Sweetwater Reservoir is surrounded by coastal sage scrub and chaparral with riparian forest along stream channels.

#### *10.3.6.5 Non-SWP Reservoir in San Bernardino County*

Lake Arrowhead, in San Bernardino County, is used to store SWP water by the Lake Arrowhead Community Services District (County of San Bernardino 2011; LACSD 2014a, 2014b). Lake Arrowhead is located within chaparral, sage scrub, oak woodlands, oak and sycamore woodlands, dogwood tree along the lake, cottonwood and willow forests along stream channels, Ponderosa pine forests, and wetlands. The habitat supports Stellar Jay, blue jay, quail, ducks, western Tanager, Northern Tanager, woodpecker, chickadee, Barn Owl, Bald Eagle, hawks, rattlesnake, coyote, bobcat, Black Bear, Gray Squirrel, Ground Squirrel, chipmunk, raccoon, mountain lion, skunk, and cougar.

## 10.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in terrestrial resources; results of the impact analysis; potential mitigation measures; and cumulative effects.

### 10.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in terrestrial resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change surface water resources affected by CVP and SWP operations.

#### *10.4.1.1 Changes in CVP and SWP Reservoir Elevations*

Changes in surface water elevations at the CVP and SWP reservoirs would influence the extent of the drawdown zone (the area of shoreline between the full inundation elevation and the water level), which can influence the availability and quality of nesting habitat for some ground-nesting birds (e.g., waterfowl) and possibly the prey base for nesting fish-eating raptors (e.g., Bald Eagle and Osprey) in March through June. The creation of barren zones through reservoir drawdown can also affect the ability of wildlife species to access water, which could cause them to be more vulnerable to predation.

As described in Chapter 5, Surface Water Resources and Water Supplies, surface water elevations would be similar in all months and all water year types at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir under Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison. Surface water elevations would change at San Luis Reservoir under Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison. However, it does not appear that nesting fish-eating raptors or ground-nesting waterfowl use the San Luis Reservoir shoreline during these nesting lifestages (Reclamation 2013). Therefore, changes in CVP and SWP operations under the alternatives would result in similar conditions (within 5 percent change) for terrestrial resources at CVP and SWP reservoirs; and these factors are not analyzed in this EIS.

##### *10.4.1.2 Changes in Rivers Downstream of the CVP and SWP Reservoirs*

Operation of the CVP and SWP would influence flow regimes that renew and support adjacent riparian and wetland plant and wildlife communities. For example, certain riparian plants (e.g., willows) require a specific sequence and timing of flow events to prepare the seedbed and to support germination and seedling growth in March through May. Changes in flow that support or interfere with these processes could influence riparian vegetation and its value as wildlife habitat. The analysis is focused on Trinity, Sacramento, Feather, American, and Stanislaus rivers because these rivers are used to convey water from the reservoirs to CVP and SWP water users. Therefore, changes in CVP and SWP operations could result in substantial changes in flow patterns in these rivers. At other reservoirs that are used to store CVP and SWP water supplies (e.g., San Luis Reservoir), the CVP and SWP water are conveyed from the reservoirs in canals or pipelines. The reservoirs may be operated to provide minimum flows to support habitat in streams adjacent to these reservoirs; however, changes in CVP and SWP operations would not affect the minimum instream flow releases. Therefore, changes in terrestrial resources in these streams is not analyzed in this EIS.

Channel maintenance flows to improve adjacent floodplain habitat conditions would occur along Clear Creek under the No Action Alternative and Alternatives 2 and 5, to the extent possible. The high-flow, short-duration pulse flows would be released, if physically possible, from Whiskeytown Lake to mobilize streambed material in Clear Creek in accordance with the 2009 NMFS Biological Opinion (BO).

##### *10.4.1.3 Changes in Sacramento, American, and Stanislaus Rivers Habitats due to Fish Passage at Dams*

Fish passage would be provided under the No Action Alternative and Alternative 5 around Shasta, Folsom, and New Melones dams. Salmon runs play an important role in the transfer of large quantities of marine-derived nutrients to adjacent forest ecosystems with substantial effects on plant and wildlife production. Spawning salmon contribute to the release of nutrients into streams through normal metabolic processes, release of gametes during spawning, decay of their carcasses following death, and through consumption of their flesh by predators and scavengers (Merz and Moyle 2006). Returning fish to the upper stream segments, fish passage could influence the forest ecosystem and associated wildlife in the upper watersheds and result in less nutrients along the rivers downstream of the dams. This analysis would assume that the objectives of the 2009 NMFS BO were achieved by 2030, including implementation of fish passage at these CVP reservoirs. However, any changes in nutrients in the stream corridors are expected to be minimal based on information in Merz and Moyle (2006). Therefore, habitat conditions related to changes in nutrient loading associated with fish passage actions would be the same under Alternatives 1 through 5 as under the No Action Alternative and the Second Basis of Comparison. Therefore, this potential change is not analyzed in this EIS.

#### *10.4.1.4 Changes in River and Delta Floodplains*

Alternative 4 assumes additional institutional requirements for development within the floodplain and floodways that would require compliance with Endangered Species Act in defining floodplain map revisions, allow for improvements in floodplain management criteria to support natural and beneficial functions, and prohibit new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway. However, as described in Chapter 13, Land Use, in 2030, development along major river corridors in the Central Valley would continue to be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE.

Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations, as implemented in all alternatives and the Second Basis of Comparison, would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta, as described in Chapter 13. Provisions in Alternative 4 would require additional setbacks along the floodways as compared to other alternatives and the Second Basis of Comparison. The qualitative analysis considers the potential changes in habitat due to these changes in floodplain and floodway development regulations.

Another potential change in Delta habitat would occur under Alternative 4, additional vegetation would remain along the levees in the Delta as compared to conditions under the other alternatives, the No Action Alternative, and the Second Basis of Comparison, as described in Chapter 3, Description of Alternatives. Under Alternatives 1, 2, 3, and 5; the No Action Alternative; and the Second Basis of Comparison existing vegetation would remain along the Delta levees until the levees are repaired. Following repairs, vegetation would be removed along the riparian corridor to improve the structural reliability of the levees in accordance with USACE requirements. It is assumed that by 2030, much of the vegetation would be removed from the levees due to levee repairs.

#### *10.4.1.5 Changes in Flows over Fremont Weir into the Yolo Bypass*

All of the alternatives, including the No Action Alternative and the Second Basis of Comparison, include operations of an operable gate at Fremont Weir, as described in Chapter 3, Description of Alternatives. However, the flow patterns into the Yolo Bypass would change based upon the magnitude of flows in the Sacramento River at Fremont Weir.

#### *10.4.1.6 Changes in Wetlands Habitat*

The No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison all include implementation of restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass; and continued delivery of refuge water supplies under the Central Valley Project Improvement Act. There would be no changes in wetlands habitat between Alternatives 1 through 5 as compared to the No Action Alternative, and the Second Basis of Comparison. Therefore, changes to wetland habitats are not analyzed in this EIS.

#### *10.4.1.7 Changes in Delta Habitat*

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison would change the Delta salinity which could affect survival of riparian vegetation. The analysis evaluates changes in salinity by comparing the end of month X2 position.

Another potential change in Delta habitat would occur under Alternative 4, due to additional vegetation along the levees in the Delta as compared to conditions under the other alternatives, the No Action Alternative, and the Second Basis of Comparison, as described in Chapter 3, Description of Alternatives.

#### *10.4.1.8 Changes in Irrigated Agricultural Acreage Habitats in Areas that use CVP and SWP Water*

As described in Section 10.3, Affected Environment, agricultural lands provide considerable value to terrestrial wildlife, which varies with crop type and wildlife species. Generally, rice production provides high habitat value for some species because it supports many of the attributes of wetlands. Most notably, flooded rice fields during the growing season provide foraging and nesting habitat for waterfowl and shorebirds, as well as habitat for the federally listed Giant Garter Snake. In the fall and early winter, flooding for rice straw decomposition plays an important role in providing habitat for migrating waterbirds. Other crops, such as alfalfa and irrigated pasture, also provide habitat value, primarily because of their perennial nature and the application of flood irrigation. These crops provide valuable foraging habitat for species such as the state-listed Swainson’s Hawk. Grain crops provide seasonal value to species such as Greater Sandhill Crane and others, but orchards, vineyards, vegetable, and truck crops generally provide relatively low habitat value for terrestrial species.

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and associated habitats over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison, as described in Chapter 12, Agricultural Resources. However, irrigated acreage under Alternatives 1 through 5 would be similar (within 5 percent change) to irrigated acreage under the No Action Alternative and the Second Basis of Comparison. Therefore, there would be no change in terrestrial habitat at the irrigated acreage; and this factor is not analyzed in this EIS.

#### *10.4.1.9 Effects due to Cross Delta Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water and who can make the water available through releasing previously stored water, pumping groundwater instead of using surface water (groundwater substitution); idling crops; or substituting crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future terrestrial resources conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014d). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 10.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions.

Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to terrestrial resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *10.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley.
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies, including general plan development, future water management and supply projects, and river and Delta floodplain development.

##### 10.4.2.1.1 Climate Change and Sea Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

The Delta estuarine habitat is complex due to the freshwater-saltwater interface that supports numerous terrestrial species that require freshwater conditions primarily in the winter and spring and may withstand periods of higher salinity in the late summer and fall months. Climate change and sea level rise and CVP and SWP operations would change the location of the freshwater-saltwater interface in the Delta which would affect the survivability of vegetation within that area, especially in the western Delta and Suisun Marsh. Operations of the CVP and SWP would continue to maintain freshwater conditions in the spring in accordance with the State Water Resources Control Board Decision 1641. However, higher salinity conditions would occur in the summer months and in the fall of drier years which would affect the types of riparian vegetation in the western Delta and in Suisun Marsh under the No Action Alternative and Second Basis of Comparison in 2030 as compared to recent historical conditions.

#### 10.4.2.1.2 Reasonable and Foreseeable Projects and Programs

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change terrestrial resources, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that would affect terrestrial resources, including:

- Habitat Restoration includes restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.
- Sacramento River, American River, and Clear Creek Spawning Gravel Augmentation.
- Battle Creek Restoration.
- Lower American River Flow Management Standard.

#### 10.4.2.1.3 Changes in River and Delta Floodplains

It is assumed that under the No Action Alternative and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta (DWR 2013b). These programs would be implemented in a manner that would be coordinated with opportunities to restore or maintain the function of natural systems with consideration of future conditions with climate change and sea level rise. However, terrestrial resources would be changed by 2030 as compared to recent historical conditions.

Terrestrial resources along Delta levees also would be affected through implementation of USACE policies for vegetation on levees. Historically, the USACE has allowed brush and small trees to be located on the waterside of federal flood management project levees if the vegetation would preserve, protect, and/or enhance natural resources, and/or protect rights of Native Americans, while maintaining the safety, structural integrity, and functionality of the levee (DWR 2011). After Hurricane Katrina in 2005, the USACE issued a policy and draft policy guidance to remove substantial vegetation from these levees throughout the nation (USACE 2009). This policy requires federally authorized levee systems that have maintenance agreements with the USACE (including Delta levees along the Sacramento and San Joaquin rivers) and other levees that are eligible for the federal Rehabilitation and Inspection Program (Public Law 84-99) to remove vegetation in the following manner.

- Removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, or within 15 feet of the toe of the levee on the landside ("toe" is where the levee slope meets the ground surfaces).
- Removal of all vegetation over 2 inches in diameter on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface.

In 2010, the USACE issued a draft policy guidance letter, *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls—75 Federal Register 6364-68* (USACE 2010) that included procedures for State and local agencies to request variances on a site-specific basis. DWR has been in negotiations with USACE to remove vegetation on the upper third of the waterside slope, top, and landside of the levees, and continue to allow vegetation on the lower two-thirds of the waterside slope of the levee and along benches above the water surface (DSC 2011). By 2030, it is anticipated that much of the existing vegetation on the upper third of the waterside slopes, tops, landside slopes, and within 15 feet of the landside toe of the levees would be removed.

By 2030 under the No Action Alternative and the Second Basis of Comparison, development along major river corridors in the Central Valley would continue to be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways would continue to be regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These requirements would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta.

### 10.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

#### *10.4.3.1 No Action Alternative*

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

##### 10.4.3.1.1 Trinity River Region

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under the No Action Alternative and the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under the No Action Alternative and Second Basis of Comparison.

##### 10.4.3.1.2 Central Valley Region

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased flows in the Stanislaus River downstream of Goodwin Dam (over 100 percent); and reduced in the Feather River downstream of Thermalito Complex (25 to 30 percent) under the No Action Alternative as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under the No Action Alternative as compared to the Second Basis of Comparison, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Stanislaus rivers; and the potential for reduced terrestrial resources would occur along the Feather River.

Monthly Clear Creek flows under the No Action Alternative as compared to the Second Basis of Comparison are identical except in May. In May, under the No Action Alternative, flows are up to 40.7 percent higher than under the Second Basis of Comparison in accordance with the 2009 NMFS BO. Terrestrial resources habitat in the floodplains of lower Clear Creek would be slightly improved under the No Action Alternative as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least

Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Feather River.

*Changes in River and Delta Floodplains*

It is assumed that under the No Action Alternative and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir are similar under the No Action Alternative and the Second Basis of Comparison; therefore, terrestrial habitat could be similar.

*Changes in Delta Habitat due to Changes in Water Quality*

Under the No Action Alternative, the freshwater interface would be similar to conditions under the Second Basis of Comparison in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the west in September through December under the No Action Alternative as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Lower Delta salinity under the No Action Alternative as compared to the Second Basis of Comparison would improve habitat for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### ***10.4.3.2 Alternative 1***

Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because water resource conditions under Alternative 1 are identical to water resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### **10.4.3.2.1 Alternative 1 Compared to the No Action Alternative**

*Trinity River Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 1 and the No Action Alternative. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 1 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased in the Feather River downstream of Thermalito Complex (35 percent); and reduced flows in the Stanislaus River downstream of Goodwin Dam (60 percent) under Alternative 1 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 1 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 1 as compared to the No Action Alternative are identical except in May. In May, under Alternative 1, flows are up to 29 percent lower as compared to the No Action Alternative. Terrestrial resources habitat in the floodplains of lower Clear Creek could be decreased under Alternative 1 as compared to the No Action Alternative.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell’s Vireo, Least Bittern, Swainson’s Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

*Changes in River and Delta Floodplains*

It is assumed that under Alternative 1 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 1 and the No Action Alternative.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would be similar or higher under Alternative 1 as compared to the No Action Alternative; therefore, terrestrial habitat could be similar or increased depending upon the flow pattern.

*Changes in Delta Habitat due to Changes in Water Quality*

Under Alternative 1, the freshwater interface would be similar to conditions under the No Action Alternative in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the east in September through December under Alternative 1 as compared to the No Action Alternative. This could adversely affect terrestrial species that have acclimated to freshwater conditions.

*Potential Effects on Special Status Species*

Higher Delta salinity under Alternative 1 as compared to the No Action Alternative would reduce habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009

NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 1 as compared to the No Action Alternative.

#### 10.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *10.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 10.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in terrestrial resources under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 10.4.3.1, No Action Alternative.

### *10.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 10.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 3 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased in the Feather River downstream of Thermalito Complex (25 to 35 percent); and reduced flows in the Stanislaus River downstream of Goodwin Dam (60 percent) under Alternative 3 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 3 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 3 as compared to the No Action Alternative are identical except in May. In May, under Alternative 3, flows are up to 29 percent lower as compared to the No Action Alternative. Terrestrial resources habitat in the floodplains of lower Clear Creek would be decreased under Alternative 3 as compared to the No Action Alternative.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

*Changes in River and Delta Floodplains*

It is assumed that under Alternative 3 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat that would occur due to implementation of the flood management projects would be the same under Alternative 3 and the No Action Alternative.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would be similar or higher (10 to 30 percent) under Alternative 3 as compared to the No Action Alternative. Terrestrial habitat could be similar or increased due to the flow patterns.

*Changes in Delta Habitat due to Changes in Water Quality*

Under Alternative 3, the freshwater interface would be similar to conditions under the No Action Alternative in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the east in September through December under Alternative 3 as compared to the No Action Alternative.

*Potential Effects on Special Status Species*

Higher Delta salinity under Alternative 3 as compared to the No Action Alternative would reduce habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 3 as compared to the No Action Alternative.

#### 10.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 3 and the Second Basis of Comparison. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport, Feather River downstream of Thermalito Complex, and American River downstream of Nimbus Dam; and reduced flows in the Stanislaus River downstream of Goodwin Dam (6 to 52 percent, depending upon water year type) under Alternative 3 as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 3 as compared to the Second Basis of Comparison, the potential for similar terrestrial resources habitat would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 3 as compared to the Second Basis of Comparison are identical under Alternative 3; therefore, terrestrial resources habitat in the floodplains of lower Clear Creek would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

*Changes in River and Delta Floodplains*

It is assumed that under Alternative 3 and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 3 and the Second Basis of Comparison.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir and associated terrestrial habitat would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Changes in Delta Habitat due to Changes in Water Quality*

Under Alternative 3, the freshwater-saltwater interface would be similar to conditions under the Second Basis of Comparison in all months and in all water year types.

*Potential Effects on Special Status Species*

Delta salinity under Alternative 3 as compared to the Second Basis of Comparison would result in similar habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 as compared to the Second Basis of Comparison.

#### *10.4.3.5 Alternative 4*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Alternative 4 also includes additional institutional requirements for development within the floodplain and floodways, including the following items.

- Compliance with Endangered Species Act in defining floodplain map revisions.
- Improvements in floodplain management criteria to support natural and beneficial functions.
- Prohibition of new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway.
- Modification of USACE requirements to remove vegetation along portions of the waterside of levees, as described in Section 10.4.3.1, No Action Alternative.

Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 10.4.3.5.1 Alternative 4 Compared to the No Action Alternative

These actions would not change CVP and SWP operations; and would only affect the Changes in River and Delta Floodplains. Therefore, changes in terrestrial resources due to changes in CVP and SWP under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

*Changes in River and Delta Floodplains*

It is assumed that under the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The USACE policies for vegetation on levees would be implemented; and by 2030, much of the vegetation along Delta channels would have been removed.

Under Alternative 4, implementation of institutional provisions would result in development of the floodplains and floodways, especially in the Delta, that would be similar to development under the No Action Alternative. Under the No Action Alternative, as described in Chapter 13, Land Use, development along major river corridors in the Central Valley would be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta. Under Alternative 4, development would be prevented within 170 feet from the ordinary high water line of any floodway. This setback area could provide opportunities to establish vegetative corridors.

Under Alternative 4 and the No Action Alternative, vegetation management along the Delta levees would include removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, and within 15 feet on the landside of the toe of the levee ("toe" is where the levee slope meets the ground surfaces). Under Alternative 4, vegetation could be maintained on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface. This would provide shaded riverine aquatic habitat and riparian vegetation along many of the Delta channels as compared to the No Action Alternative.

Overall, Alternative 4 would result in increased vegetation along the riparian corridors related to recruitment of riparian vegetation in the Delta watershed as compared to the No Action Alternative.

#### 10.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

The changes in river and Delta floodplain actions would not change CVP and SWP operations which would be identical under Alternative 4 and under the Second Basis of Comparison.

*Changes in River and Delta Floodplains*

It is assumed that under the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The USACE policies for vegetation on levees would be implemented; and by 2030, much of the vegetation along Delta channels would have been removed.

Under Alternative 4, implementation of institutional provisions would result in development of the floodplains and floodways, especially in the Delta, that would be similar to development under the Second Basis of Comparison. Under the Second Basis of Comparison, as described in Chapter 13, Land Use, development along major river corridors in the Central Valley would be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta. Under Alternative 4, development would be prevented within 170 feet from the ordinary high water line of any floodway. This setback area could provide opportunities to establish vegetative corridors.

Under Alternative 4 and the Second Basis of Comparison, vegetation management along the Delta levees would include removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, and within 15 feet on the landside of the toe of the levee ("toe" is where the levee slope meets the ground surfaces). Under Alternative 4, vegetation could be maintained on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface. This would provide shaded riverine aquatic habitat and riparian vegetation along many of the Delta channels as compared to the Second Basis of Comparison.

Overall, Alternative 4 would result in increased terrestrial resources along the riparian corridors related to recruitment of riparian vegetation in the Delta watershed as compared to the Second Basis of Comparison.

#### *10.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 10.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 5 and the No Action Alternative. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 5 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam; and flows in the Stanislaus River downstream of Goodwin Dam would increase 22 to 40 percent in some spring months and 8 to 18 percent in other spring months, depending upon water year type under Alternative 5 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 5 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources habitat would occur along the Sacramento, Feather, and American rivers; and the potential for both increased and reduced terrestrial resources habitat would occur along the Stanislaus River.

Monthly Clear Creek flows would be identical under Alternative 5 as compared to the No Action Alternative; therefore, terrestrial resources habitat in the floodplains of lower Clear Creek would be similar under Alternative 5 as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

*Changes in River and Delta Floodplains*

It is assumed that under Alternative 5 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 5 and the No Action Alternative.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir and associated terrestrial habitat would be similar under Alternative 5 as compared to the No Action Alternative.

*Changes in Delta Habitat due to Changes in Water Quality*

Under Alternative 5, the freshwater interface would be similar to conditions under the No Action Alternative in all months and in all water year types.

*Potential Effects on Special Status Species*

Similar Delta salinity under Alternative 5 as compared to the No Action Alternative would result in similar habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 as compared to the No Action Alternative.

#### 10.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 5 and the Second Basis of Comparison. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 5 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Changes in Rivers Downstream of CVP and SWP Reservoirs*

Flows in the spring months would be similar in the American River downstream of Nimbus Dam; increased flows in the Stanislaus River downstream of Goodwin Dam (over 100 percent); and reduced in the Sacramento River at Keswick and Freeport and Feather River downstream of Thermalito Complex (8 to 13 percent and 25 to 45 percent, respectively) under Alternative 5 as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 5 as compared to the Second Basis of Comparison, the potential for similar or improved terrestrial resources habitat would occur along the American and Stanislaus rivers; and the potential for reduced terrestrial resources habitat would occur along the Sacramento and Feather rivers.

Monthly Clear Creek flows under Alternative 5 as compared to the Second Basis of Comparison are identical except in May. In May, under Alternative 5, flows are up to 40.7 percent higher than under the Second Basis of Comparison in accordance with the 2009 NMFS BO. Terrestrial resources habitat in the floodplains of lower Clear Creek would be improved under Alternative 5 as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Sacramento and Feather rivers.

*Changes in River and Delta Floodplains*

It is assumed that under Alternative 5 and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 5 and the Second Basis of Comparison.

*Changes in Flows over Fremont Weir into the Yolo Bypass*

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would similar or lower (24 percent) under Alternative 5 as compared to the Second Basis of Comparison. The decrease in the extent of flow inundation in the Yolo Bypass could cause degradation of terrestrial habitat as compared to the Second Basis of Comparison.

*Changes in Delta Habitat due to Changes in Water Quality*

Under Alternative 5, the freshwater interface would be similar to conditions under the Second Basis of Comparison in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the west in September through December under Alternative 5 as compared to the Second Basis of Comparison.

*Potential Effects on Special Status Species*

Lower Delta salinity under Alternative 5 as compared to the Second Basis of Comparison would improve habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

*Effects Related to Cross Delta Water Transfers*

Potential effects to terrestrial resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under Alternative 5 as compared to the Second Basis of Comparison.

#### 10.4.3.7 Summary of Environmental Consequences

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 10.2 and 10.3.

**Table 10.2 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions.<br>Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir.<br>Increased salt water habitat in the western Delta in the fall months of wet and above normal water years could adversely affect species that have acclimated to freshwater conditions. | No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types. |
| Alternative 2 | No effects on terrestrial resources. | None needed |
| Alternative 3 | Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions.<br>Similar or improved terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir.<br>Increased salt water habitat in the western Delta in the fall months of wet and above normal water years could adversely affect species that have acclimated to freshwater conditions. | No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative; except for increased terrestrial vegetation along the riparian corridors related to recruitment of riparian vegetation. | No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 5 | Similar flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Increased flows along the Stanislaus River in the spring; therefore, could be improved terrestrial habitat conditions.<br>Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir.<br>Similar freshwater and salt water habitats. | None needed. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be "similar."

**Table 10.3 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Similar or increased flows along Trinity, Sacramento, American, and Stanislaus rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Feather River in the spring; therefore, could be reduced terrestrial habitat conditions.<br>Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir.<br>Increased freshwater habitat in the western Delta. | Not considered for this comparison. |
| Alternative 1 | No effects on terrestrial resources. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions.<br>Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir.<br>Similar freshwater and salt water habitats. | Not considered for this comparison. |
| Alternative 4 | Similar effects except for increased terrestrial vegetation along the riparian corridors related to recruitment of riparian vegetation. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 5 | Similar or increased flows along Trinity, American, and Stanislaus rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Sacramento and Feather rivers in the spring; therefore, could be reduced terrestrial habitat conditions.<br>Similar or decreased terrestrial conditions in Yolo Bypass related to similar or lower water that flows from the Sacramento River at the Fremont Weir.<br>Increased freshwater habitat in the western Delta. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

#### *10.4.3.8 Potential Mitigation Measures*

Mitigation measures are included in EISs to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of alternatives as compared to the No Action Alternative. Mitigation measures are not included in this EIS to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1, 3, and 4 as compared to the No Action Alternative would result in adverse changes in terrestrial resources along Stanislaus River when spring flows are less than under the No Action Alternative; and when the salinity increases in the western Delta. However, mitigation measures have not been identified at this time to reduce the adverse effects of flow reductions in the spring on the Stanislaus River and of increased salinity in the western Delta in the fall months of wet and above normal water year types under Alternatives 1, 3, and 4.

#### *10.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Terrestrial Resources are summarized in Table 10.4.

**Table 10.4 Summary of Cumulative Effects on Terrestrial Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions Included in the No Action Alternative an d in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives) including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- San Joaquin River Restoration Program<br>- Contra Loma Recreation Resource Management Plan<br>- San Luis Reservoir State Recreation Area Resource Management Plan/General Plan | These effects would be the same under all alternatives.<br>Climate change and sea level rise and development under the general plans are anticipated to reduce carryover storage in reservoirs and changes in stream flow patterns in a manner that would change shoreline, riparian, and floodplain habitat.<br>Other actions, including restoration projects, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to improve shoreline, riparian, and floodplain habitat. |
| Future Actions Considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program | These effects would be the same under all alternatives.<br>Some of the future reasonably foreseeable actions to improve water quality and FERC Relicensing projects would improve shoreline, riparian, and floodplain habitat.<br>Other future reasonably foreseeable actions, such as expanded or new reservoirs, would reduce some types of terrestrial habitat and increase other types of terrestrial habitat within the reservoir area. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Full implementation of the USACE vegetation standards for levees | Implementation of No Action Alternative with future reasonably foreseeable actions would result in changes in stream flows and levee vegetation policies that would result in changes to related terrestrial resources as compared to conditions prior to the BOs.<br>Reduced riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to recent conditions. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Full implementation of the USACE vegetation standards for levees | Implementation of Alternative 1 with future reasonably foreseeable actions would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions.<br>Similar riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description.<br>Full implementation of the USACE vegetation standards for levees | Implementation of Alternative 2 with future reasonably foreseeable actions for terrestrial resources would be the same as for the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months<br>Full implementation of the USACE vegetation standards for levees | Implementation of Alternative 3 with future reasonably foreseeable action would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions.<br>Similar riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>No implementation of the USACE vegetation standards for levees | Implementation of Alternative 4 with future reasonably foreseeable actions would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions.<br>Implementation of Alternative 4 also would result in increased riparian habitat along effected levees<br>Increased riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months<br>Full implementation of the USACE vegetation standards for levees | Implementation of Alternative 5 with future reasonably foreseeable actions for terrestrial resources would be similar as under the No Action Alternative with the added actions. |

## 10.5 References


BLM (Bureau of Land Management). 2006. *Welcome to the Sacramento River Rail Trail*.

BLM and NPS (Bureau of Land Management and National Park Service). 2008. *Environmental Assessment for the Lower Clear Creek Anadromous Fish Restoration & Management Project. BLM EA RE-2008-16*. April.

CALFED (CALFED Bay-Delta Program). 2000. *Final Programmatic Environmental Impact Statement/Environmental Impact Report*. July.

CALFED et al. (CALFED Bay-Delta Program, Yolo Bypass Working Group, and Yolo Basin Foundation). 2001. *A Framework for the Future: Yolo Bypass Management Strategy*. August.

Cal-IPC (California Invasive Plant Council). 2006. *California Invasive Plant Inventory*. Cal-IPC Publication 2006-02. February.

CalTrans and DFG (California Department of Transportation and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2010. *California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California*. February.

CBDA (California Bay-Delta Authority). 2004. *Environmental Water Program Pilot Flow Augmentation Project: Concept Proposal for Flow Acquisition on Lower Clear Creek*. August.

CCWA (Central Coastal Water Authority). 2013. *Central Coast Water Authority fiscal year 2013/14 Budget*. April 25.

CDFW (California Department of Fish and Wildlife). 2014a. *Los Banos Wildlife Area – Merced County*. Site accessed July 28, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Los-Banos-WA.

CDFW (California Department of Fish and Wildlife). 2014b. *Volta Wildlife Area – Merced County*. Site accessed July 28, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Volta-WA.

CDFW (California Department of Fish and Wildlife). 2014c. *North Grasslands Wildlife Area – Merced & Stanislaus County*. Site accessed July 28, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/North-Grasslands-WA.

CDFW (California Department of Fish and Wildlife). 2014d. *Miner Slough Wildlife Area – Solano County*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Miner-Slough-WA.

CDFW (California Department of Fish and Wildlife). 2014e. *Rhode Island Wildlife Area – Contra Costa County*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Rhode-Island-WA.

CDFW (California Department of Fish and Wildlife). 2014f. *White Slough Wildlife Area – San Joaquin County*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/White-Slough-WA.

CDFW (California Department of Fish and Wildlife). 2014g. *Hill Slough Wildlife Area – Solano County*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Hill-Slough-WA.

CDFW (California Department of Fish and Wildlife). 2014h. *Grizzly Island Wildlife Area – General Information*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Grizzly-Island-WA.

CDFW (California Department of Fish and Wildlife). 2014i. *What's Going on at Grizzly Island Wildlife Area During the Year*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Grizzly-Island-WA.

CDFW (California Department of Fish and Wildlife). 2014j. *Point Edith Wildlife Area – Contra Costa County*. Site accessed August 15, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Point-Edith-WA.

CDFW (California Department of Fish and Wildlife). 2014k. *Fremont Weir Wildlife Area – Sutter and Yolo Counties*. Site accessed October 7, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Fremont-Weir-WA.

CDFW (California Department of Fish and Wildlife). 2014l. *Sacramento Bypass Wildlife Area –Yolo County*. Site accessed October 7, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Sacramento-Bypass-WA.

CDFW (California Department of Fish and Wildlife). 2014m. *Calhoun Cut Ecological Reserve –Solano County*. Site accessed October 7, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Calhoun-Cut-ER.

City of Escondido. 2012. *Escondido General Plan Update, Downtown Specific Plan Update, and Climate Action Plan, Environmental Impact Report*. April 23.

City of Hemet. 2012. *City of Hemet General Plan 2030, Environmental Impact Report, Final*. January 12.

County of Orange. 1996. *Final (Administrative Record Copy) Natural Community Conservation Plan & Habitat Conservation Plan*. July 17.

County of San Bernardino. 2011. *County of San Bernardino General Plan Amendment and Greenhouse Gas Reduction Plan, Draft Supplemental Program Environmental Impact Report*. March.

County of Sacramento. 2008. *American River Parkway Plan 2008.*

CVAG (Coachella Valley Association of Governments). 2007. *Final Recirculated Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan*. September.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1988. *California Wildlife Habitat Relationships System, Fresh Emergent Wetland* by Gary Kramer. Site accessed October 6, 2014. https://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1995. *Stanislaus River Basin and Calaveras River Water Use Program Threatened and Endangered Species Report*. March. Site accessed September 30, 2014. http://www.dfg.ca.gov/delta/reports/stanriver/ with 56 attachments from this website.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1999a. *California Wildlife Habitat Relationships System, Deciduous Orchard* by Robert F. Schultze. Site accessed October 6, 2014. https://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1999b. *California Wildlife Habitat Relationships System, Evergreen Orchard* by Robert F. Schultze. Site accessed October 6, 2014. https://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 1999c. *California Wildlife Habitat Relationships System, Vineyard* by Robert F. Schultze. Site accessed October 6, 2014. https://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2007. *Lower Sherman Island Wildlife Area Land Management Plan, Final*. April.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2008. *California Aquatic Invasive Species Management Plan*. January.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2011a. *Gray Lodge Wildlife Area Water Management Plan*. July 11.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2011b. *North Grasslands Wildlife Area, China Island Unit, Water Management Plan*. June 23.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2011c. *North Grasslands Wildlife Area, Salt Slough Unit, Water Management Plan*. February 16.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. California Natural Diversity Database

DFG and Yolo Basin Foundation (California Department of Fish and Game [now known as Department of Fish and Wildlife] and Yolo Basin Foundation). 2008. Y*olo Bypass Wildlife Area Land Management Plan*. June.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

DSC (Delta Stewardship Council). 2011. *Draft Delta Plan Program Environmental Impact Report*. November.

DWR (California Department of Water Resources). 1997. *Quail Lake*. July.

DWR (California Department of Water Resources). 2001. *South Bay Aqueduct (Bethany Reservoir and Lake Del Valle)*. April.

DWR (California Department of Water Resources). 2003. *Initial Study/Mitigated Negative Declaration, Public Review Draft, Decker Island Phase II Habitat Development and Levee Rehabilitation Project*. July.

DWR (California Department of Water Resources). 2004a. *Draft Final Report SP-T1: Effects of Project Operations and Features on Wildlife and Wildlife Habitat, Oroville Facilities Relicensing FERC Project No. 2100*. April.

DWR (California Department of Water Resources). 2004b. *SP-T3/5 Project Effects on Riparian Resources, Wetlands, and Associated Floodplains, Draft Final Report, Oroville Facilities Relicensing FERC Project No. 2100*. July.

DWR (California Department of Water Resources). 2004c. *Draft Environmental Impact Report for the Simulation of Natural Flows in Middle Piru Creek.* November.

DWR (California Department of Water Resources). 2005. *Department of Water Resources South Bay Aqueduct Improvement and Enlargement Project, Conformed EIR*. June.

DWR (California Department of Water Resources). 2007a. *Draft Environmental Impact Report Oroville Facilities Relicensing*—FERC Project No. 2100. May.

DWR (California Department of Water Resources). 2007b. *Monterey Plus Draft Environmental Impact Report*. October.

DWR (California Department of Water Resources). 2007c. *Value Engineering Study, Franks Tract Pilot Project, Final Report*. June.

DWR (California Department of Water Resources). 2009a. *The California Water Plan Update 2009, Bulletin 160-09*. December.

DWR (California Department of Water Resources). 2009b. *East Branch Extension Phase I Improvements Project, Draft Supplemental Environmental Impact Report No. 2*. March.

DWR (California Department of Water Resources). 2010a. *Perris Dam Remediation Program, Draft Environmental Impact Report*. January.

DWR (California Department of Water Resources). 2010b. *Final Environmental Impact Report, North Delta Flood Control and Ecosystem Restoration Project*. October.

DWR (Department of Water Resources). 2011. Effects of U.S. Army Corps of Engineers' Policy on Levee Vegetation in California. Accessed September 26, 2011. water.ca.gov/floodsafe/leveeveg/.

DWR (California Department of Water Resources). 2012. *2012 Central Valley Flood Protection Plan Consolidated Final Program Environmental Impact Report*. July.

DWR (California Department of Water Resources). 2013a. *Upper Feather River Lakes*. April.

DWR (California Department of Water Resources). 2013b. *California's Flood Future Highlights, Recommendations for Managing the State's Flood Risk, Final*. November.

DWR (California Department of Water Resources). 2014. *Initial Study/Proposed Mitigated Negative Declaration, Bethany Reservoir Sediment Removal Project*. May.

DWR and Reclamation (Department of Water Resources and Bureau of Reclamation). 2002. *Riparian Vegetation of the San Joaquin River*. *Technical Information Record SJD-02-1*. May.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

DWR et al. (California Department of Water Resources, Yuba County Water Agency, Bureau of Reclamation). 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord*. June.

EBMUD (East Bay Municipal Utility District). 1999. *East Bay Watershed Master Plan*. March.

EBRPD (East Bay Regional Park District). 1996. *Master Plan 1997*. December 17.

EBRPD (East Bay Regional Park District). 2001. *Wildland Management Policies and Guidelines*. June 5.

EBRPD (East Bay Regional Park District). 2012. *Del Valle Regional Park, Checklist of Wild Plants, Sorted Alphabetically by Growth, Form Scientific Name*. February 27.

EBRPD (East Bay Regional Park District). 2013. *Master Plan 2013*. July 16.

ECCCHCPA (East Contra Costa County Habitat Conservation Plan Association). 2006. *Final East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan*. October.

FERC (Federal Energy Regulatory Commission). 2007. *Final Environmental Impact Statement for Hydropower License, Oroville Facilities – FERC Project No. 2100-052*. May.

FERC (Federal Energy Regulatory Commission). 2013. *Draft Environmental Impact Statement for the Drum-Spaulding Project (P-2310-173) and Yuba-Bear Hydroelectric Project (P-2266-096)*. May 17.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp.

Goodwin Power, LLC. 2013. Submittal to Federal Energy Regulatory Commission by American Renewables, LLC. Re: Goodwin Dam Hydroelectric Project. FERC Project No. 13728. Transmittal of Notification of Intent and Pre-Application Document, Request for Comments. October 30.

GRCD (Grasslands Resource Conservation District). 2014. *Grasslands Resource Conservation District*. Site accessed October 1, 2014. http://gwdwater.org/grcd/who-we-are.php.

Green Diamond Resource Company. 2006. *Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances*. October.

Hartman, C.A., and K. Kyle. 2010. *Farming for Birds: Alfalfa and Forages as Valuable Wildlife Habitat*. IN: Proceedings, 2010 California Alfalfa & Forage Symposium and Corn/Cereal Silage Mini-Symposium, Visalia, CA, 1-2. December, 2010. UC Cooperative Extension, Plant Sciences Department, University of California, Davis.

Hickson, D., and T. Keeler-Wolf. 2007. *Vegetation and Land Use Classification and Map of the Sacramento-San Joaquin River Delta*. February.

Huddleston, Robert J. 2001. “Mendota Wildlife Area: A key habitat in the San Joaquin Valley” Outdoor California, July-August 2001.

Kozlowski, T.T., and S.G. Pallardy. 2002. “Acclimation and Adaptive Responses of Woody Plants to Environmental Stresses”. *The Botanical Review*, Vol. 68, No. 2, pp. 270–334.

Lake Arrowhead. 2014a. *Lake Arrowhead*. Site accessed May 19, 2014. http://www.lakearrowhead.com/activities.html.

Lake Arrowhead. 2014b. *Lake Arrowhead, Hiking Tips*. Site accessed October 5, 2014. http://www.lakearrowhead.com/hikingtips.html.

Merz, J.E., Moyle, P.B. 2006. *Salmon, Wildlife, and Wine: Marine-derived Nutrients in Human-Dominated Ecosystems of Central California*. Ecological Applications 16: 999–1009.

MWD (Metropolitan Water District of Southern California). 2014. *Diamond Valley Lake, Southwestern Riverside County Multi-Species Reserve*. Site accessed October 5, 2014. http://www.dvlake.com/shipley01.html.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board, Bureau of Reclamation, Bureau of Land Management). 2013. *Trinity River Channel Rehabilitation Sites: Bucktail, (River Mile 105.3-106.35) and Lower Junction City (River Mile 78.8-79.8), Draft Environmental Assessment/Initial Study*. December.

NID (Nevada Irrigation District). 2005. *Raw Water Master Plan Update, Phase I: Technical Analysis, Volume I, Final Report*. September.

Nogeire T.M., F.W. Davis, J.M. Duggan, K.R. Crooks, and E.E. Boydston. 2013. *Carnivore Use of Avocado Orchards across an Agricultural-Wildland Gradient*. PLoSONE 8(7): e68025. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0068025.

NPS (National Park Service). 1999. *Whiskeytown Unit, Whiskeytown-Shasta-Trinity National Recreation Area General Management Plan and Environmental Impact Statement*. June.

NPS (National Park Service). 2014. *Whiskeytown National Recreation Area, Environmental Assessment and Assessment of Effect, Princess Ditch Trail Construction*. March.

PFC (Pacific Flyway Council). 2014. *Pacific Flyway Council, Coordinated Management*. Site accessed October 7, 2014. http://www.pacificflyway.gov/.

Philipp, M. 2005. *Decker Island Wildlife Area: Enhancing Delta wetlands one phase at a time*. Outdoor California. March-April edition. Pages 4-8.

Plumas County. 2012. *2035 Plumas County General Plan Update Draft Environmental Impact Report*. November.

Putnam, D., M. Russelle, S. Orloff, J. Kuhn, L. Fitzhugh, L. Godfrey, A. Kleiss, and R. Long. 2001. *Alfalfa, Wildlife, and the Environment: the Importance and Benefits if Alfalfa in the 21st Century*. Published by California Alfalfa and Forage Association.

RCWD (Rancho California Water District). 2015. *Welcome to Vail Lake*. Site accessed June 15, 2015. http://www.ranchowater.com/index.aspx?NID=265.

Reclamation (Bureau of Reclamation). 2005a. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2005b. *Central Valley Project Long-Term Water Service Contract Renewal San Luis Unit, Public Draft Environmental Impact Statement and Appendices*. September.

Reclamation (Bureau of Reclamation). 2010a. *2010-2011 Water Transfer Program Draft Environmental Assessmen*t. January.

Reclamation (Bureau of Reclamation). 2010b. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

Reclamation (Bureau of Reclamation). 2010c. *Cachuma Lake Final Resource Management Plan/Environmental Impact Statement*. May.

Reclamation (Bureau of Reclamation). 2012. *Refuge Water Supply Program 2012 Annual Work Plan, CVPIA 3406(b)(3) & (d)(1)(2)(5)*.

Reclamation (Bureau of Reclamation). 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2014a. *Draft Resource Management Plan and Draft Environmental Impact Statement, Contra Loma Reservoir and Recreation Area*. May.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014d. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014e. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2011. *San Joaquin River Restoration Program Environmental Impact Statement/Report*.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2010. *Millerton Lake Final Resource Management Plan/General Plan Environmental Impact Statement/Environmental Impact Report*. April.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2013. *San Luis Reservoir State Recreation Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/ Environmental Impact Report*. June.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros*

*Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game (now known as Department of Fish and Wildlife Service)). 2001a. *Final NEPA Environmental Assessment and CEQA Initial Study, Refuge Water Supply Long-Term Water Supply Agreements, Sacramento River Basin*. January.

Reclamation et al. (Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game (now known as Department of Fish and Wildlife Service)). 2001b. *Final NEPA Environmental Assessment and CEQA Initial Study, Refuge Water Supply Long-Term Water Supply Agreements, San Joaquin River Basin*. January.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Department of Water Resources, State of California Reclamation Board, and Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2009. *Draft Los Vaqueros Reservoir Expansion Project, Environmental Impact Statement Environmental Impact Report*. February.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*. November.

Riverside County. 2003. *Western Riverside County Multiple Species Habitat Conservation Plan*. June 17, 2003.

Riverside County Habitat Conservation Agency. 2014. *Habitat Conservation Plan for the Stephen's Kangaroo Rat in Western Riverside County, California*. Site accessed October 7, 2014. http://www.skrplan.org/skr.html.

Roberts et al. (Roberts, M.D., D.R. Peterson, D.E. Jukkola, and V.L. Snowden). 2002. *A Pilot Investigation of Cottonwood Recruitment on the Sacramento River, The Nature Conservancy*. May.

SANDAG (San Diego Association of Governments). 2003. *Final MHCP Plan, Multiple Habitat Conservation Program*. March.

San Diego County. 2011. *San Diego County General Plan Update, Final Environmental Impact Report*. August.

San Diego County. 2014a. *Multiple Species Conservation Program*. Site accessed October 7, 2014. http://www.sandiegocounty.gov/pds/mscp/.

San Diego County. 2014b. *About the MSCP*. Site accessed October 7, 2014. http://www.sandiegocounty.gov/content/sdc/pds/mscp/overview.html.

San Diego County. 2015. *About the MSCP*. Site accessed June 15, 2015. http://www.sandiegocounty.gov/content/sdc/pds/mscp/overview.html.

Santa Clara County et al. (County of Santa Clara, City of San Jose, City of Morgan Hill, City of Gilroy, Santa Clara Valley Water District, and Santa Clara Valley Transportation Authority). 2012. *Final Santa Clara Valley Habitat Plan*. August.

SBCWD (San Benito County Water District). 2012. *Initial Study, Zebra Mussel Eradication Project: San Justo Reservoir, Hollister Conduit, & San Benito County Water District Subsystems*. January.

SCVWD (Santa Clara Valley Water District). 2010. *Urban Water Management Plan*.

SDCWA and USACE (San Diego County Water Authority and U.S. Army Corps of Engineers). 2008. *Final Environmental Impact Report/Environmental Impact Statement for the Carryover Storage and San Vicente Dam Raise Project*. April 2008.

SDCWA and USFWS (San Diego County Water Authority and U.S. Fish and Wildlife Service). 2010. *Final Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the San Diego County Water Authority Subregional Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP)*. October.

SDRP (San Dieguito River Park). *Keep Your Eye on Lake Hodges Wildlife.* Site accessed June 15, 2015. http://www.sdrp.org/resources/What's%20Growing%20On/Lake%20Hodges%20Wildlife.htm.

SDRWWG (San Diego River Watershed Work Group). 2005. *San Diego River Watershed Management Plan, Final Watershed Management Plan*. March.

SFEI (San Francisco Estuary Institute-Aquatic Science Center). 2012. *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process*. Whipple, A.A., R.M. Grossinger, D. Rankin, B. Stanford, and R.A. Askevold. Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. Historical Ecology Program Publication #672. August.

Siegel et al. (Siegel, S., C. Enright, C. Toms, C. Enos, and J. Sutherland). 2010a. “Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model. Chapter 1: Physical Processes, Final Review Draft”. *Suisun Marsh Habitat Management, Restoration and Preservation Plan*. September 15.

Siegel et al. (Siegel, S., C. Toms, D. Gillenwater, and C. Enright). 2010b. “Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model.

Chapter 3: Tidal Marsh, In-progress Review Draft." *Suisun Marsh Habitat Management, Restoration and Preservation Plan*. October 26.

State Parks (California Department of Parks and Recreation). 2006. *Silverwood Lake State Recreation Area*. Site accessed February 21, 2013. www.rockymountainrec.com/lakes/lake-silverwood.htm.

State Parks (California Department of Parks and Recreation). 2009. *Silverwood Lake State Recreation Area, Nature Center Interpretive Project Plan*. April.

STNF (Shasta-Trinity National Forest). 2014. *Management Guide, Shasta and Trinity Units*. Version 2.12.2014.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January.

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Tri-Dam Project. 2003. Letter from Steve Felte, Tri-Dam Project, and Mick Klasson, Stanislaus County, to Interested Agencies Re: Request for Preliminary Input on the Proposed Goodwin Hydroelectric Project. August 8.

Tri-Dam Project. 2007. Submittal to Federal Energy Regulatory Commission by Tri-Dam Project, Re: Tulloch Project No. 2067, License Compliance Filings, *Tulloch Project, FERC No. 2067, Tulloch Reservoir Shoreline Management Plan*. November 21.

Tri-Dam Project. 2008. Submittal to Federal Energy Regulatory Commission by Tri-Dam Project, Re: Tulloch Project No. 2067, License Compliance Filings, *Tulloch Project, FERC No. 2067, Tulloch Reservoir Shoreline Management Plan*. June 23.

USACE (U.S. Army Corps of Engineers). 2009. *ETL 1110-2-571 Guidelines For Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*. April 10.

USACE (U.S. Army Corps of Engineers). 2010. *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls--75 Fed. Reg. 6364-68*. February 9.

USACE (U.S. Army Corps of Engineers). 2013. *Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River*. October.

USACE (U.S. Army Corps of Engineers). 2014. *Voluntary Conservation Measures – Habitat Enhancement on the Lower Yuba River, Yuba County, California, Draft Environmental Assessment*. July.

USFS (U.S. Forest Service). 2005. *Upper Trinity River Watershed Analysis,* Shasta-*Trinity National Forest.*

USFS (U.S. Forest Service). 2012. *Bald Eagles of Shasta, Trinity, and Lewiston Lakes*. April.

USFWS (U.S. Fish and Wildlife Service). 1975. *Deer Loss Compensation Program Resulting from Trinity River Division*. April.

USFWS (U.S. Fish and Wildlife Service). 2002. *Environmental Assessment Proposed North Delta National Wildlife Refuge*.

USFWS (U.S. Fish and Wildlife Service). 2004. Intra-Service Formal Section 7 Consultation/Conference for Issuance of an Endangered Species Act Section 10(a)(1)(B) Permit (TE-088609-0) for the Western Riverside County Multiple Species Habitat Conservation Plan, Riverside County, California. June 22.

USFWS (U.S. Fish and Wildlife Service). 2006. S*an Joaquin River National Wildlife Refuge Draft Comprehensive Conservation Plan and Environmental Assessment*. Prepared by California/Nevada Operations Office, San Luis National Wildlife Refuge Complex, and California/Nevada Refuge Planning Office.

USFWS (U.S. Fish and Wildlife Service). 2007. *Stone Lakes National Wildlife Refuge Comprehensive Conservation Plan*. January.

USFWS (U.S. Fish and Wildlife Service). 2010. *Notice of Availability of Federal Assistance 2010 Request for Proposals, Mill Creek.*

USFWS (U.S. Fish and Wildlife Service). 2012a. *San Luis National Wildlife Refuge*, *Resource Management*. December 18. Site accessed September 30, 2014. http://www.fws.gov/Refuge/San_Luis/what_we_do/resource_management.html.

USFWS (U.S. Fish and Wildlife Service). 2012b. *San Luis National Wildlife Refuge*, *Wildlife & Habitat*. December 18. Site accessed September 30, 2014. http://www.fws.gov/Refuge/San_Luis/wildlife_and_habitat/index.html.

USFWS (U.S. Fish and Wildlife Service). 2012c. *San Luis National Wildlife Refuge*. December 18. Site accessed September 30, 2014. http://www.fws.gov/Refuge/San_Luis/about.html.

USFWS (U.S. Fish and Wildlife Service). 2012d. Merced National Wildlife Refuge, *About the Merced National Wildlife Refuge*. December 19. Site accessed on July 28, 2014. http://www.fws.gov/Refuge/Merced/about.html.

USFWS (U.S. Fish and Wildlife Service). 2012e. *San Joaquin River National Wildlife Refuge Wildlife & Habitat*. December 21. Site accessed July 28, 2014. http://www.fws.gov/Refuge/San_Joaquin_River/wildlife_and_habitat/index.html.

USFWS (U.S. Fish and Wildlife Service). 2012f. *San Joaquin River National Wildlife Refuge, About the Refuge*. December 21. Site accessed October 1, 2014. http://www.fws.gov/Refuge/San_Joaquin_River/about.html.

USFWS (U.S. Fish and Wildlife Service). 2013a. *Sacramento National Wildlife Refuge, About the Sacramento NWR Complex*. Site accessed July 28, 2014. http://www.fws.gov/refuge/Sacramento/Aboutthecomplex.html.

USFWS (U.S. Fish and Wildlife Service). 2013b. *San Luis National Wildlife Refuge, About the Complex*. April 2. Site accessed September 30, 2014. http://www.fws.gov/refuge/san_luis/About_the_Complex.html.

USFWS (U.S. Fish and Wildlife Service). 2013c. *San Luis National Wildlife Refuge, Grasslands Wildlife Management Area*. April 9. . Site accessed July 28, 2014. http://www.fws.gov/refuge/san_luis/grasslands.html.

USFWS (U.S. Fish and Wildlife Service). 2013d. *Kern National Wildlife Refuge, About the Complex*. November 21. Site accessed July 29, 2014. http://www.fws.gov/refuge/Kern/About_the_Complex.html.

USFWS (U.S. Fish and Wildlife Service). 2013e. *Kern National Wildlife Refuge, Wildlife & Habitat*. November 21. Site accessed July 29, 2014. http://www.fws.gov/refuge/Kern/wildlife_and_habitat/index.html.

USFWS (U.S. Fish and Wildlife Service). 2014a. Critical habitat list for Alameda County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014b. Critical habitat list for Butte County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014c. Critical habitat list for Colusa County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014d. Critical habitat list for Contra Costa County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014e. Critical habitat list for Del Norte County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014f. Critical habitat list for El Dorado County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014g. Critical habitat list for Fresno County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/politicalList.do

USFWS (U.S. Fish and Wildlife Service). 2014h. Critical habitat list for Glenn County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014i. Critical habitat list for Humboldt County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014j Critical habitat list for Kern County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014k. Critical habitat list for Kings County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014l. Critical habitat list for Los Angeles County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014m. Critical habitat list for Madera County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014n. Critical habitat list for Merced County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014o. Critical habitat list for Nevada County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014p. Critical habitat list for Orange County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014q. Critical habitat list for Placer County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014r. Critical habitat list for Plumas County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014s. Critical habitat list for Riverside County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014t. Critical habitat list for Sacramento County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014u. Critical habitat list for San Benito County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014v. Critical habitat list for San Bernardino County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014w. Critical habitat list for San Diego County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014x. Critical habitat list for San Joaquin County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014y. Critical habitat list for Santa Barbara County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014z. Critical habitat list for Santa Clara County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014aa. Critical habitat list for Shasta County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ab. Critical habitat list for Solano County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ac. Critical habitat list for Stanislaus County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ad. Critical habitat list for Sutter County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ae. Critical habitat list for Tehama County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014af. Critical habitat list for Trinity County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ag. Critical habitat list for Tulare County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ah. Critical habitat list for Ventura County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ai. Critical habitat list for Yolo County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014aj. Critical habitat list for Yuba County. Site accessed September 28, 2014. http://ecos.fws.gov/crithab/.

USFWS (U.S. Fish and Wildlife Service). 2014ak. *Pixley National Wildlife Refuge*. Site accessed October 1, 2014. http://www.fws.gov/refuges/profiles/index.cfm?id=81612.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. *Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report*. October.

UWCD (United Water Conservation District). 1999. *Lake Piru Recreation Area Master Plan, Final Initial Study/Mitigated Negative Declaration*. August.

UWCD (United Water Conservation District). 2014. *Facilities and Strategies*. Site accessed March 26, 2014. http://www.unitedwater.org/about-us-6/facilities-a-strategies.

Witham, C.W and Karacfelas, G.A. 1994. *Final Report, Botanical Resources Inventory At Calhoun Cut Ecological Reserve Following California's Recent Drought*. Prepared for California Department of Fish and Game (now known as California Department of Fish and Wildlife). August 15.

YNHP (Yolo County Natural Heritage Program). 2015. *Yolo Natural Heritage Plan*. Site accessed June 3, 2015. http://www.yoloconservationplan.org/.

Yolo County. 2013. *Final Report: Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals*. Prepared by Richard Howitt, Duncan MacEwan, Chloe Garnache, Josue Medellin Azura, Petrea Marchand, Doug Brown, Johan Six, and Juhwan Lee. April.

Yurok Tribe. 2000. *Lower Klamath River Sub-Basin Watershed Restoration Plan*. April.

Yuba County. 2011. *Final Yuba County 2030 General Plan Environmental Impact Report.* May.

**Chapter 11**

# Geology and Soils Resources

## 11.1 Introduction

This chapter describes the geology and soils resources in the project area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of alternatives could affect geology and soils resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP).

## 11.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect reservoirs, streams, and lands served by CVP and SWP water supplies located on lands affected by seismic, landslide, and liquefaction hazards; subsidence; and unstable soils. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analysis.

## 11.3 Affected Environment

This section describes the geological, regional seismic, and soils characteristics and subsidence potential that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in soils characteristics due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, and Central Coast and Southern California regions. Geomorphic provinces in California are shown on Figure 11.1.

### 11.3.1 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

#### *11.3.1.1 Geologic Setting*

The Trinity River Region is located within the southwest area of the Klamath Mountains Geomorphic Province and the northwest area of the Coast Ranges Geomorphic Province, as defined by the U.S. Geological Survey (USGS) geomorphic provinces (CGS 2002a). The Klamath Mountains Geomorphic Province covers approximately 12,000 square miles of northwestern California between the Coast Range on the west and the Cascade Range on the east and is considered to be a northern extension of the Sierra Nevada (CGS 2002a, Reclamation 1997).

The Klamath Mountains trend mostly northward. The province is primarily formed by the eastern Klamath Mountain belt, central metamorphic belt, the western Paleozoic and Triassic, and the western Jurassic belt. Rocks in this province include Paleozoic meta-sedimentary and meta-volcanic rocks, Mesozoic igneous rocks, Ordovician to Jurassic aged marine deposits in the Klamath belt, Paleozoic hornblend, mica schists and ultramafic rocks in the central metamorphic belt and slightly metamorphosed sedimentary and volcanic rocks in the western Jurassic, Paleozoic, and Triassic belt (Reclamation 1997).

The Trinity River watershed is located within the Klamath Mountain Geomorphic Province. Although the Trinity River watershed includes portions of both the Coast Ranges Province and the Klamath Mountains Province, the Trinity River riverbed is underlain by rocks of the Klamath Mountains Province (NCRWQCB et al. 2009). The Klamath Mountains Province formations generally dip towards the east and are exposed along the riverbed. Downstream of Lewiston Dam to Deadwood Creek, the area is underlain by the Eastern Klamath Terrane of the Klamath Mountains Province. The rocks in this area are primarily Copley Greenstone, metamorphosed volcanic sequence with intermediate and mafic volcanic rocks; and Bragdon formation, metamorphosed sedimentary formation with gneiss and amphibolite. Along the Trinity River between Lewiston Dam and Douglas City, outcrops of the Weaverville Formation occur. The Weaverville Formation, a series of nonmarine deposits, includes weakly consolidated mudstone, sandstone, and conglomerate of clays matrix and sparse beds of tuff. Downstream of Douglas City, the Trinity River is underlain by the Northfork and Hayfork terranes. The Northfork Terrane near Douglas City includes silicious tuff, chert, mafic volcanic rock, phyllite, and limestone sandstone and pebble conglomerate with serpentine intrusions. As the riverbed extends towards the Klamath River, the geologic formation extends into the Hayfork Terrane that consists of metamorphic and meta-volcanic rock. Terraces of sand and gravel from glacial erosion along the Trinity River flanks near Lewiston Dam contribute sediment into Trinity River.

The Trinity River flows into the Klamath River near Weitchpec. Downstream of the Weitchpec, the Klamath River flows to the Pacific Ocean through the Coast Ranges Geomorphic Province. The geology along the Klamath River in the Coast Ranges Geomorphic Province is characterized by the Eastern Belt of the Franciscan Complex and portions of the Central Belt of this complex. The Franciscan Complex consists of sandstone with some shale, chert, limestone, conglomerate, serpentine, and blueschist. The Eastern Belt is composed of schist and meta-sedimentary rocks with minor amounts of shale, chert, and conglomerate. The Central Belt is primarily composed of an argillite-matrix mélange with slabs of greenstone, serpentinte, graywacke, chert, high-grade metamorphics, and limestone.

#### *11.3.1.2 Regional Seismicity*

The areas along the Trinity River have been categorized as regions that are distant from known, active faults and generally would experience infrequent, low levels of shaking. However, infrequent earthquakes with stronger shaking could occur (CGS 2008). The closest areas to the Trinity River with known seismic active areas capable of producing an earthquake with a magnitude of 8.5 or greater are the northern San Andreas Fault Zone and the Cascadia Subduction Zone which are approximately 62 and 124 miles away, respectively (NCRWQCB et al. 2009).

The areas along the lower Klamath River downstream of the confluence with the Trinity River have a slightly higher potential for greater ground shaking than areas along the Trinity River (CGS 2008). The lower Klamath River is closer than the Trinity River to the offshore Cascadia Subduction Zone, which runs offshore of Humboldt and Del Norte counties and Oregon and Washington states. The Klamath River is approximately 30 to 40 miles from the Trinidad Fault, which extends from the area near Trinidad northwest to the coast near Trinidad State Beach. The Trinidad Fault is potentially capable of generating an earthquake with a moment magnitude of 7.3 (Humboldt County 2012).

The San Andreas Fault, under the Pacific Ocean in a northwestern direction from the Humboldt and Del Norte counties, is where the Pacific Plate moves towards the northwest relative to North America (Humboldt County 2012). The Cascadia Subduction Zone, located under the Pacific Ocean offshore from Cape Mendocino in southwest Humboldt County to Vancouver Island in British Columbia, has produced numerous earthquakes with magnitudes greater than 8. The Cascadia Subduction Zone is where the Gorda Plate and the associated Juan de Fuca Plate descend under the North American Plate.

#### *11.3.1.3 Regional Volcanic Potential*

Active centers of volcanic activity occur in the vicinity of Mount Shasta, located near the northeastern edge of the Trinity River Region. Mount Shasta is located about 45 miles north of Shasta Lake. Over the past 10,000 years, Mount Shasta erupted about once every 800 years. During the past 4,500 years, Mount Shasta erupted about once every 600 years with the most recent eruption in 1786. Lava flows, dome, and mudflows occurred during the eruptions (Reclamation 2013a).

#### *11.3.1.4 Soil Characteristics*

Soils in the southern region of the Klamath Mountain Geomorphic Province, where the Trinity River is located, are generally composed of gravelly loam with some alluvial areas with dredge tailings, river wash, and xerofluvents (NCRWQCB et al. 2009).

Soils along the lower Klamath River are generally composed of gravelly clay loam and gravelly sandy loam with sand and gravels within the alluvial deposits (DOI and DFG 2012). Alluvial deposits (river gravels) and dredge tailings provide important spawning habitat for salmon and steelhead.

#### *11.3.1.5 Subsidence*

Land subsidence is not a major occurrence in the Trinity River Region.

### 11.3.2 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

#### *11.3.2.1 Geologic Setting*

The Central Valley Region is bounded by the Klamath Mountains, Cascade Range, Great Valley, Coast Ranges, and Sierra Nevada geomorphic provinces (CGS 2002a).

The Klamath Mountains Geomorphic Province was described in subsection 11.3.2, Trinity River Region. The Cascade Range Geomorphic Province consists of volcanic rocks of the Miocene to Pleistocene age. Several volcanoes within the Cascade Range Geomorphic Province and the Central Valley Region include Mount Shasta and Lassen Peak (Reclamation 2013a).

The Great Valley Geomorphic Province is an approximately 400 mile long, 50 mile wide valley that extends from the northwest to the southeast between the Sierra Nevada and Coast Ranges geomorphic provinces. The faulted and folded sediments of the Coast Range extend eastward beneath most of the Central Valley; and the igneous and metamorphic rocks of the Sierra Nevada extend westward beneath the eastern Central Valley (Reclamation 1997). The valley floor is an alluvial plain of sediments that have been deposited since the Jurassic age (CGS 2002a). Below these deposits are Cretaceous Great Valley Sequence shales and sandstones and upper Jurassic bedrock of metamorphic and igneous rocks associated in the east with the Sierra Nevada and in the west with the Coast Ranges (DWR 2007). Sediments deposited along the submarine fans within the Great Valley Geomorphic Province include mudstones, sandstones, and conglomerates from the Klamath Mountains and Sierra Nevada geomorphic provinces.

The valley floor in the Great Valley Geomorphic Province includes dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms. The dissected uplands include consolidated and unconsolidated Tertiary and Quaternary continental deposits. The alluvial fans along the western boundary include poorly sorted fine sand, silt, and clay. The alluvial fans along the eastern boundary consist of well sorted gravel and sand along major tributaries, and poorly sorted materials along intermittent streams. River and floodplains primarily consist of coarse sands and fine silts. The lake bottoms primarily occur in the in the southern San Joaquin Valley and composed of clay layers (Reclamation 1997).

The Sierra Nevada Geomorphic Province along the eastern boundary of the Great Valley Geomorphic Province is composed of pre-Tertiary igneous and metamorphic rocks. The Sierra Nevada Geomorphic Province is an uplifted fault block nearly 400 miles long with a series of metamorphic rock on the east and deep river cuts on a gentle slope, which disappears under sediments of the Central Valley on the west. Gold-bearing veins are present in the northwest trending

Mother Lode metamorphic bedrock. The province is bordered by the Cascade Range on the north (Placer County 2007).

The Coast Ranges Geomorphic Province is composed of pre-Tertiary and Tertiary semiconsolidated to consolidated marine sedimentary rocks. The Coast Ranges Province is characterized by active uplift related to the San Andreas Fault and plate boundary system tectonics. The province extends westward toward the coastline and eastward toward the Great Valley Geomorphic Province. Rocks in this region include mafic and ultramafic rock associated with the Coast Range ophiolite, and Miocene volcanic rocks (Sonoma Volcanics) and marine and terrestrial sedimentary from the Cretaceous to the Neogene period (Reclamation et al. 2010).

#### 11.3.2.1.1 Sacramento Valley Geological Setting

Major watersheds within the Sacramento Valley that could be affected by CVP and SWP operations include the Sacramento River, Feather River, and the Lower American River watersheds.

*Sacramento River Watershed Geological Setting*

The Sacramento River flows from Shasta Lake to the Delta. The area along the Sacramento River from Shasta Lake to downstream of Red Bluff is characterized by loosely consolidated deposits of Pliocene and or Pleistocene age sandstone, shale, and gravel. Downstream of Red Bluff to the Delta, the river flows through Quaternary age alluvium, lake, playa, and terrace deposits that are unconsolidated or poorly consolidated with outcrops of resistant, cemented alluvial units such as the Modesto and Riverbank formations (CALFED 2000).

The active river channel maintains roughly constant dimensions as it migrates across the floodplain within the limits of the meander belt which is constrained only by outcrops of resistant units or artificial bank protection. Sediment loads in the tributary streams and lower reaches of the Sacramento River occur due to past and current land use practices on the tributary streams.

*Feather River Watershed Geological Setting*

Portions of the Feather River watershed analyzed in this EIS extend from Antelope Lake, Lake Davis, and Frenchman Lake upstream of Lake Oroville, through Lake Oroville and the Thermalito Reservoir complex, and along the Feather River to the confluence with the Sacramento River. The Yuba and Bear rivers are the major tributaries to the Feather River downstream of Thermalito Dam.

The Feather River watershed upstream of Thermalito Dam is located in the Cascade Range Geomorphic Province and the metamorphic belt of the Sierra Nevada Geomorphic Province. The lower watershed downstream of Thermalito Dam is located in the Great Valley Geomorphic Province.

West of Lake Oroville, scattered sedimentary and volcanic deposits cover the older bedrock, including (from oldest to youngest) the marine Chico formation from the upper Cretaceous; the auriferous gravels and mostly non-marine Ione formation of the Eocene Epoch; the extrusive volcanic Lovejoy basalt of the late Oligocene to early Miocene; and volcanic flows and volcaniclastic rocks of the Tuscan formation of the late Pliocene. Late Tertiary and Quaternary units in this area include alluvial terrace and fan deposits of the Plio-Pliestocene Laguna formation, the Riverbank and Modesto formations of the Pleistocene, riverbed sediments of the Holocene, and historical dredge and mine tailings from 20th century mining activities (DWR 2007).

Alluvium deposits occur in active channels of the Feather, Bear, and Yuba rivers and tributary streams. These deposits contain clay, silt, sand, gravel, cobbles, and boulders in various layers and mixtures. Historical upstream hydraulic mining significantly increased the sediment covering the lower Feather River riverbed with a thick deposit of fine clay-rich, light yellow-brown slickens (i.e., powdery matter from a quartz mill or residue from hydraulic mining). More recent floodplain deposits cover these slickens in the banks along most of the Feather River. Cobbles and coarse gravel dredge tailings constitute most of the banks, slowing the bank erosion process between the cities of Oroville and Gridley. The river is wide and shallow, with low sinuosity and a sand bed between Honcut Creek and the mouth of the Feather River.

*American River Watershed Geological Setting*

The Folsom Lake area is located within the Sierra Nevada and the Great Valley Geomorphic Province at the confluence of the North and South Forks of the American River. The Folsom Lake region primarily consists of rolling hills and upland plateaus between major river canyons. Three major geologic divisions within the area include a north-northwest trending belt of metamorphic rocks, granitic plutons that have intruded and obliterated some of the metamorphic belt, and deposits of volcanic ash, debris flows, and alluvial fans that are relatively flat lying. These deposits overlie older rocks (Reclamation et al. 2006).

Igneous, metamorphic, and sedimentary rock types are present within the Folsom Lake area. Major rock divisions are ultramafic intrusive rocks, metamorphic rocks, granodiorite intrusive rocks, and volcanic mud flows and alluvial deposits. Ultramafic rocks are most common on Flagstaff Mountain (Hill) on the Folsom Reservoir Peninsula located on a peninsula between the North Fork American River and South Fork American River. This rock division may contain trace amounts of serpentine minerals, chromite, minor nickel, talc, and naturally occurring asbestos (Reclamation et al. 2006).

Metamorphic rocks are found in a north-northwest trending band primarily on the eastern portions of the Folsom Lake area through most of the peninsula between the North Fork American River and South Fork American River (CGS 2010). The Metamorphic rocks are mainly composed of Copperhill Volcanics (metamorphosed basaltic breccia, pillow lava, and ash) and Ultramafic rocks, two formations that may contain trace amounts of naturally occurring asbestos (Reclamation et al. 2006).

Granodiorite intrusive rocks occur in the Rocklin Pluton on both sides of Folsom Lake extending to Lake Natoma, and the Penryn Pluton upstream of the Rocklin

Pluton. Granodiorite intrusive rocks are composed of a coarse-grained crystalline matrix with slightly more iron and magnesium-bearing minerals and less quartz than granite. Of the granodiorite, the feldspar and hornblend are less resistant than the quartz crystals and easily weathers. When weathering occurs, the remaining feldspars separate from the quartz resulting in decomposed granite (Reclamation et al. 2006).

Volcanic mud flows and alluvial deposits are present downstream of Folsom Lake in the southwest corner of two major formations, the Mehrten and Laguna Formation. The Mehrten Formation contains volcanic conglomerate, sandstone, and siltstone; all derived from andesitic sources and portions are gravels deposited by ancestral streams. The Laguna Formation, deposited predominately as debris flow on the Mehrten Formation, is a sequence of gravel, sand and silt derived from granitic sources (Reclamation et al. 2006).

The area along the American River downstream of Folsom Lake and Nimbus Reservoir is located in the Great Valley Geomorphic Province. The area includes several geomorphic land types including dissected uplands and low foothills, low alluvial fans and plains, and river floodplains and channels. The dissected uplands consist of consolidated and unconsolidated continental deposits of Tertiary and Quaternary that have been slightly folded and faulted (Reclamation 2005).

The alluvial fans and plains consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor (Reclamation 2005). The alluvial plains in the American River watershed include older Quaternary deposits (Sacramento County 2010). River flood plains and channels lay along the American River and smaller streams that flow into the Sacramento River south of the American River. Some floodplains are well-defined, where rivers are incised into their alluvial fans. These deposits tend to be coarse and sandy in the channels and finer and silty in the floodplains (Reclamation 2005; Sacramento County 2010).

#### 11.3.2.1.2 Delta Geological Setting

The Delta is a northwest-trending structural basin, separating the primarily granitic rock of the Sierra Nevada from the primarily Franciscan Formation rock of the California Coast Range (CWDD 1981). The Delta is a basin within the Great Valley Geomorphic Province that is filled with a 3- to 6-mile thick layer of sediment deposited by streams originating in the Sierra Nevada, Coast Ranges, and South Cascade Range. Surficial geologic units throughout the Delta include peat and organic soils, alluvium, levee and channel deposits, dune sand deposits, older alluvium, and bedrock.

The historical delta at the confluence of the Sacramento River and San Joaquin River is referred to as the Sacramento–San Joaquin Delta, or Delta. The Delta is a flat-lying river delta that evolved at the inland margin of the San Francisco Bay Estuary as two overlapping and coalescing geomorphic units: the Sacramento River Delta to the north and the San Joaquin River Delta to the south. During large river-flood events, silts and sands were deposited adjacent to the river channel, formed as a tidal marsh with few natural levees, and was dominated by tidal flows, allowing for landward accumulation of sediment behind the bedrock barrier at the Carquinez Strait. The sediment formed marshlands, which consisted of approximately 100 islands that were surrounded by hundreds of miles of channels. Generally, mineral soils formed near the channels during flood conditions and organic soils formed on marsh island interiors as plant residues accumulated faster than they could decompose (Weir 1949).

In the past, because the San Joaquin River Delta had less well-defined levees than under current conditions, sediments were deposited more uniformly across the floodplain during high water, creating an extensive tule marsh with many small, branching tributary channels. Because of the differential amounts of inorganic sediment supply, the peat of the San Joaquin River Delta grades northward into peaty mud and mud toward the natural levees and flood basins of the Sacramento River Delta (Atwater et al. 1980).

The Delta has experienced several cycles of deposition, nondeposition, and erosion that have resulted in the thick accumulation of poorly consolidated to unconsolidated sediments overlying the Cretaceous and Tertiary formations since late Quaternary time. Shlemon and Begg (1975) calculated that the peat and organic soils in the Delta began to form about 11,000 years ago during an episode of sea level rise. Tule marshes established on peat and organic soils in many portions of the Delta. Additional peat and other organic soils formed from repeated inundation and accumulation of sediment of the tules and other marsh vegetation.

#### 11.3.2.1.3 Suisun Marsh Geological Setting

The Suisun Marsh area is located within the Coast Ranges Geomorphic Province. The Suisun Marsh is bounded by the steep Coast Range on the west and by the rolling Montezuma Hills on the east. The Montezuma Hills consist of uplifted Pleistocene sedimentary layers with active Holocene age alluvium in stream drainages that divide the uplift. Low-lying flat areas of the marshland are covered by Holocene age Bay Mud deposits. The topographically higher central portions of Grizzly Island in the marshlands north of the Suisun Bay are formed by the Potrero Hills. These hills primarily consist of folded and faulted Eocene marine sedimentary rocks and late Pleistocene alluvial fan deposits (Reclamation et al. 2010).

#### 11.3.2.1.4 San Joaquin Valley Geological Setting

The San Joaquin Valley is located within the southern half of the Great Valley Geomorphic Province. The 250-mile-long and 50-to-60-mile-wide valley lies between the Coast Ranges on the west, the Sierra Nevada on the east, and extends northwestward to the Delta near the City of Stockton. The San Joaquin Valley is the southern portion of a large, northwest-to-southeast-trending asymmetric trough filled with up to six vertical miles of Jurassic to Holocene age sediments. The trough is primarily made up of Tertiary and Quaternary continental rocks, and deposits, which become separated by lacustrine, marsh, and floodplain deposits of varying thicknesses. The continental deposits, which include the Mehrten, Kern River, Laguna, San Joaquin, Tulare, Tehama, Turlock, Riverbank, and Modesto formations, form the San Joaquin Valley aquifer (Ferriz 2001, Reclamation et al. 2011, Reclamation 2009).

Dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms are the several geomorphic land types within the San Joaquin Valley. Dissected uplands consist of slightly folded and faulted, consolidated and unconsolidated, Tertiary and Quaternary age continental deposits. The alluvial fans and plains, which cover most of the valley floor, consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor. In general, alluvial sediments of the western and southern parts of the San Joaquin Valley tend to have lower permeability than deposits on the eastern side. River floodplains and channels lie along the major rivers and are well-defined where rivers incise their alluvial fans. Typically, these deposits are coarse and sandy in the channels and finer and silty in the floodplains (Reclamation et al. 2011).

Lake bottoms of overflow lands in the San Joaquin Valley include historic beds of Tulare Lake, Buena Vista Lake, and Kern Lake as well as other less defined areas in the valley trough. Near the valley trough, fluvial deposits of the east and west sides grade into fine-grained deposits. The largest lake deposits in the Central Valley are found beneath the Tulare Lake bed where up to 3,600 feet of lacustrine and marsh deposits form the Tulare Formation. This formation is composed of widespread clay layers, the most extensive being the Cocoran Clay member which also is found in the western and southern portions of the San Joaquin Valley. The Cocoran Clay member is a confining layer that separates the upper semi-confined to unconfined aquifer from the lower confined aquifer (Reclamation 1997).

The valley floor and foothills portions of the San Joaquin Valley and San Joaquin River area, and the Stanislaus River watershed could be affected by CVP and SWP operations. The Stanislaus River watershed originates in the Sierra Nevada Geomorphic Province, including the area with New Melones Reservoir, and extends into the Great Valley Geomorphic Province. New Melones Reservoir is oriented along a northwest trend that is produced by the Foothill Metamorphic Belt in the Sierra Nevada Geomorphic Province (Reclamation 2010). The area is underlain by Cenozoic sedimentary rocks which dip towards the southwest and overlies the Cretaceous sedimentary rocks of the Great Valley sequence and older metamorphic basement rocks along the edges of the Sierra Nevada. Tertiary sedimentary formations were deposited along the Stanislaus River from an area east of Knights Ferry to Oakdale (CGS 1977). The oldest Tertiary geologic unit, Eocene Ione Formation, primarily consists of quartz, sandstone, and interbedded kaolinitic clays with a maximum thickness of about 200 feet near Knights Ferry. The Oligocene-Miocene Valley Springs Formation of rhyolitic ash, sandy clay, and gravel deposits overlay the Ione Formation. Andestic flows, lahars, and volcanic sediments of the Mehrten Formation were deposited by volcanism, especially from Table Mountain (CGS 1977; Reclamation 2010). Three major alluvial fan deposits occurred along the Stanislaus River after deposition of the

Mehrten Formation, including the Turlock Lake Formation (between Orange Blossom Road and Oakdale) composed of fine sand and silt with some clay, sand, and gravel; Riverbank Formation (between Oakdale and Riverbank) composed of silt and clay; and Modesto Formation (between Riverbank and the confluence with the San Joaquin River) composed of sand, silt, clay, and gravel.

#### *11.3.2.2 Regional Seismicity*

Most of the areas in the Central Valley Region have been categorized as regions that are distant from known, active faults and generally would experience infrequent, low levels of shaking. However, infrequent earthquakes with stronger shaking could occur (CGS 2008). Areas within and adjacent to the Delta Region and along Interstate 5 in the San Joaquin Valley have a higher potential for stronger ground shaking due to their close proximity to the San Andreas Fault Zone.

The San Andreas Fault Zone is located to the west of the Central Valley Region along a 150-mile northwest-trending fault zone (Reclamation 2013a). The fault zone extends from the Gulf of California to Point Reyes where the fault extends under the Pacific Ocean (CGS 2006). The fault zone is the largest active fault in California (Reclamation 2005d).

In the Sacramento Valley, the major fault zones include the Battle Creek Fault Zone located to the east of the Sacramento River, Corning Fault that extends from Red Bluff to Artois parallel to the Corning Canal, Dunnigan Hills Fault located west of Interstate 5 near Dunnigan, Cleveland Fault located near Oroville, and Great Valley Fault system along the west side of the Sacramento Valley (Reclamation 2005a, Reclamation 2013a).

The Delta and Suisun Marsh are located in proximity to several major fault systems, including the San Andreas, Hayward-Rodgers Creek, Calaveras, Concord-Green Valley, and Greenville faults (DWR et al. 2013a). There are also many named and unnamed regional faults in the vicinity. The majority of seismic sources underlying the Delta and Suisun Marsh are “blind” thrusts that are not expected to rupture to the ground surface during an earthquake. The known blind thrusts in the Delta and Suisun Marsh area include the Midland, Montezuma Hills, Thornton Arch, Western Tracy, Midland, and Vernalis faults. Blind thrust faults with discernible geomorphic expression/trace located at the surface occur near the southwestern boundary of the Delta include Black Butte and Midway faults. Two surface crustal fault zones (e.g., areas with localized deformation of geologic features near the surface) are located within the Suisun Marsh, including the Pittsburgh-Kirby Hills fault which occurs along an alignment between Fairfield and Pittsburg, and Concord-Green Valley fault which crosses the western portion of the Suisun Marsh. The Cordelia fault is a surface crustal fault zone that occurs near the western boundary of the Suisun Marsh. Since 1800, no earthquakes with a magnitude greater than 5.0 have been recorded in the Delta or Suisun Marsh.

In the San Joaquin Valley, the eastern foothills are characterized by strike-slip faults that occur because the rock underlying the valley sediment is slowly moving downward relative to the Sierra Nevada Block to the east. An example of this type of faulting is the Kings Canyon lineament which crosses the valley north of Chowchilla and continues nearly to Death Valley in southeastern California (Reclamation et al. 2011). Uplift and tilting of the Sierra Nevada block towards the west and tilting of the Coast Ranges block to the east appear to be causing gradual downward movement of the valley basement rock, in addition to subsidence caused by aquifer compaction and soil compaction discussed below. The San Joaquin Valley is bounded by the Stockton Fault of the Stockton Arch on the north and the Bakersfield Arch on the south. Most of the fault zones in the San Joaquin Valley do not appear to be active. However, numerous faults may not be known until future seismic events, such as the Nunez reverse fault which was not known until the 1983 Coalinga earthquake. In areas adjacent to the San Joaquin Valley, the dominant active fault structure is the Great Valley blind thrust associated with San Andreas Fault. Other active faults occur along the western boundary of the San Joaquin Valley, including the Hayward, Concord-Green Valley, Coast Ranges-Sierra Block boundary thrusts, Mount Diablo, Greenville, Ortigalita, Rinconada, and Hosgri faults (Reclamation 2005d).

#### *11.3.2.3 Regional Volcanic Potential*

Active centers of volcanic activity occur in the vicinity of Mount Shasta and Lassen Peak in the Central Valley Region. Mount Shasta is located about 45 miles north of Shasta Lake. Over the past 10,000 years, Mount Shasta erupted about once every 800 years. During the past 4,500 years, Mount Shasta erupted about once every 600 years with the last eruption in 1786. Lava flows, domes, and mudflows occurred during the eruptions (Reclamation 2013a).

Lassen Peak, located about 50 miles southeast of Shasta Lake, is a cluster of dacitic domes and vents that have formed during eruptions over the past 250,000 years. The last eruptions were relatively small and occurred between 1914 and 1917. The most recent large eruption occurred about 1,100 years ago. Large eruptions appear to occur about once every 10,000 years (USGS 2000a).

#### *11.3.2.4 Soil Characteristics*

The Central Valley Region includes the Sacramento Valley, Delta, Suisun Marsh, and San Joaquin Valley. The soil characteristics are similar in many aspects in the Sacramento and San Joaquin valleys; therefore, the descriptions are combined in the following sections.

##### 11.3.2.4.1 Sacramento Valley and San Joaquin Valley Soil Characteristics

The Sacramento Valley and San Joaquin Valley contain terrace land and upland soils along the foothills; and alluvial, Aeolian, clayey, and saline/alkaline soils in various locations along the valley floors (CALFED 2000, Reclamation 1997).

Foothills soils, located on well-drained, hilly-to-mountainous terrain along the east side of the Central Valley, form through in-place weathering of the underlying rock. Soils in the northern Sacramento Valley near Shasta Lake are different than soils along other foothills in the Sacramento and San Joaquin valleys. The soils near Shasta Lake are related to the geologic formations of the Klamath Mountains, Cascade Ranges, and Sierra Nevada geomorphic provinces.

These soils are formed from weathered metavolcanic and metasedimentary rocks and from intrusions of granitic rocks, serpentine, and basalt. These soils are generally shallow with numerous areas of gravels, cobbles, and stones; therefore, they do not have high water-holding capacity or support topsoil productivity for vegetation (Reclamation 2013a). Soils derived from in-place weathering of granitic rock, referred to as decomposed granite, are coarse-grained, quartz-rich and erodible.

Upland soils along other foothills in the Sacramento and San Joaquin valleys are formed from the Sierra Nevada and Coast ranges geomorphic provinces. Along the western boundary of the Central Valley, the soils primarily are formed from sedimentary rocks. Along the eastern boundary of the Central Valley, the soils primarily are formed from igneous and metamorphic rock. The soils include serpentine soils (which include magnesium, nickel, cobalt, chromium, iron, and asbestos); sedimentary sandstones; shales; conglomerates; and sandy loam, loam, and clay loam soils above bedrock (Reclamation 1997, Reclamation et al. 2011, Reclamation 2013a, DWR 2007). Erosion occurs in the upland soils around reservoirs and rivers especially downgradient of urban development where paving increases the peak flow, volume, and velocity of precipitation runoff (GCI 2003).

Along the western boundary of the Sacramento Valley and the southeastern boundary of the San Joaquin Valley, the terrace lands include brownish loam, silt loam, and/or clayey loam soils. The soils are generally loamy along the Sacramento Valley terraces, and more clayey along the San Joaquin Valley terraces. Along the eastern boundaries of Sacramento and San Joaquin valleys, the terraces are primarily red silica-iron cemented hardpan and clays, sometimes with calcium carbonate (also known as “lime”) (DWR 2007, Reclamation 1997, Reclamation 2005b, Reclamation 2012).

Surface soils of the Central Valley include alluvial and Aeolian soils. The alluvial soils include calcic brown and noncalcic brown alluvial soils on deep alluvial fans and floodplains. The calcic brown soil is primarily made of calcium carbonate and alkaline (also known as “calcerous” soils). The noncalcic brown soils do not contain calcium carbonate and are either slightly acidic or neutral in chemical properties. In the western San Joaquin Valley, light colored calcerous soils occur with less organic matter than the brown soils (Reclamation 1997).

Basin soils occur in the San Joaquin Valley and portions of the Delta. These soils include organic soils, imperfectly drained soils, and saline alkali soils. The organic soils are typically dark, acidic, high in organic matter, and generally include peat. The organic soils occur in the Delta, as discussed below, and along the lower San Joaquin River adjacent to the Delta. The poorly drained soils contain dark clays and occur in areas with high groundwater in the San Joaquin Valley trough and as lake bed deposits (Reclamation et al. 2011). One of the most substantial stratigraphic features of the San Joaquin Valley and a major aquitard is the Corcoran Clay, located in the western and central valley (Galloway et al. 1999). The western boundary of the Corcoran Clay is generally located along the Delta-Mendota Canal and California Aqueduct (as described in Chapter 5, Surface Water Resources and Water Supply). The Corcoran Clay generally extends from Mendota Pool area through the center of the valley to the Tehachapi Mountains. The depth to the Corcoran Clay varies from 160 feet under the Tulare Lake bed to less than a foot near the western edge of the Central Valley. The Corcoran Clay compromised of numerous aquitards and coarser interbeds.

Selenium salts and other salts occur naturally in the western and central San Joaquin Valley soils that are derived from marine sedimentary rocks of the Coast Ranges. Salts are leached from the soils by applied pre-irrigation and irrigation water and collected by a series of drains. The drains also reduce high groundwater elevations in areas with shallow clay soils. Reclamation and other agencies are implementing programs to reduce salinity issues in the San Joaquin Valley that will convey and dispose of drainage water in a manner that would protect the surface water and groundwater resources (Reclamation et al. 2011). As described in Chapter 12, Agricultural Resources, many portions of the western and central San Joaquin Valley are no longer supporting irrigated crops or are experiencing low crop yields due to the saline soils.

Soils in the eastern San Joaquin Valley come from the Sierra Nevada and contain low levels of salt and selenium. Most soils in the western and southern San Joaquin Valley are formed from Coast Range marine sediments, and contain higher concentrations of salts as well as selenium and molybdenum. Soluble selenium moves from soils into drainage water and groundwater, especially during agricultural operations to leach salts from the soils. As described in Chapter 3, Description of Alternatives, Reclamation and other agencies are implementing programs to reduce the discharge of selenium from the San Joaquin Valley into receiving waters (Reclamation 2005d, Reclamation et al. 2011, Reclamation 2009). Additional information related to concerns with salinity and selenium in the San Joaquin Valley is presented in Chapter 6, Surface Water Quality, and Chapter 12, Agricultural Resources.

Soil wind erosion is related to soil erodibility, wind speeds, soil moisture, surface roughness, and vegetative cover. Aeolian soils are more susceptible to wind erosion than alluvial soils. Non-irrigated soils that have been disturbed by cultivation or other activities throughout the Central Valley are more susceptible to wind erosion and subsequent blowing dust than soils with more soil moisture. Dust from eroding soils can create hazards due to soil composition (such as naturally-occurring asbestos), allergic reactions to dust, adverse impacts to plants due to dust, and increased risk of valley fever (as discussed in Chapter 18, Public Health) (Reclamation 2005d).

#### 11.3.2.4.2 Delta Soil Characteristics

Soils in the Delta include organic and/or highly organic mineral soils; deltaic soils along the Sacramento and San Joaquin rivers; basin rim soils; floodplain and stream terrace soils; valley alluvial and low terrace soils; and upland and high terrace soils (Reclamation 1997). Basin, deltaic, and organic soils occupy the lowest elevation ranges and are often protected by levees. In many areas of the western Delta, the soils contain substantial organic matter and are classified as peat or muck.

Basin rim soils are found along the eastern edges (rims) of the Delta, and are generally moderately deep or deep mineral soils that are poorly drained to well-drained and have fine textures in surface horizons. Some areas contain soils with a hardpan layer in the subsurface (SCS 1992, 1993). Floodplain and stream terrace soils are mineral soils adjacent to the Sacramento and San Joaquin rivers and other major tributaries. These soils are typically deep and stratified, with relatively poor drainage and fine textures. Valley fill, alluvial fan, and low terrace soils are typically very deep with variable texture and ability to transmit water ranging from somewhat poorly drained fine sandy loams and silty clay loams to well-drained silt loams and silty clay loams. Upland and high terrace soils are generally well-drained ranging in texture from loams to clays and are primarily formed in material weathered from sandstone, shale, and siltstone, and can occur on dissected terraces or on mountainous uplands.

Soils within the Yolo Bypass area range from clays to silty clay loams and alluvial soils (CALFED 2001, DFG et al. 2008). The higher clay content soils occur in the western portion of the basin north of Interstate 80 and in the eastern portion of the basin south of Interstate 80. The silty clay loams and alluvial soils occur in the western portion of the basin south of Interstate 80, including soils within the Yolo Bypass Wildlife Area.

Soil erosion by rainfall or flowing water occurs when raindrops detach soil particles or when flowing water erodes and transports soil material. Sandy alluvial soils, silty lacustrine soil, and highly organic soil are erodible. Organic soil (peat) in the Delta is also susceptible to wind erosion (deflation). Clay soils are erosion resistant.

#### 11.3.2.4.3 Suisun Marsh Soil Characteristics

Soil within the Suisun Bay include the Joice muck, Suisun peaty muck, and Tamba mucky clay; Reyes silty clay; and Valdez loam (SCS 1977a, Reclamation et al. 2010). The Joice muck generally is poorly drained organic soils in saline water areas interspersed with fine-grain sediment. Suisun peaty muck is formed from dark colored organic soils and plant materials with high permeability. These soils are generally located in areas with shallow surface water and groundwater; therefore, surface water tends to accumulate on the surface. Tamba mucky clay also are poorly drained organic soils formed from alluvial soils and plant materials that overlays mucky clays. Reyes silty clays are poorly drained soils formed from alluvium. The upper layers of the silty clays are acidic and saline. The lower layers are alkaline that become acidic when exposed to air, especially under wetting-drying conditions in tidal areas. Valdez loam soils are poorly drained soils formed on alluvial fans.

Suisun Marsh soils have a low susceptibility to water and wind erosion (SCS 1977a, Reclamation et al. 2010).

#### *11.3.2.5 Subsidence*

Land subsidence occurs for different reasons throughout the Central Valley as described in the following sections.

##### 11.3.2.5.1 Sacramento and San Joaquin Valley Subsidence

Land subsidence in the Sacramento Valley primarily occurs due to aquifer-system compaction as groundwater elevations decline; weathering of underlying of some-types of bedrock, such as limestone; decomposition of organic matter; and natural compaction of soils (Reclamation 2013a). Historic subsidence of the Sacramento Valley has been far less than that observed in the San Joaquin Valley. For example, the range of recent historic subsidence in the Sacramento Valley is generally less than 10 feet. Historical subsidence in the San Joaquin Valley has caused changes in land elevations of more than 30 feet.

In the 1970s, land subsidence exceeded 1 foot near Zamora; however, additional subsidence has not been reported since 1973 (Reclamation 2013a). Subsidence has been reported of two feet near Davis and three to four feet over the last several decades in the areas north of Woodland and east of Davis and Woodland (Davis 2007).

San Joaquin Valley subsidence primarily occurs when groundwater elevations decline which reduces water pressure in the soils and results in compressed clay lenses and subsided land elevations. Other factors that may influence the rate of subsidence in the San Joaquin Valley is the Sierran uplift, sediment loading and compressional down-warping or thrust loading from the Coast Ranges, and near surface compaction (Reclamation et al. 2011). Some of the first reports of land subsidence in the San Joaquin Valley occurred in 1935 in the area near Delano (Galloway et al. 1999). By the late 1960s, San Joaquin Valley subsidence had occurred over 5,212 square miles, or almost 50 percent of the San Joaquin Valley (Reclamation 2005d). During that period, some areas subsided over 33 vertical feet since the late 1880s. The rate of subsidence reduced initially following implementation of CVP and SWP water supplies in the San Joaquin Valley during the 1970s and 1980s. The rate of subsidence for the next twenty years appeared to continue at a rate of 0.008 to 0.016 inches/year in recent years (Reclamation et al. 2011). However, the amount of water available for irrigation from the CVP and SWP has declined more than 20 to 30 percent since the early 1980s due to hydrologic, regulatory, and operational concerns, as described in Chapter 1, Introduction. Due to the reduction in the availability of CVP and SWP water supplies, many water users have increased groundwater withdrawal. A recent study by the USGS of subsidence along the CVP Delta-Mendota Canal (USGS 2013b) reported that in areas where groundwater levels fluctuated consistently on a seasonal basis but were stable on a long-term basis, the land elevations also were relatively stable. Subsidence occurred in portions of the San Joaquin Valley where groundwater elevations below the Corcoran clay and in the shallow groundwater declined on a long-term basis between 2003 and 2010. The highest subsidence rates occurred along the Delta Mendota Canal between Merced and Mendota with subsidence of 0.8 inches to 21 inches between 2003 and 2010.

Shallow subsidence, or hydrocompaction, occurs when low density, relatively dry, fine-grained sediments soften and collapse upon wetting. Historically, hydrocompaction has been most common along the western margin of the San Joaquin Valley (Reclamation 2005c). In the southern San Joaquin Valley, extraction of oil also can result in compaction. Changes in elevation, both subsidence and uplift, occurred near Coalinga following the 1983 Coalinga earthquake with uplift up to 1.6 feet and subsidence of 2 inches.

#### 11.3.2.5.2 Delta and Suisun Marsh Subsidence

Land subsidence on the islands in the central and western Delta and Suisun Marsh may be caused by the elimination of tidal inundation that formed the islands through sediment deposition and transport, and the oxidation and decay of plant materials that would compact to form soils. Following construction of levees, subsidence initially occurred through the mechanical settling of peat as the soil dried; and then, the dried peat and other soils shrunk (Reclamation et al. 2013, Drexler et al. 2009). Agricultural burning of peat (which has been discontinued), wind erosion, oxidation, and leaching of organic material. The rate of subsidence has declined from a maximum of 1.1 to 4.6 inches/year in the 1950s to less than 0.2 to 1.2 inches/year in the western Delta (Drexler et al. 2009, Rojstaczer et al. 1991). Many of the islands in the western and central Delta have subsided to elevations that are 10 to nearly 55 feet below sea level (USGS 2000b, Deverel and Leighton 2010).

Recently, the California Department of Water Resources has implemented several projects to reverse subsidence. The 274-acre Mayberry Farms Duck Club Subsidence Reversal Project on Sherman Island includes creation of emergent wetlands ponds and channels through excavation of peat soils, improving of water movement, and waterfowl habitat. The facility was constructed in 2010 and is being monitored to determine the effectiveness of subsidence reversal, methyl mercury management, and carbon sequestration (DWR 2013). The Department of Water Resources and USGS implemented wetlands restoration for about 15 acres on Twitchell Island in 1997 (DWR et al. 2013b) to encourage tule and cattail growth. After the growing season, the decomposed plant material accumulates and increases the land elevation. Since 1997, elevations have increased at a rate of 1.3 to 2.2 inches/year.

### 11.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, San Benito, and Napa counties that are within the CVP and SWP service areas. Portions of Napa County are within the SWP service area that use water diverted from Barker Slough in the Sacramento River watershed for portions of Solano and Napa counties. Solano County was discussed under the Delta area of the Central Valley Region. Napa County is described under the San Francisco Bay Area Region.

#### *11.3.3.1 Geologic Setting*

The San Francisco Bay Area Region primarily is located within the Coast Ranges Geomorphic Province. Eastern Contra Costa and Alameda counties are located in the Great Valley Geomorphic Province. The Coast Ranges and Great Valley geomorphic provinces were described in Section 11.3.2, Central Valley Region. San Francisco Bay is a structural trough formed as a gap in the Coast Range down-dropped to allow the Sacramento, San Joaquin, Napa, Guadalupe, and Coyote Rivers to flow into the Pacific Ocean. When the polar ice caps melted 10,000 to 25,000 years ago the ocean filled the inland valleys of the trough and formed San Francisco Bay, San Pablo Bay, and Suisun Bay (CALFED 2000). Initially, alluvial sands, silts, and clays filled the bays to form Bay Mud along the shoreline areas. Sedimentation patterns have changed over the past 150 years due to development of upstream areas of the watersheds which changed sedimentation and hydraulic flow patterns, hydraulic mining, and formation of levees and dams.

The San Francisco Bay Area is formed from the Salinian block located west of the San Andreas Fault; Mesozoic Franciscan complex located between the San Andreas and Hayward faults; and the Great Valley sequence located to the east of Hayward Fault (WTA 2003). The Salinian block generally is composed of granitic plutonic rocks probably from the Sierra Nevada Batholith that was displaced due to movement along the San Andreas Fault. The Franciscan complex includes deep marine sandstone and shale formed from oceanic crust with chert and limestone. The Great Valley sequence primarily includes marine sedimentary rocks.

#### *11.3.3.2 Regional Seismicity*

Large earthquakes have occurred in the San Francisco Bay Area Region along the San Andreas, Hayward, Calaveras, Greenville, Antioch, Concord-Green Valley, Midway, Midland, and Black Butte fault zones over the past 10,000 years. The San Francisco earthquake of 1906 took place as the result of movement along the San Andreas Fault. The San Andreas Fault remains active, as does the Hayward Fault, based on evidence of slippage along both (CALFED 2000).

#### *11.3.3.3 Soil Characteristics*

The San Francisco Bay Area Region soils include basin floor/basin rim, floodplain/valley land, terrace, foothill, and mountain soils (CALFED 2000). Basin floor/basin rim soils are organic-rich saline soils and poorly drained clays, clay loams, silty clay loams, and muck along the San Francisco Bay shoreline (SCS 1977b, 1981a; CALFED 2000). Well-drained sands and loamy sands and poorly-drained silty loams, clay loams, and clays occur on gently sloping alluvial fans of the San Francisco Bay Area Region that surround the floodplain and valley lands. Drained loams, silty loams, silty clay loams, and clay loams interbedded with sedimentary rock and some igneous rock occur in the foothills. Terrace loams are located along the southeastern edge of the San Francisco Bay Area Region above the valley land.

#### *11.3.3.4 Subsidence*

Subsidence in the San Francisco Bay Area Region primarily occurs in the Santa Clara Valley of Santa Clara County. The Santa Clara Valley is characterized by a groundwater aquifer with layers of non-consolidated porous soils interspersed with clay lenses. Historically, when the groundwater aquifer was in overdraft, the water pressure in the soils declined which resulted in compressed clay lenses and subsided land elevations. Between 1940 and 1970, soils near San Francisco Bay declined to elevations below sea level (SCVWD 2000). Under these conditions, salt water intrusion and tidal flooding occurred in the tributary streams of Guadalupe River and Coyote Creek. As of 2000, the land elevation in downtown San Jose subsided 13 feet since 1915. In 1951, water deliveries from San Francisco Water Department were initiated (Ingebritsen et al. 1999). In 1965, SWP deliveries were initiated in Santa Clara County. CVP water deliveries were initiated in 1987. The CVP and SWP water supplies are used to reduce groundwater withdrawals when groundwater elevations are low to allow natural recharge from local surface waters. The CVP and SWP also are used to directly recharge the groundwater through spreading basins in Santa Clara Valley.

#### *11.3.3.5 Central Coast and Southern California Regions*

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

As described in Chapter 4, Approach to Environmental Analysis, the Southern California Region includes areas affected by operations of the SWP, including the Coachella Valley in Riverside County. The Coachella Valley Water District receives water under a SWP entitlement contract; however, SWP water cannot be conveyed directly to the Coachella Valley due to lack of conveyance facilities. Therefore, Coachella Valley Water District receives water from the Colorado River through an exchange agreement with the Metropolitan Water District of Southern California, as described in Chapter 5, Surface Water Resources and Water Supplies. The Imperial Valley, located to the southeast of the Southern California Region, receives irrigation water from the Colorado River through Reclamation canals; and does not use CVP or SWP water.

#### *11.3.3.6 Geologic Setting*

The Central Coast and Southern California Regions are located in the Coast Ranges, Transverse Ranges, Peninsular Ranges, Colorado Desert, and Mojave Desert geomorphic provinces (CGS 2002a).

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties that use SWP water supplies. These areas are located within the Coast Ranges and Transverse Ranges geomorphic provinces. The Coast Ranges Geomorphic Province was described in Section 11.3.2, Central Valley Region. The Transverse Ranges Geomorphic Province consists of deeply folded and faulted sedimentary rocks (CGS 2002a, SBCAG 2013). Bedrock along the stream channels, coastal terraces, and coastal lowlands is overlain by alluvial and terrace deposits; and, in some area, ancient sand dunes. The geomorphic province is being uplifted at the southern border along San Andreas Fault and compressed at the northern border along the Coast Ranges Geomorphic Province. Therefore, the geologic structure of the ridges and valleys are oriented along an east-west orientation, or in a "transverse" orientation, as compared to the north-south orientation of the Coast Range.

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties that use SWP water supplies. These areas are located within the Transverse Ranges, Peninsular Ranges, Mojave Desert, and Colorado Desert geomorphic provinces. The Transverse Ranges Geomorphic Province includes Ventura County and portions of Los Angeles, San Bernardino, and Riverside counties. The Colorado Desert Geomorphic Province is also known as the Salton Trough where the Pacific and North American plants are separating.

The Peninsular Ranges Geomorphic Province is composed of granitic rock with metamorphic rocks (CGS 2002a, SCAG 2011, San Diego County 2011). The geologic structure is similar to the geology of the Sierra Nevada Geomorphic Province. The faulting of this geomorphic province has resulted in northwest trending valleys and ridges that extend into the Pacific Ocean to form the Santa Catalina, Santa Barbara, San Clemente, and San Nicolas islands. The Peninsular Ranges Geomorphic Province includes Orange County and portions of southern Los Angeles County, western San Diego County, northwestern San Bernardino County, and northern Riverside County (including the northern portion of the Coachella Valley).

The Mojave Desert Geomorphic Province is located between the Garlock Fault along the southern boundary of the Sierra Nevada Geomorphic Province and the San Andreas Fault (CGS 2002a, SCAG 2011, RCIP 2000). This geomorphic province includes extensive alluvial basins with non-marine sediments from the surrounding mountains and foothills; and many isolated ephemeral lakebeds (also known as "playas") occur within this region with tributary streams from isolated mountain ranges. The Mojave Desert Geomorphic Province includes portions of Kern, Los Angeles, Riverside, and San Bernardino counties.

The Colorado Desert Geomorphic Province, or Salton Trough, is characterized by a geographically-depressed desert that extends northward from the Gulf of California (located at the mouth of the Colorado River) towards the Mojave Desert Geomorphic Province where the Pacific and North American plants are separating (CGS 2002a, SCAG 2011, RCIP 2000, San Diego County 2011). Large portions of this geomorphic province were formed by the inundation of the ancient Lake Cahuilla and are filled with sediments several miles thick from the historic Colorado River overflows and erosion of the Peninsular Ranges uplands. The Salton Trough is separated from the Gulf of California by a large ridge of sediment. The Salton Sea occurs within the trough along an ancient playa. The Colorado Desert Geomorphic Province includes portions of Riverside County in the Coachella Valley; and portions of San Diego and Imperial counties that are located outside of the study area.

### *11.3.3.7 Regional Seismicity*

Most of the areas in the Central Coast and Southern California regions are characterized by active faults that are capable of producing major earthquakes with substantial ground displacement. The San Andreas Fault Zone extends from the Gulf of California and extends in a northwest direction throughout the Central Coast and Southern California regions (CGS 2006).

Within portions of San Luis Obispo County that use SWP water supplies, the Nacimiento Fault also can result in major seismic events (CGS 2006, San Luis Obispo County 2010a).

The northern portions of Santa Barbara County that use SWP water supplies include Lion's Head Fault along the Pacific Ocean shoreline to the southwest of Santa Maria and along the northern boundary of Vandenberg Air Force Base (CGS 2006, SBCAG 2013). The Big Pine Fault may extend into the Vandenberg Air Force Base area. Areas near the mouth of the Santa Ynez River and Point Arguello could be affected by Lompoc Terrace Fault and Santa Ynez-Pacifico Fault Zone. The Santa Ynez Fault extends across this county and could affect communities near Santa Ynez. Along the southern coast of Santa Barbara County from Goleta to Carpinteria, the area includes many active faults, including More Ranch, Mission Ridge, Arroyo Parida, and Red Mountain faults; and potentially active faults, including Goleta, Mesa-Rincon, and Carpinteria faults.

Portions of Ventura County that use SWP water supplies are located in the southern portion of the county adjacent to Los Angeles County. Major faults in this area include the Oak Ridge Fault that extends into the Oxnard Plain along the south side of the Santa Clara River Valley and may extend into San Fernando Valley in Los Angeles County; Bailey Fault that extends from the Pacific Ocean to the Camarillo Fault; Simi-Santa Rosa, Camarillo, and Springville faults in Simi and Tierra Rejada valleys and near Camarillo; Sycamore Canyon and Boney Mountain faults that extend from the Pacific Ocean towards Thousand Oaks (CGS 2006, Ventura County 2011).

Los Angeles County major fault zones include Northridge Hills, San Gabriel, San Fernando, Verduga, Sierra Madre, Raymond, Hollywood, Santa Monica, and Malibu Coast fault zones; Elysian Park Fold and Thrust Belt in Los Angeles County; and Newport, Inglewood, Whittier, and Palos Verdes fault zones that extend into Los Angeles and Orange counties (CGS 2006, Los Angeles 2005). Recent major seismic events that have occurred in Southern California along faults in Los Angeles include the 1971 San Fernando, 1987 Whittier Narrows, 1991 Sierra Madre, and 1994 Northridge earthquakes.

Riverside and San Bernardino counties are characterized by the San Andreas Fault Zone that extends from the eastern boundaries of these counties and crosses to the western side of San Bernardino County (CGS 2006, RCIP 2000, Riverside County 2000, SCAG 2011, DWR 2009). The San Jacinto Fault Zone also extends through the center of Riverside County and along the western side of San Bernardino County. The Elsinore Fault Zone extends along the western sides of both counties. In San Bernardino County, the Cucamonga Fault extends into

Los Angeles County where it intersects with the Sierra Madre and Raymond faults. The Garlock and Lockhart fault zones extend into both San Bernardino and Kern counties. San Bernardino County also includes several other major fault zones, including North Frontal, and Helendale faults.

Portions of San Diego County that use SWP water supplies include the Rose Canyon Fault Zone located along the Pacific Ocean shoreline and extends into the City of San Diego (San Diego County 2011).

#### *11.3.3.8 Soil Characteristics*

In the Central Coast Region, areas within San Luis Obispo and Santa Barbara counties that use SWP water supplies are located within coastal valleys or along the Pacific Ocean shoreline. In San Luis Obispo County, Morro Bay, Pismo Beach, and Oceano areas are located along the coast with soils that range from sands and loamy sands in areas near the shoreline to shaly loams, clay loams, and clays in the terraces and foothills located along the eastern boundaries of these communities (SBCAG 2010b, NRCS 2014a, NRCS 2014b). In Santa Barbara County, the Santa Maria, Vandenberg Air Force Base, Santa Ynez, Goleta, Santa Barbara, and Carpinteria areas are located in alluvial plains, along stream channels with alluvium deposits, along the shoreline, or along marine terrace deposits above the Pacific Ocean. The soils range from sands, sandy loams, loams, shaly loams, and clay loams in the alluvial soils and along the shoreline. The terrace deposits include silty clays, clay loams, and clays (NRCS 2014c, NRCS 2014d, NRCS 2014e, SCS 1972, SCS 1981b).

Southern California Region soils include gravelly loams and gravelly sands, sands, sandy loams and loamy sands, and silty loams along the Pacific Coast shorelines and on alluvial plains. The mountains and foothills of the region include silty loams, cobbly silty loam, gravelly loam, sandy clay loams, clay loams, silty clays, and clays (SCAG 2011, UCCE 2014, SCS 1978, SCS 1986, SCS 1973). The inland region in Riverside and San Bernardino counties include sand to silty clays to cobbles and boulders on the alluvial fans, valley floor, terraces, and mountains, and dry lake beds (CVWD 2011).

#### *11.3.3.9 Subsidence*

Subsidence in the Central Coast and Southern California regions occur due to soil compaction following groundwater withdrawals at rates greater than groundwater recharge rates, oil and gas withdrawal, seismic activity, and hydroconsolidation of soils along alluvial fans (Los Angeles 2005). The USGS described areas with subsidence related to groundwater overdraft in the Central Coast and Southern California regions in San Luis Obispo, Santa Barbara, Los Angeles, Riverside, and Santa Bernardino counties (USGS 1999, Ventura County 2011, Los Angeles 2005, RCIP 2000). Many of the areas with subsidence have alluvial unconsolidated sands and silty sands with lenses of silt and clayey silt.

A recent study by the USGS in the southern Coachella Valley portion of Riverside described land subsidence of about 0.5 feet between 1930 and 1996 (USGS 2013c). Groundwater elevations in this area had declined since the early

1920s until 1949 when water from the Colorado River was provided to the area. This area is served by Coachella Valley Water District; and as described in Chapter 5, Surface Water Resources and Water Supply, the availability of surface water has not always been available to this area in recent years. The recent USGS study indicated that land subsidence of up to approximately 0.4 feet have occurred at some locations between 1996 and 2005; and possibly greater subsidence at other locations. A Coachella Valley Water District study indicated that up to 13 inches have occurred in parts of the valley between 1996 and 2005 (CVWD 2011).

# 11.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in soils resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

## 11.4.1 Potential Mechanisms for Change in Soils Resources

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in soils resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change soil erosion potential due to crop idling on lands irrigated with CVP and SWP water supplies and along rivers downstream of CVP and SWP reservoirs, and potential changes in soils as lands are converted to seasonal floodplain or tidal-influenced wetlands.

### *11.4.1.1 Changes in Soil Erosion*

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and the potential for soil erosion on crop idled lands over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and the Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives also could change peak flows in rivers downstream of CVP and SWP reservoirs in the Trinity River and Central Valley regions as compared to historical conditions which could lead to soil erosion during high peak flow events during storms in wet years along the river banks as compared to the No Action Alternative and the Second Basis of Comparison. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the results of the analysis indicate that peak flows would be within historical range of peak flows in these rivers and would be similar under Alternatives 1 through 5, No Action Alternative, and Second Basis of Comparison. Therefore, changes in CVP and SWP operations would not result in changes to peak flow events that could result in soil erosion along these rivers. Therefore, these changes are not analyzed in this EIS.

#### *11.4.1.2 Changes in Soils at Restored Wetlands*

Restoration of seasonal floodplains and tidally-influenced wetlands would affect soils resources at the restoration locations. However, these actions would occur in a similar manner under the No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison, as described in Chapter 3, Description of Alternatives; in addition, the conditions of the soils would be the same under all of the alternatives and the Second Basis of Comparison. Therefore, these changes are not analyzed in this EIS.

#### *11.4.1.3 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis.

The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution), idle crops, or substitute crops that use less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future soil conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 11.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to soils resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *11.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end-of-September storage would also reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling that could be subject to erosion.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would result in disruption of soils resources; however, the development of general plans includes preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.

Under the No Action Alternative and the Second Basis of Comparison, development of future water resources management projects by 2030 which would result in disruption of soils resources. However, the development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

## 11.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison. The evaluation of alternatives is focused on portions of the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions that use CVP and SWP water for irrigation.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

### *11.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 11.4.3.1.1 Central Valley Region

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under the No Action Alternative would be similar (within 5 percent) to the conditions under the Second Basis of Comparison over long-term conditions (throughout the 81-year model simulation period) and during dry and critical dry years due to the increased use of groundwater.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to soils resources were identified as increased erosion and shrinking of expansive soils in the seller's service areas if crop idling is used to provide water for transfers; and increased potential for shrinking of expansive soils and soil movement in areas that use the transferred water. The analysis indicated that these potential impacts would not be substantial because farmers manage idle fields as part of normal agricultural operations and they would continue to use the same practices to avoid erosion impacts. The analysis also indicated that shrinking and soil movement occur as part of normal planting and harvesting practices and the changes with the water transfer programs would not result in substantial changes.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and the 2009 National Marine Fisheries Service (NMFS) BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

##### 11.4.3.1.2 San Francisco Bay Area, Central Coast, and Southern California Regions

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under the No Action Alternative is anticipated to be similar as conditions under the Second Basis of Comparison due to the increased use of groundwater.

#### *11.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because CVP and SWP operations conditions under Alternative 1 are identical to conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 11.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Central Valley Region*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 1 would be similar to conditions under the No Action Alternative over long-term conditions and during dry and critical dry years due to the increased availability of CVP and SWP water supplies.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on soils resources would not be substantial in the seller’s service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 1 is anticipated to be similar as conditions under the No Action Alternative due to increased availability of CVP and SWP water supplies.

#### 11.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *11.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, the soils resources conditions under Alternative 2 are only compared to the Second Basis of Comparison.

#### 11.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to soils resources under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 11.4.3.1, No Action Alternative.

### *11.4.3.4 Alternative 3*

The CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and Alternative 1 with modified Old and Middle River flow criteria.

#### 11.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Central Valley Region*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 would be similar to the conditions under the No Action Alternative over long-term conditions and during dry and critical dry years due to the increased availability of CVP and SWP water supplies.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on soils resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 is anticipated to be similar to conditions under the No Action Alternative due to increased availability of CVP and SWP water supplies.

#### 11.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Central Valley Region*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 would be similar to the conditions under the Second Basis of Comparison over long-term conditions and during dry and critical dry years due to the increased use of groundwater.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on soils resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 is anticipated to be similar to conditions under the Second Basis of Comparison due to the increased use of groundwater.

#### *11.4.3.5 Alternative 4*

Soil resources conditions under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 11.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in soil resources conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 11.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *11.4.3.6 Alternative 5*

The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations.

##### 11.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Central Valley Region*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 would be similar to conditions under the No Action Alternative over long-term conditions and during dry and critical dry years because the availability of CVP and SWP water supplies would be similar.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on soils resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 is anticipated to be similar as conditions under the No Action Alternative because CVP and SWP water deliveries would be similar.

#### 11.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Central Valley Region*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 would be similar to the conditions under the Second Basis of Comparison over long-term conditions and during dry and critical dry years due to increased use of groundwater.

*Effects Related to Cross Delta Water Transfers*

Potential effects to soils resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on soils resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Soil Erosion*

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 is anticipated to be similar to conditions under the Second Basis of Comparison due to the increased use of groundwater.

### *11.4.3.7 Summary of Impact Analysis*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 11.1 and 11.2, respectively.

**Table 11.1 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects on soils resources | None needed |
| Alternative 2 | No effects on soils resources | None needed |
| Alternative 3 | No effects on soils resources | None needed |
| Alternative 4 | No effects on soils resources | None needed |
| Alternative 5 | No effects on soils resources | None needed |

**Table 11.2 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | No effects on soils resources | Not considered for this comparison |
| Alternative 1 | No effects on soils resources | Not considered for this comparison |
| Alternative 2 | No effects on soils resources | Not considered for this comparison |
| Alternative 3 | No effects on soils resources | Not considered for this comparison |
| Alternative 4 | No effects on soils resources | Not considered for this comparison |
| Alternative 5 | No effects on soils resources | Not considered for this comparison |

#### *11.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in changes in soils resources. Therefore, there would be no adverse impacts to soils resources as compared to the No Action Alternative; and no mitigation measures are required.

#### *11.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Geology and Soils Resources are summarized in Table 11.3.

**Table 11.3 Summary of Cumulative Effects on Geology and Soils Resources with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions | Consistent with Affected Environment conditions plus: | These effects would be the same under all alternatives. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| included in the No Action Alternative and in All Alternatives in Year 2030 | Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives) including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Climate Change and Sea Level Rise<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Folsom Dam Water Control Manual Update<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks | Developments under the general plans and future water supply, water quality improvement, and restoration projects could affect soils resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.<br><br>Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to soils resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | and wellfields, and conveyance facilities (projects with completed environmental documents) | |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan and California WaterFix<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- Westlands Water District v. United States Settlement<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | These effects would be the same in all alternatives.<br>Developments under the future projects are anticipated to potentially effect soils resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.<br>Some of the future cumulative effects actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to soils resources. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of the No Action Alternative with reasonably foreseeable actions would include developments under general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect soils resources. However, |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | | development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

# 11.5 References

Atwater, B. F. and D. F. Belknap. 1980. Tidal-wetland Deposits of the Sacramento–San Joaquin Delta, California. In *Quaternary Depositional*

*Environments of the Pacific Coast*, 89–103. Proceedings of the Pacific Coast Paleogeography, Symposium 4, eds. M. E. Field, A. H. Bouma, I. P. Colburn, 7 R. G. Douglas, and J. C. Ingle. Society of Economic Paleontologists and Mineralogists, Pacific Section, Los Angeles.

CALFED (CALFED Bay-Delta Program). 2000. *Final Programmatic Environmental Impact Report/Environmental Impact Statement*. July. Sacramento.

____. 2001. *A Framework for the Future: Yolo Bypass Management Strategy*. August.

CGS (California Department of Conservation, California Geologic Survey). 2002a. *California Geomorphic Provinces Note 36*.

____. 2002b. Interactive fault parameter map of California. Site accessed February 20, 2013. http://www.conservation.ca.gov/cgs/rghm/psha/fault_parameters/htm/Pages/Index.aspx

____. 2006. *Simplified Geologic Map of California*.

____. 2008. *Earthquake Shaking Potential*.

____. 2010. 2010 Geologic Map of California. Site accessed March 21, 2013. http://www.quake.ca.gov/gmaps/GMC/stategeologicmap.html.

____. n.d. *Sacramento Probabilistic Seismic Hazards Map*. Site accessed March 21, 2013. www.conservation.ca.gov/cgs/rghm/psha/Map_index/Pages/Sacramento.aspx

CVWD (Coachella Valley Water District). 2011. *Coachella Valley Water Management Plan 2010 Update, Administrative Draft Subsequent Program Environmental Impact Report*. July.

CWDD (Converse Ward Davis Dixon). 1981. *Partial Technical Background Data for the Mokelumne Aqueduct Security Plan for EBMUD, Oakland, CA*.

Davis (City of Davis in association with University of California, Davis, and City of Woodland). 2007. *Davis-Woodland Water Supply Project, Draft Environmental Impact Report*. April.

Deverel, S. and D. Leighton. 2010. *Historic, recent, and future subsidence, Sacramento-San Joaquin Delta, California, USA*. *San Francisco Estuary and Watershed Science*. 8(2):23.

DFG et al. (California Department of Fish and Game [now known as Department of Fish and Wildlife] and Yolo Basin Foundation). 2008. *Yolo Bypass Wildlife Area*. June.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath*

*Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

Drexler, J.Z, C.S. de Fontaine, and S.J. Deverel. 2009. *The Legacy of Wetland Drainage on the Remaining Peat in the Sacramento-San Joaquin Delta, California, USA. Wetlands. Vol. 29, No. 1, March 2009, pp. 372-386*. March.

DWR (California Department of Water Resources). 2007. *Draft Environmental Impact Report Oroville Facilities Relicensing—FERC Project No. 2100*. May.

____. 2009. *East Branch Extension Phase II, Final Environmental Impact Report*. January.

____. 2013. Mayberry Farms Duck Club Subsidence Reversal Project (Sherman Island). Site accessed January 19, 2014. http://www.water.ca.gov/floodsafe/fessro/environmental/dee/mayberry.cfm.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper), Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR et al. (Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013a. *Bay Delta Conservation Plan, Draft Environmental Impact Report/Environmental Impact Statement*. November.

DWR et al. (Department of Water Resources and U.S. Geological Survey). 2013b. Twitchell Wetlands. Site accessed January 19, 2014. http://www.water.ca.gov/floodsafe/fessro/levees/west_delta/twitchell.cfm.

Ferriz, H. 2001. Groundwater Resources of Northern California: An overview. *Engineering Geology Practice in Northern California: Association of Engineering Geologists Special Publication 12 and California Division of Mines and Geology Bulletin 210.*

Galloway et al. (Galloway, D. and F.S. Riley, U.S. Geological Survey). 1999. *San Joaquin Valley, California, Largest human alteration of the Earth's surface*. In Galloway, D.L., Jones, D.R., and Ingebritsen, S.E., eds., Land Subsidence in the United States: U.S. Geological Survey Circular 1182, p. 23–34.

GCI (Geotechnical Consultants, Inc.). 2003. *Environmental Conditions, Geology, Folsom Lake State Recreation Area*. April.

Humboldt County. 2012. *Humboldt 21st Century General Plan Update, Draft Environmental Impact Report*. April 2. http://co.humboldt.ca.us/countycode/t6-div3.pdf.

Ingebritsen (Ingebritsen, S.E. and D.R. Jones, U.S. Geological Survey). 1999. *Santa Clara Valley, California, A case of arrested subsidence*. In Galloway, D.L., Jones, D.R., and Ingebritsen, S.E., eds., Land Subsidence in the United States: U.S. Geological Survey Circular 1182, p. 23–34.

Los Angeles (City of Los Angeles, Department of Public Works). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NRCS (Natural Resources Conservation Service). 2014a. *Soil Map-San Luis Obispo County, California, Coastal Part* – focused on Morro Bay. Site accessed 012414. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.

____. 2014b. *Soil Map-San Luis Obispo County, California, Coastal Part* – focused on Pismo Beach_Oceano. Site accessed 012414. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.

____. 2014c. *Soil Map-Santa Barbara County, California, Coastal Part* – focused on Santa Maria. Site accessed 012414. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.

____. 2014d. *Soil Map-Santa Barbara County, California, Coastal Part* – focused on Vandenberg Air Force Base. Site accessed 012414. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.

____. 2014e. *Soil Map-Santa Barbara County, California, Coastal Part* – focused on Goleta_Santa Barbara_Carpenteria. Site accessed 012414. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.

Placer County. 2007. *North Fork American River Trail Project Draft Environmental Impact Report*. August.

Reclamation (Bureau of Reclamation). 1997. *Central Valley Project Improvement Act, Draft Programmatic Environmental Impact Statement*. September.

____. 2005a. *Long-Term Renewal of Water Service Contracts in the Black Butte Unit, Corning Canal Unit, and Tehama-Colusa Canal Unit of the Sacramento River Division, Central Valley Project, California, Final Environmental Assessment*. February.

____. 2005b. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

____. 2005c. *San Luis Drainage Feature Re-evaluation Draft Environmental Impact Statement*. May.

____. 2005d. *Central Valley Project Long-Term Water Service Contract Renewal San Luis Unit, Public Draft Environmental Impact Statement and Appendices*. September.

____. 2009. *Delta-Mendota Canal/California Aqueduct Intertie Draft Environmental Impact Statement*. July.

____. 2010. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

____. 2012. *San Luis Reservoir State Recreation Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/Final Environment Impact Report*. August.

____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

____. 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

____. 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

____. 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2010. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Draft Environmental Impact Statement/Environmental Impact Report*.

Reclamation et al. (Bureau of Reclamation, and California Department of Water Resources). 2011. *San Joaquin River Restoration Program Environmental Impact Statement/Report*.

RCIP (Riverside County Integrated Project). 2000. *Existing Setting Report*. March.

Riverside County (County of Riverside, Department of Regional Planning). 2000. *Natural Hazard Mapping, Analysis, and Mitigation: a Technical Background Report in Support of the Safety Element of the New Riverside County 2000 General Plan*. August.

Rojstaczer, S.A., Hamon, R.E., Deverel, S.J., and Massey, C.A. 1991. *Evaluation of selected data to assess the causes of subsidence in the Sacramento San Joaquin Delta. California: U.S. Geological Survey Open-File Report 91-193*, 16 p.

Sacramento County (County of Sacramento). 2010. *Sacramento County General Plan Update, Final Environmental Impact Report*. April.

San Diego County (County of San Diego). 2011. *San Diego County General Plan Update, Final Environmental Impact Report*. August.

San Luis Obispo County (County of San Luis Obispo). 2010a. *County of San Luis Obispo General Plan, Conservation and Open Space Element, Appendix 7, Open Space Resources*. May.

____. 2010b. *County of San Luis Obispo General Plan, Conservation and Open Space Element, Appendix 8, Soil Resources*. May.

SBCAG (Santa Barbara County Association of Governments). 2013. *2040 Santa Barbara County Regional Transportation Plan and Sustainable Communities Strategy, Draft Environmental Impact Report*. May.

SCAG (Southern California Association of Governments). 2011. 2012-2035 *Regional Transportation Plan/Sustainable Communities Strategy Draft Program Environmental Impact Report*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1972. *Soil Survey of Northern Santa Barbara Area, California*.

SCS (Soil Conservation Service and Forest Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station, U.S. Department of the Interior Bureau of Indian Affairs, Department of the Navy, U.S. Marine Corps). 1973. *Soil Survey San Diego Area, California*. December.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1977a. *Soil Survey of Solano County, California*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1977b. *Soil Survey of Contra Costa County, California*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1978. *Soil Survey of Orange County and Western Part of Riverside County, California*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1981a. *Soil Survey of Alameda County, California, Western Part*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1981b. *Soil Survey of Santa Barbara County, California, South Coastal Part*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1986. *Soil Survey of San Bernardino County, California, Mojave River Area*.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station and California Department of Conservation). 1992. *Soil Survey of San Joaquin County, California*. October.

SCS (Soil Conservation Service, U.S. Department of Agriculture, in cooperation with University of California Agricultural Experiment Station). 1993. *Soil Survey of Sacramento County, California*. April.

SCVWD (Santa Clara Valley Water District). 2000. *Relationship Between Groundwater Elevations and Land Subsidence in Santa Clara County*. May.

Shlemon, R. J., and E. L. Begg. 1975. *Ho66locene Evolution of the Sacramento–San Joaquin Delta, California. International Union for Quaternary Research* Sponsored by the Royal Society of New Zealand.

TCDOT (Trinity County Department of Transportation). 2003. *Trinity County Hyampom Road Improvements Project, PM 6.8-9.3 Draft Environmental Impact Report*. Weaverville.

UCCE (University of California Cooperative Extension). 2014. *University of California Cooperative Extension, Agricultural and Natural Resources Ventura County, General Soil Map*. Site accessed January 23, 2014. http://ceventura.ucanr.edu/Com_Ag/Soils.

USGS (U.S. Geological Survey). 1999. *Land Subsidence in the United States*. Circular 1182.

____. 2000a. *Volcano Hazards of the Lassen Volcanic National Park Area, California*.

____. 2000b. *Delta Subsidence in California: The sinking heart of the State*. April.

____. 2013a. *Quaternary Fault and Fold Database of the United States*. Site accessed February 20, 2013. http://earthquake.usgs.gov/hazards/qfaults/.

____. 2013b. *Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-10, Scientific Investigations Report 2013-5142*.

____. 2013c. *Detection and Measurement of Land Subsidence Using Global Positioning System Surveying and Interferometric Synthetic Aperture Radar, Coachella Valley, California, 1996-2005*. Scientific Investigations Report 2007-5251. Version 2.0. June.

Ventura County (County of Ventura). 2011. *Ventura County General Plan, Hazards Appendix*. June.

Weir, Walter W. 1949. *Peat Lands of the Delta*. California Agriculture. July.

WTA (Water Transit Authority). 2003. *Final Program Environmental Impact Report Expansion of Ferry Transit Service in the San Francisco Bay Area*. June.


Figure 11.1 Geomorphic Provinces in California

**Chapter 12**

# Agricultural Resources

## 12.1 Introduction

This chapter describes agricultural resources in the study area, and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect land use through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

Changes in non-agricultural land use and resources are described in Chapter 13, Land Use.

## 12.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect agricultural resources served by CVP and SWP water supplies. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 12.3 Affected Environment

This section describes agricultural resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in agricultural resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions. Direct or indirect agricultural resource effects due to implementation of the alternatives analyzed in this EIS are related to changes in agricultural land uses due to the availability and reliability of CVP and SWP water supplies.

Changes in agricultural resources can affect agriculture throughout the state. An overview of California agriculture is presented prior to discussions of agricultural resources in each of the regions.

### 12.3.1 Overview of California Agriculture

California agriculture is an important resource that produces over 400 types of crops. California is the nation’s leading producer of nearly 80 commodities; and produces more than 99 percent of the nation’s almonds, artichokes, dates, figs, raisins, kiwifruit, olives, clingstone peaches, pistachios, prunes, pomegranates, and walnuts (USDA-NASS 2012). In 2011, cultivation of 25.4 million acres of agricultural land contributed about $43.5 billion to California's economy and 11.6 percent of total agricultural revenues in the United States. This section provides:

- Recent trends in California agricultural resources
- Crop production practices
- Cropping pattern changes in response to water supply availability
- Water supply and crop acreage relationships in the San Joaquin Valley

#### *12.3.1.1 Recent Trends in Agricultural Production*

The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) California Field Office publishes annual reports containing data from County Agricultural Commissioners and periodic statewide census of agricultural producers. County Agricultural Commissioners' data covers acres planted, total production, prices, yield per acre, and value of production across crop groups and counties.

From 1960 to 2012, total acreage in production fluctuated between eight and nine million acres, as summarized in Figure 12.1. Over the last fifteen years, total acreage has trended down. Most of the variability over time, and the more recent downward trend, are largely attributable to changes in field and forage crop acreage. The percentage of field and forage acreage decreased from 77 percent of total acreage in 1960 to 48 percent in 2012. The proportion of acreage of permanent crops (e.g. orchards and vine) has steadily increased from 1960 to 2012. Orchard and vine acreage rose from 14 percent of total acreage in 1960 to 38 percent in 2012.

From 1960 to 2012, statewide annual value of production rose from $20 billion (all values are in 2012 US dollars) to $45 billion, as summarized in Figure 12.2. Of the crop categories, orchard and vine values grew the fastest over this period, from around $3 billion in annual value of production in 1960 to over $17 billion in 2012. This increase may be attributable to both the expansion of acreage planted, as shown in Figure 12.1, as well as price and yield increases. Orchard and vine values of production rose from 17 percent of the total statewide value of production in 1960 to 38 percent in 2012. Other crop categories that have also experienced an increase in value of production over this time period are: vegetable, livestock, dairy and poultry, and nursery. Field crops have shown a downward trend. The percentage from field and forage crops decreased from the peak of 28 percent of state value of production in 1980 to 11 percent in 2012. Total value of production is influenced by both the acreage planted each year as well as market prices and yields.

#### *12.3.1.2 Crop Production Practices*

Crop production practices vary by crop and locational differences such as soil, slope, local climate, and water source and reliability. Production practices discussed in this subsection include:

- Crop rotation and fallowing.

- Crop water use.
- Crop irrigation methods.
- Crop responses to water quality.
- Crop drainage methods.
- Crop adaptation to changes in water supply availability.

#### 12.3.1.2.1 Crop Rotation and Fallowing

Crop rotation is the planned variation in the crop grown on a given field. Growers rotate annual crops and some forage crops in order to control plant pests, diseases, and weeds, and to improve soil structure, microbial diversity, and nutrient and mineral availability. Growers select a series of crops that are compatible for rotation that are planned to be grown in a field in a succession of years and plan their operations schedule and build their on-farm infrastructure (e.g., equipment, facilities and staffing) to a scale that meets the production needs of those crop acreage mixes (Baldwin 2006).

Field fallowing is the practice of not planting a crop in a field for one or more growing seasons. Fallowing can be a planned part of the rotation, or may be a consequence of another event like water supply shortage, flooding, land improvement, or poor crop prices. Rotations are not fixed, so changes in market conditions or Federal farm programs can affect crop mix and the pattern and magnitude of fallowing.

Fallowed fields without cover crops can lose topsoil to surface drainage and wind erosion. Loss of topsoil to erosion reduces land productivity, and can reduce nearby crop yields and marketability.

#### 12.3.1.2.2 Crop Water Use

Crop irrigation water use depends on crop type, stage of crop growth, soil moisture profile from winter rains, soil moisture holding capacity (total amount of water in the soil potentially available to plants), management of plant pests and diseases, weather conditions (solar radiation, temperature and humidity) and irrigation water use efficiency. Irrigation water use efficiency can be defined in different ways. The California Department of Water Resources (DWR) defines the agronomic water use fraction as the irrigation water beneficially used for necessary agronomic functions (e.g., transpiration, leaching, frost protection, germination) divided by the total applied water (DWR 2012). Applied irrigation water is transpired by plants (crops and weeds), percolates into the groundwater below the root zone (necessary salt leaching component or over-irrigation loss to groundwater), evaporates directly from water or soil surfaces, or runs off the field as surface drainage (Edinger-Marshall and Letey 1997).

Reuse of water from fields to irrigate other fields, often multiple times, occurs throughout California. As a result, relatively low field-level efficiency (agronomic water use fraction) can result in relatively high efficiency from a regional or basin perspective (DWR 2013a).

#### 12.3.1.2.3 Crop Irrigation

Agricultural irrigation needs vary by season. In the winter, rainfall refills the soil moisture profile that was depleted from the crop root zone the previous summer and fall. If soil moisture is not adequate for planting of annual crops, pre-irrigation water is applied. Pre-irrigation and early growing season irrigations generally occur in the time period from March through May. Peak agricultural irrigation water supply demand generally occurs from the late spring through late summer. Permanent crops are irrigated post-harvest to refill the root zone. Post-harvest irrigation of annual crop land is sometimes used to help break down crop residue and suppress some pests and diseases, especially in rice fields.

Irrigation methods vary by area, soil, crop type, and existing facilities. Annual row crops are often sprinkler irrigated for crop germination and furrow irrigated for the rest of the season. Permanent crops are typically irrigated with drip, sprinkler, furrow, border, or flood irrigation methods. Irrigated pasture and alfalfa are typically irrigated with sprinkler or flood irrigation methods. Rice is generally irrigated with flood irrigation. Irrigation methods utilized in the Central Valley include:

- **Flood and Border Irrigation:** Water is released into a leveled field or block that is segmented into "checks" with a small berm to contain the water. Water applied to the check until it is flooded and the water seeps into the ground or some is allowed to drain off the lower elevation end of the field.
- **Furrow Irrigation:** Water is released into furrows at the higher side of the field and flows down to the lower end of the field. To provide adequate water to the low end of the field, surface irrigation requires that a certain amount of water be spilled or drained off as tailwater. Recycling the tailwater to the head of the field or to an adjacent field can significantly increase overall efficiency. Furrow irrigation is used on annual row crops and on some vineyards.
- **Sprinkler Irrigation:** Sprinkler irrigation uses pressurized water through movable or solid set pipe to a sprinkler. Sprinklers lose some irrigation water to evaporation in the air before the water reaches the ground. Sprinklers also apply water to ground that does not have crop roots, and this applied water goes to surface evaporation, weed transpiration, or percolation to groundwater leaching. Sprinklers are often used during the germination stage of vegetables, and can also be used for frost control on orchards, especially citrus. Sprinkler irrigation can be used on most crops except those for which direct contact with the water drops could cause fruit cracking, fungal growth, or other issues.
- **Surface Drip and Micro-sprinkler Irrigation:** Surface drip and micro-sprinkler irrigation also use pressurized water that is delivered through flexible tubes to drip emitters or micro-sprinkler heads. Surface drip irrigation generally applies water only to the crop root areas. Drip irrigation and micro-sprinklers are used on most orchards and vineyards.

- **Subsurface Drip Irrigation:** Subsurface drip irrigation is similar to the drip irrigation described above, but the tubing or drip tape is buried a few inches to several feet, depending on the crop. Subsurface drip irrigation generally applies water only to crop root areas and reduces surface evaporation. Subsurface drip is used on some row crops and vineyards.

Flood and furrow irrigated acreage has declined over time, especially for trees and vines by drip and micro-sprinkler irrigation (NCWA 2011). Crops that continue to rely upon flood irrigation, such as rice, have improved irrigation efficiency through the use of laser leveling of the fields. The use of furrow and flood irrigation has declined in California from 67 percent of the total irrigated acreage in 1991 to 43 percent in 2010 (DWR 2013a). During this same time period, the use of drip, micro-sprinkler, and subsurface drip irrigation increased from 16 percent of total irrigated acreage in 1991 to 42 percent in 2010.

#### 12.3.1.2.4 Crop Response to Water Quality

Water quality of the surface water streams in the Central Valley is generally very suitable for agricultural production with low salinity, neutral acidity/alkalinity (i.e., pH), minerals, nutrients, and dissolved metal concentrations that are appropriate for agricultural uses. However, groundwater quality varies substantially across California, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

Agricultural production can be affected by high salinity, minerals, and boron in the irrigation water and the soils. In the Sacramento Valley, water temperature can reduce crop yields; cold water is a particular concern for rice production (Roel et al., 2005). Irrigation water can carry debris and biological contaminants that affect agricultural operations and the value of crop production (USDA 2006).

High salinity concerns occur on agricultural lands receiving CVP and SWP water from the Delta. As described in Chapter 6, Surface Water Quality, surface waters in the Delta and lower San Joaquin River water frequently are characterized by high salinity. These waters are used by agricultural water users in the Delta and CVP and SWP water users located within and to the south of the Delta.

Evaporation and transpiration of irrigation water cause salts to accumulate in soils unless adequate leaching and drainage are provided (Reclamation 2005). High water tables with elevated concentrations of salts can draw the salinity vertically through the soil by capillary action into the plant root zone and cause damage to the plant. Excessive irrigation water salinity and accumulated soil salinity can adversely affect soil structure, reduce water infiltration rates, reduce seed germination, increase seedling mortality, impede root growth, impede water uptake by the plant (from increased osmotic pressure), reduce plant growth rate, and reduce yields.

All irrigation water adds soluble salts to the soil, including sodium, calcium, magnesium, potassium, sulfate, and chlorides (Grattan 2002). Salinity is usually measured either in parts per million of total dissolved solids or by electrical conductivity (EC). Water salinity of irrigation water is measured as “$EC_w$.”

Accumulated salts in the soil are measured as "$EC_e$." The strength of the electrical conductivity depends upon the water temperature, types of salts, and salt concentrations.

High salinity can affect the amount of irrigation water applied for crop irrigation and necessary soil leaching component (washing soil salts out of the plant root zone) compared to the total quantity of irrigation water applied (Reclamation 2005). Irrigation in the San Joaquin Valley typically includes a salt leaching component. The leaching water generally conveys the salts into installed drains in the fields or into the groundwater. Therefore, in locations where adequate drainage does not exist, continued irrigation with high salinity water has increased groundwater salinity, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

Table 12.1 presents $EC_e$ and $EC_w$ values for salinity tolerances of a range of crops grown in the Central Valley.

**Table 12.1 Salinity Tolerance of Selected Crops (as percent of maximum yield)**

| | Crop Tolerance based on Soil Salinity (measured as $EC_e$) | | | Crop Tolerance based on Water Salinity (measured as $EC_w$) | | |
|---|---|---|---|---|---|---|
| **Crops[a, b]** | **100%** | **50%** | **0%[c]** | **100%** | **50%** | **0%[c]** |
| Alfalfa | 2.0 | 8.8 | 16 | 1.3 | 5.9 | 10 |
| Almond[d] | 1.5 | 4.1 | 6.8 | 1.0 | 2.8 | 4.5 |
| Apricot[d] | 1.6 | 3.7 | 5.8 | 1.1 | 2.5 | 3.8 |
| Bean | 1.0 | 3.6 | 6.3 | 0.7 | 2.4 | 4.2 |
| Corn, sweet | 1.7 | 5.9 | 10 | 1.1 | 3.9 | 6.7 |
| Cucumber | 2.5 | 6.3 | 10 | 1.7 | 4.2 | 6.8 |
| Grape[e] | 1.5 | 6.7 | 12 | 1.0 | 4.5 | 7.9 |
| Peach | 1.7 | 4.1 | 6.5 | 1.1 | 2.7 | 4.3 |
| Rice (paddy) | 3.0 | 7.2 | 11 | 2.0 | 4.8 | 7.6 |
| Squash, Zucchini | 4.7 | 10 | 15 | 3.1 | 6.7 | 10 |
| Sudan Grass | 2.8 | 14 | 26 | 1.9 | 9.6 | 17 |
| Sugar Beet[e] | 7.0 | 15 | 24 | 4.7 | 10 | 16 |
| Tomato | 2.5 | 7.6 | 13 | 1.7 | 5.0 | 8.4 |

Sources: Ayers and Westcot 1994; Grattan 2002; Maas and Hoffman 1977

Notes:

a. These data should be used as a guide to relative tolerances among crops. Absolute tolerances will change based upon climate, soil conditions, and cultural practices. Plants will tolerate about 2 deciSiemens per meter (dS/m) higher soil salinity ($EC_e$) than indicated if soils have high gypsum, however the water salinity ($EC_w$) tolerances do not change.

b. $EC_e$ is average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, and $EC_w$ is electrical conductivity of the irrigation water, both reported in dS/m) at 25°C. The data is based upon a relationship between soil salinity and water salinity of $EC_e = 1.5\ EC_w$ with a 15 to 20 percent leaching fraction and a 40-30-20-10 percent water use pattern for the upper to lower quarters of the root zone.

c. The zero yield potential or maximum $EC_e$ indicates the theoretical soil salinity ($EC_e$) at which crop growth ceases.

d. Tolerance evaluations are based on tree growth and not on yield.

e. For beets, which are more sensitive during germination, the $EC_e$ should not exceed 3 dS/m in the seeding area for garden beets and sugar beets.

The most sensitive crops are affected when $EC_e$ values exceed 1 dS/m, and include the following crops with threshold values: beans (1.0 dS/m); walnuts 1.1 dS/m), bulb onions (1.2 dS/m); grapes, peppers and almonds (1.5 dS/m); apricots (1.6 dS/m); corn and peaches (1.7 dS/m); alfalfa (2.0 dS/m); and cucumbers and tomatoes (2.5 dS/m).

In addition to salinity, boron is also a concern in some areas. Dry beans are one of the more boron sensitive crops with a threshold value of 0.75 to 1.0 mg/l in the soil water within the crop root zone.

#### 12.3.1.2.5 Crop Drainage Methods

Agricultural crop surface and subsurface drainage is important for the suitability of agricultural production (DWR 2013a; Reclamation 2005; SJVDIP 1998). Drainage of most agricultural fields occurs by a combination of surface drainage and subsurface drainage. Poor drainage can lead to crop loss or damage from lack of soil oxygen availability for plant roots, pest infestations (e.g., pathogenic root fungi, such as *phytothora*), and salt accumulation in the root zone. High water tables, high salinity, and poor drainage can limit crop selection and limit the ability of farmers to use irrigation water to leach excess salts out of the crop root zone.

Surface water drainage from agricultural fields is collected in on-farm drainage ditches which are typically connected to larger drainage facilities. The drainage water either flows by gravity or is pumped into adjacent water bodies. Water quality issues related to disposal of surface water drainage can include high concentrations of sediment; nutrients from fertilizers; or residual organic carbon constituents from herbicides, pesticides, or nematicides. On-farm surface drainage systems sometimes include local methods to remove sediment or nutrients, such as the inclusion of vegetative strips to remove sediment and improve drain water quality (CALFED 2000). During the irrigation season, surface drainage water collected from irrigation can be recirculated for subsequent irrigation; however, this can lead to a long-term increase in soil salinity (DWR 2013a; SJVDIP 1998).

Subsurface drainage is used to control groundwater depth to avoid or limit its encroachment into the root zone of crops (Panuska 2011). For example in the Delta, subsurface and surface drainage is used not only to control groundwater depths related to irrigation practices, but also to control groundwater that seeps into the soils from the surface water that surrounds the islands and tracts. Areas in the western and southern San Joaquin Valley are affected by shallow, saline groundwater that accumulates due to irrigation; and the shallow groundwater is underlain by soils with poor drainage (CALFED 2000; DWR 2013a; SJVDP 1990; SJVDIP 1998; WWD 2013a, 2013b). Some areas of northern San Joaquin, Valley collect and discharge subsurface drainage to the San Joaquin River (Reclamation, 2013). Areas in the central and southern San Joaquin Valley manage poor drainage conditions by careful and integrated management of crop patterns, land retirement, irrigation methods and application rates, and/or drainage water reuse and blending, (USGS 2008; WRCD 2004).

#### 12.3.1.2.6 Crop Adaptation in Response to Changes in Water Supply Availability

Farmers and water suppliers can react to changes in water supply in a range of ways. Some farmers adapt to variability by maintaining a mix of crops that can be shifted or fallowed in response to water supply changes. Some farmers have groundwater wells that can be used to replace surface water in times of shortage. Short term responses can also include reducing irrigation water application below what is needed to maintain full crop yield (water stressing). Over the long term, irrigation systems and management can be changed to apply less water. Decisions that farmers make in response to changes in water supply affect other aspects of their operations, and affect the economy of the surrounding community. For example, crop mix and irrigation methods affect the kinds of tractors and other equipment used on the farm.

Some types of on-farm infrastructure also are specialized for the crops grown including: grain driers and storage, hullers, fruit sorting and packing, fruit driers, cotton gins and cold storage plants. Crop-specific equipment, infrastructure, and marketing agreements may prevent a grower from change crops quickly due to changes in water supply availability.

Input suppliers, equipment dealers, labor force, and processing facilities are also dependent on, and affected by, cropping decisions. As crop types change, the mix of these related economic activities also change. This can happen over a period of time, but is difficult to achieve in the short term.

*Response to Variability in CVP and SWP Water Supplies*

Water availability provided by the CVP and SWP varies each year based upon hydrologic conditions and regulatory requirements, as described in Chapter 5, Surface Water Resources and Water Supplies. The CVP and SWP water supply allocations are initially announced in the late winter. The allocations can be revised throughout the spring months as the hydrologic conditions become more certain. Growers often delay finalizing some of their crop decisions until water supply allocations are announced as late as April or May. Delays in finalizing crop decisions also can result in delays in finalizing crop financing and orders to suppliers (e.g., seed, fertilizer), and contracting with labor suppliers and crop processors. Responses to variations in water allocations depend on many factors, including but not limited to: feasibility of alternative water supplies (availability, suitability of water quality, cost); types of crops grown and need for changes in equipment, processing, and labor; and long-term crop supply contracts and obligations, (WWD 2013a, 2013b). A study of changes that occurred during the 1986 through 1992 drought indicated that implementation of the changes will probably occur over a longer period of time and not necessarily during the water supply shortage, especially if groundwater or other surface water supplies can be obtained within the growing season (Dale et al. 1998).

The effects on the surrounding communities of the variability of CVP and SWP water supplies are discussed in Chapter 19, Socioeconomics, and Chapter 21, Environmental Justice.

Typical responses of a farmer or water supplier to increasing shortage of water supplies include the following actions.

- **Increase the use of groundwater**: Reduction in surface water supplies can induce substitution with groundwater using new or existing wells. Water supplies are used conjunctively in some areas with groundwater storage so that during surface water shortages, water historically used to recharge groundwater can be used for applied irrigation uses.
- **Use alternative/supplemental surface water supplies**: Alternative water supplies may include local exchanges or transfers of surface water, water transfers/purchases from more distant areas, and/or use of water stored in surface water reservoirs or groundwater banks. These all depend on the infrastructure to convey the water and the financial ability to pay for the alternatives water supplies.
- **Increased water use efficiency:** Reduced use of irrigation water may be achieved by on-farm system and irrigation management improvements, water reuse, water source blending, and delivery system improvements. Specific on-farm and delivery system improvements can include irrigation scheduling, field leveling, application system changes, and conveyance system loss reduction such as canal lining, spill reduction, and automation. Some of the changes require only management changes, such as irrigation scheduling, and can occur within the growing season. Other changes, such as conveyance system modifications, require capital investments and generally require several years to implement.
- **Field fallowing or changing to lower-water-use crops:** Fallowing, or temporary idling, reduces gross water use by the entire applied water amount, and reduces net water use by at least the evapotranspiration of the crop not planted. Typically fields with higher water use crops or lower value rotation crops would be the first fields to be fallowed. Farmers generally would avoid or minimize fallowing permanent crops or crops with long-term obligations (e.g., cannery contracts). A farmer receiving a partial allocation of water could decide to reduce irrigated acreage and transfer that acreage’s water allocation to the remaining fields in production or sell the water to other water users. A smaller reduction in water use can be achieved by switching from a crop using more water to one using less water (Dale et al. 1998). Permanent

crops, such as trees and vines, that are the least economically viable or that are approaching the end of their lifespan can be removed or abandoned, and the land fallowed until adequate water is available. In extreme dry periods, such as 2014 when there were no deliveries of CVP water to San Joaquin Valley water supply agencies with CVP water service contracts, permanent crops were removed because the plants would not survive the stress of no water or saline groundwater (Fresno Bee 2014).

- **Stress Irrigation:** Farmers generally try to irrigate to achieve maximum economic yield. For some permanent crops, severe pruning could reduce water use, but could reduce yield over multiple years (AgAlert 2010).

#### *12.3.1.3 Cropping Pattern Changes in Response to Water Supply Availability*

Conversion of farm lands to other land uses has occurred historically and continues to occur. Agricultural lands have been converted to different crop patterns, urban areas, habitat restoration, off-farm infrastructure (e.g., utilities and transportation), and on-farm infrastructure (e.g., storage, maintenance, and processing facilities). Crop conversions occur in response to changes in water supply reliability, changes in market demand for specific crops, and decisions to convert lands to urban or infrastructure land uses.

One method used to indicate changes in California agricultural acreage is related to a loss of the value of production on “Important Farmland” and “Grazing Land” acreages, as reported by the California Department of Conservation since 1988 (CDOC 2004). The comparison of the acreage of lands within each category can be used to identify trends in agricultural land conversions. This information is provided in the following subsections for the years 2000 and 2010 for counties within the study area.

Another factor to be considered prior to crop conversion is the costs related to crop establishment. Costs of irrigated crop production include labor, purchased inputs (e.g., seed, fertilizer, chemicals), custom services, investment in growing stock, other capital (including machinery and structures), and other overhead costs.

Reliability of water supply can be especially important for maintaining substantial investments in growing stock of perennial and multi-year crops. Perennial crops include orchards and vineyards that may have useful lives of 25 years or more. Multiyear forage crops, such as alfalfa and irrigated pasture, also may be in production for years. Investment in growing stock may be expressed as the accumulated costs incurred during the period when the crop is planted and brought to bearing age, called the establishment period. Establishment costs for perennial crops can range up to $15,000 per acre in total costs (including cash outlays plus noncash and allocated overhead costs). The example establishment costs provided in Table 12.2 are for the Central Valley, but are generally representative of establishment costs in other regions.

**Table 12.2 Typical Establishment Costs for Some Perennial Crops in the Central Valley**

| Example Crop | Establishment Period (years) | Assumed Life of Stand (years) | Accumulated Total Cost during Establishment ($ per acre) | University of California Cooperative Extension Cost of Production Study |
|---|---|---|---|---|
| Alfalfa Hay | 1 | 4 | 534 | Sacramento Valley, 2013 |
| Almonds | 4 | 25 | 10,117 | San Joaquin Valley North, 2011 |
| Irrigated Pasture | 1 | 20 | 408 | Sacramento Valley, 2003 |
| Walnuts | 5 | 25 | 14,133 | San Joaquin Valley North, 2013 |
| Wine Grapes | 3 | 25 | 18,495 | Cabernet Sauvignon, SJ Valley North, 2012 |

Sources: UCCE 2003, 2011, 2012a, 2013a

Notes: All costs are converted to 2012 dollar equivalent values using the Gross Domestic Product Implicit Price Deflator (USDOC 2014). Assumed stand life is the financial life used for the cost and budget analysis. Individual growers may decide to keep stands in production longer or to remove them sooner.

Farm expenditures are largely spent in the surrounding community in the form of input purchases, hired labor, rents paid to landlords, well drilling, and custom consulting services. Total labor in the agricultural production sector is discussed in relation to the regional economy in Chapter 19, Socioeconomics. Labor hours and input purchases vary substantially among crops, as shown in Table 12.3.

**Table 12.3 Land Rent, Labor Hours, and Custom Services for Example Crops in the Central Valley**

| Example Crop | Typical Rent ($ per acre) | Typical Annual Labor (hours per acre) | Custom Services Purchased ($ per acre) | University of California Cooperative Extension Cost of Production Study |
|---|---|---|---|---|
| Alfalfa Hay | 284 | 2 | 368 | Sacramento Valley, 2013 |
| Almonds | 763 | 31 | 828 | San Joaquin Valley North, 2011 |
| Corn, Grain | 147 | 3 | 324 | San Joaquin Valley South, 2012 |
| Irrigated Pasture | 63 | 3 | 159 | Sacramento Valley, 2003 |
| Rice | 280 | 5 | 329 | Sacramento Valley, 2012 |
| Walnuts | 690 | 8 | 1,203 | San Joaquin Valley North, 2013 |
| Wheat | 246 | 2 | 57 | San Joaquin Valley South, 2013 |
| Wine Grapes | 633 | 68 | 505 | Cabernet Sauvignon, SJ Valley North, 2012 |

Sources: UCCE 2003, 2011, 2012a, 2012b, 2012c, 2013a, 2013b, 2013c

Notes: All costs are converted to 2012 dollar equivalent values using the Gross Domestic Product Implicit Price Deflator (USDOC 2014).

#### *12.3.1.4 Water Supply and Crop Acreage Relationships in the San Joaquin Valley*

Most publically-available information on irrigated acreage and crop types is compiled at the county level, not the water district level. Water availability for CVP and SWP water is provided at a smaller geographic level, such as a water supply entity or several adjacent entities. Therefore, it is difficult to analyze the correlation of water supply availability, irrigated acreage, and crop types. However, the Westlands Water District does provide more detailed information related to water availability, irrigated acreage, and crop types in their publically-available reports, as summarized in this sub-section of Chapter 12. The purpose of this summary is to describe the relationships between cropping patterns, irrigation methods, and water supply availability. Due to the increased frequency of water supply reductions, especially in drier years (as described in Chapter 5, Surface Water Resources and Water Supplies), the amount of fallowed and non-harvested lands has increased as a percentage of total lands within Westlands Water District. The trend observed in Westlands Water District of using additional groundwater and crop idling land when CVP and SWP water supplies are reduced; and reducing groundwater use and increasing irrigated acreage when CVP and SWP become more available occurs throughout the San Joaquin Valley.

##### 12.3.1.4.1 Water Supplies in Westlands Water District

Formed in 1952, Westlands Water District currently serves over 700 farmers across 604,000 acres located on the west side of Fresno and Kings Counties, as described in Chapter 5, Surface Water Resources and Water Supplies (WWD 2013a, 2013b). There are approximately 568,000 irrigable acres in the district.

Westlands Water District began receiving CVP water in 1968. In the first 10 years of operations, irrigation water conveyance facilities were completed and cropping patterns became established. The CVP water supplies were reduced during the 1976 to 1977 drought. Crop acreage and water supply information are available for Westlands Water District from 1978 through 2013 (WWD 2013a, 2014b, 2014c).

This time period includes several major happenings and/or changes in the CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality.

- In 1978, the CVP water supplies were recovering from the 1976 to 1977 drought.
- In the late 1980s, high selenium concentrations were detected in subsurface drainage flows from areas on the west side of the San Joaquin Valley where naturally occurring selenium deposits are located. Subsequently, farmers in these areas changed irrigation practices and in some cases, eliminated irrigation of some lands.
- Between 1987 and 1992, another drought occurred.

- In mid-1990s, the CVP water supplies recovered from a six year drought; however, CVP water supplies available to the district were limited due to initial restrictions on CVP operations to protect winter-run Chinook salmon and delta smelt and to provide refuge water supplies in accordance with the federal Central Valley Project Improvement Act (Public Law 102-575).
- By 2000, the CVP was initially operated under the requirements of State Water Resources Control Board Decision 1641 and the federal Central Valley Project Improvement Act which reduced the long-term availability of CVP water as compared to the 1980s.
- In 2007, the CVP operations were modified in accordance with the Interim Remedial Order issued by the U.S. District Court for the Eastern District of California in *Natural Resources Defense Council, et al. v. Kempthorne*.
- In 2009, the CVP operations were modified in accordance with the 2008 U.S. Fish and Wildlife Service and 2009 National Marine Fisheries Services biological opinions.
- Between 2007 and 2013, six of the seven years were designated as Below Normal, Dry, or Critical Dry water years, which reduced CVP water supplies.

As CVP water supplies have declined over the past 35 years, Westland Water District has needed to implement major conservation programs and purchase water from other CVP and SWP water users and water rights holders. Concurrently, growers have increased groundwater pumping, as illustrated in Figure 12.3. Total supply over this time period ranges from a low of 787,554 acre-feet in 2010 to a high of 1,546,883 acre-feet in 1984 (WWD 2013a, 2014a).

#### 12.3.1.4.2 Cropping Patterns in Westlands Water District

In response to varying water supplies and market factors, farmers in Westlands Water District have changed cropping patterns. In 1978, the predominant crops were cotton and grain crops, including wheat and barley, with some vegetables, including tomatoes and cantaloupe, as summarized in Figure 12.4 (WWD 2013a). Between 1980 and 1996, grain crops were replaced by vegetable crops because other areas in California that traditionally grew crops were experiencing urbanization and groundwater shortages, including southern Santa Clara County and Monterey County (WWD 2008). Planting of permanent crops, including orchards and grapevines, increased between 1978 and 2013 as the markets factors became favorable (WWD 2013a, 2014b, 2014c). Total cotton acreage remained stable between 1978 and 2000, with Acala cotton as the primary crop (WWD No Date-a, No Date-b). After 2000, the total acreage of cotton declined and the primary crop was Pima cotton due to higher market price for this crop; however, cotton prices declined in the early 2000s.

#### 12.3.1.4.3 Irrigation Methods in Westlands Water District

Conversion of the major crops from annual grains to more orchards and vines resulted in Westlands Water District modifying water conveyance facilities because the water demand patterns changed both in quantities and seasonal timing (WWD No Date-c). The change in cropping patterns and the concurrent emphasis on water conservation also resulted in changes in irrigation methods within the district, as summarized in Table 12.4.

**Table 12.4 Irrigation Methods Used in Westlands Water District, as a percentage of total irrigation methods**

| Years | Furrow or Border Strip Irrigation | Sprinkler Irrigation | Drip or Trickle Irrigation | Sprinkler and Furrow Irrigation |
|---|---|---|---|---|
| 1985 | 63% | 21% | 1% | 15% |
| 1990 | 43% | 16% | 3% | 38% |
| 1995 | 36% | 15% | 6% | 43% |
| 2000 | 30% | 13% | 13% | 44% |
| 2005 | 23% | 10% | 33% | 34% |
| 2010 | 11% | 11% | 67% | 22% |
| 2011 | 13% | 12% | 65% | 22% |

Source: WWD 2013a

These changes represent a major investment by the farmers and are considered in the cost of crop establishment costs, a consideration described in above in subsection 12.32.3.1, Crop Establishment Costs. The lower-valued grain and forage crops generally use furrow or border strip irrigation (WWD 2013a). Shallow-rooted vegetables frequently are irrigated with sprinklers or a combination of sprinklers and furrow irrigation. Recently, tomatoes for fresh-pack have been grown with drip irrigation. New orchard and vines have been planted with pressurized drip or trickle irrigation. Other methods, including leveling lands with lasers guided by global positioning satellites and aerated irrigation to introduce air to plant roots, are used to increase irrigation efficiency and improve crop yield (WWD No Date-a).

#### 12.3.1.4.4 Response to Reduced Water Supplies in Westlands Water District

Westlands Water District acquired over 95,000 acres of land with inadequate drainage and the water supplies allocated to these lands are now available for other lands in the district (WWD 2008, 2013a, No Date-c). Much of the purchased land is leased to farmers for non-irrigated crops, or made available for buildings or other economic development, including about 600 acres to the U.S. Bureau of Prisons and about 1,250 acres to Pacific Gas & Electric Company for solar projects.

Frequently, the amount of available surface water is not adequate to meet the irrigation water demand. For example in the drier years of 1991, 1992, 2009, and 2013, groundwater provided more than 50 percent of the irrigation water supply. This extensive reliance on groundwater can substantially reduce groundwater elevations, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

The Westlands Water District *Water Management Handbook* discusses that during droughts, water supplies are reduced and the cost of available water supplies are generally high due to costs of water transfers and/or implementing new or expanded groundwater facilities (WWD 2013b). At the farm level, Westlands' growers use a mix of methods to respond to reduced water supplies: groundwater pumping, land fallowing, and stress irrigation. The decision to fallow land or stress crops by applying less than full irrigation depends upon the crop. Some crops require full irrigation in order to produce a profitable yield, so stress irrigation is not practical – if water is short, acreage of these crops is reduced. Other crops may be able to withstand some stress and produce profitable yield. In the most severe shortage years, such as 2014, even some orchards and vineyards may be stressed or removed from production. From 1978 through the late 1990s when the primary crops were grains and cotton, those crops continued to be grown under stressed conditions and the fallowed and non-harvested land ranged from 3 to 16 percent of the total land in the district, as summarized in Figure 12.5 (WWD 2013a, 2014b, 2014c). However, since 2000, over 40 to 55 percent of the total land in the district is planted in high value orchards, vine, and vegetable crops which cannot sustain stress. Therefore, farmers have increased the amount of fallowed and non-harvested acres to 10 to 34 percent of the total land in the district. When permanent orchards and vines are removed from production, the overall value of production in the district declines for number of years as the permanent crops require several years to become established.

### 12.3.2 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Agriculture in the Trinity River Region is primarily related to timber products and cattle ranching which generally do not rely upon irrigation. Small farms and vineyards are located adjacent to or near the Trinity River rely primarily upon groundwater that is recharged by precipitation and infiltration from local streams, as described in Chapter 7, Groundwater Resources and Groundwater Quality. No lands in Trinity River Region are irrigated with water supplies delivered through the CVP or SWP.

Total value of production and acreage by crop category in the counties that include portions of the Trinity River Region are listed in Table 12.5.

**Table 12.5 Average Annual Agricultural Acreage and Value of Production in Trinity, Humboldt, and Del Norte Counties from 2007 through 2012**

| | Orchards, Vineyards, and Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 114 | 30,846 | N/A | 231 | – | 31,191 |
| Value[b] | $1.8 | $8.1 | $108.2 | $64.5 | $1.7 | $184 |

Sources: USDA-NASS2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis.

## 12.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley and San Joaquin Valley. In this chapter, the counties within the Delta and Suisun Marsh area are included in the description of the Sacramento and San Joaquin valleys or the San Francisco Bay Area Region. The Delta counties of Sacramento, Yolo, and Solano counties are included within the Sacramento Valley discussion. Solano County also includes the Suisun Marsh. San Joaquin County is included within the San Joaquin Valley discussion. Contra Costa County is included within the San Francisco Bay Area Region discussion.

Central Valley agriculture is highly productive due to favorable climate, adequate supplies of good quality irrigation water, and deep, fertile soils. Most of the Central Valley receives rainfall in the late fall through the winter months. Very little of the annual rainfall occurs during the peak agricultural irrigation season which extends from early spring through fall. The seasonality of rainfall in the Central Valley is important for agricultural resources, as the timing of precipitation does not reliably support dryland (non-irrigated) farming. Lower value over-winter non-irrigated crops (e.g., winter wheat) can be grown economically in many years but higher value row crops and permanent crops require substantial supplemental irrigation (DWR 2009). Irrigation water provided by the CVP and SWP, local surface water, and groundwater have transformed lands in the Central Valley into some of the most productive and diverse agricultural lands in the United States.

### *12.3.3.1 Sacramento Valley Crop Patterns*

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, and Solano counties. Other counties in Sacramento Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties.

Field and forage crops dominate the irrigated acreage in Sacramento Valley with over 1.4 million acres irrigated and about 38 percent of crop value produced, as summarized in Table 12.6. Rice, irrigated pasture, and hay are the largest acreages. Second to field and forage are orchard and vine crops, making up roughly 21 percent of total acreage, but providing more than 38 percent crop value produced. Almonds and walnuts are the largest acreages in this category. Crop establishment and production costs are as summarized in Tables 12.2 and 12.3. In total, the Sacramento Valley contains nearly two million agricultural acres generating over four billion dollars per year in value of production.

**Table 12.6 Sacramento Valley Average Annual Agricultural Acreage and Value of Production from 2007 through 2012**

| | Orchards, Vineyards, and Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 419,263 | 1,435,923 | N/A | 1,658 | 91,684 | 1,948,527 |
| Value[b] | $1,569 | $1,581 | $506 | $135 | $322 | $4,113 |

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Most of the counties within the Sacramento Valley have experienced losses in Important Farmland between 2000 and 2010, as summarized in Table 12.7.

**Table 12.7 Farmland Mapping and Monitoring Program Acreages in the Sacramento Valley in 2000 and 2010**

| | | Important Farmland[b] | | | Grazing Land | | |
|---|---|---|---|---|---|---|---|
| County | Total[a] | 2000 | 2010 | Change | 2000 | 2010 | Change |
| Butte | 1.08 | 257,316 | 237,351 | -19,965 | 264,982 | 402,999 | 138,017 |
| Colusa | 0.72 | 565,890 | 554,695 | -11,195 | 7,526 | 9,161 | 1,635 |
| El Dorado | 1.1 | 68,292 | 64,259 | -4,033 | 203,798 | 193,883 | -9,915 |
| Glenn | 0.84 | 407,906 | 348,147 | -59,759 | 176,072 | 226,837 | 50,765 |
| Nevada | 0.64 | 21,973 | 25,934 | 3,961 | 129,758 | 116,808 | -12,950 |
| Placer | 0.96 | 156,701 | 132,741 | -23,960 | 23,708 | 24,193 | 485 |
| Sacramento | 1.1 | 227,931 | 211,744 | -16,187 | 168,144 | 155,822 | -12,322 |
| Shasta | 2.4 | 35,349 | 19,716 | -15,633 | 409,479 | 414,052 | 4,573 |
| Solano | 0.58 | 169,934 | 147,464 | -22,470 | 201,813 | 209,195 | 7,382 |
| Sutter | 0.39 | 301,176 | 285,820 | -15,356 | 50,958 | 53,538 | 2,580 |
| Tehama | 1.7 | 244,782 | 231,592 | -13,190 | 706,027 | 1,547,951 | 841,924 |
| Yolo | 0.65 | 409,796 | 374,534 | -35,262 | 143,365 | 160,450 | 17,085 |
| Yuba | 0.41 | 90,173 | 82,538 | -7,635 | 144,519 | 141,509 | -3,010 |

Sources: Butte County 2010; CDOC 2013; Colusa County 2011; El Dorado County 2003; Glenn County 1993; Nevada County 1995; Placer County 2011; Sacramento County 2010; Shasta County 2004; Solano County 2008; Sutter County 2010; Tehama County 2008; Yolo County 2009; Yuba County 2011

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland.

No data was reported by California Department of Conservation for Plumas County.

#### *12.3.3.2 San Joaquin Valley*

The San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. Other counties in the San Joaquin Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Calaveras, Mariposa, and Tuolumne counties.

Field and forage crops are also the largest category in by acreage in this region, as summarized in Table 12.8. Hay, cotton, and silage have the largest acreage in this category. Second to field and forage is orchard and vine crops with almost two million acres, but providing more than three times the value of production. Almonds and grapes are the two largest acreages of orchard and vine crops in the San Joaquin Valley. Crop establishment and production costs are as summarized in Tables 12.2 and 12.3. In total, the San Joaquin Valley contains over 5.5 million irrigated acres, generating over twenty-six billion dollars in value of production.

Important differences exist in water supply mix and reliability within the San Joaquin Valley. The CVP water users that are located on the west side of the valley and the SWP water users in Kings and Kern counties rely primarily on surface water conveyed through the Delta and groundwater, as discussed in Chapter 5, Surface Water Resources and Water Supplies. Agricultural producers within these CVP water service contractors and SWP entitlement holders are especially susceptible to large variation in available surface water supplies. The San Joaquin River Exchange Contractors receive CVP water supplies in exchange for their water rights on the San Joaquin River; and therefore, have much higher water supply reliability than CVP water service contractors or SWP entitlement holders, as described in Chapter 5, Surface Water Resources and Water Supplies.

On the east side of the San Joaquin Valley at the base of the Sierra Nevada, surface water is delivered under senior water rights on streams from the Sierra Nevada, or by the CVP from Millerton Lake at Friant Dam, as described in Chapter 5, Surface Water Resources and Water Supplies. The reliability of CVP water supplies from Friant Dam have generally been similar to or higher than that of CVP water supplies conveyed through the Delta. However, in 2014, the allocations were reduced to zero and available water from Friant Dam was provided to the water rights holders along the San Joaquin River (e.g., San Joaquin River Exchange Contractors).

A number of agricultural areas throughout the valley have no or very low priority surface water rights. Growers in these areas rely on groundwater for irrigation water.

**Table 12.8 San Joaquin Valley Average Annual Agricultural Acreage and Value of Production from 2007 through 2012**

| | Orchards, Vineyards, and Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 1,943,549 | 3,078,803 | N/A | 3,838 | 510,370 | 5,536,560 |
| Value[b] | $10,915 | $3,049 | $9,429 | $469 | $2,789 | $26,651 |

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis.

Most counties within the San Joaquin Valley Region have experienced losses in Important Farmland between 2000 and 2010, as summarized in Table 12.9. The acreage of Important Farmland in Kern County grew substantially due to reclassification of lands in the foothills of the county.

**Table 12.9 Farmland Mapping and Monitoring Program Acreages in the San Joaquin Valley in 2000 and 2010**

| | | Important Farmland[b] | | | Grazing Land | | |
|---|---|---|---|---|---|---|---|
| **County** | **Total[a]** | **2000** | **2010** | **Change** | **2000** | **2010** | **Change** |
| Fresno | 3.8 | 1,400,535 | 1,370,273 | -30,262 | 835,870 | 825,752 | -10,118 |
| Kern | 5.3 | 990,422 | 914,084 | -76,338 | 1,777,640 | 1,827,391 | 49,751 |
| Kings | 0.82 | 607,274 | 552,087 | -55,187 | 238,485 | 271,831 | 33,346 |
| Madera | 1.4 | 60,617 | 39,812 | -20,805 | 216,795 | 231,475 | 14,680 |
| Merced | 1.3 | 374,762 | 361,582 | -13,180 | 401,592 | 400,604 | -988 |
| San Joaquin | 0.91 | 630,990 | 614,994 | -15,996 | 150,341 | 139,235 | -11,106 |
| Stanislaus | 0.94 | 386,534 | 403,802 | 17,268 | 375,367 | 429,544 | 54,177 |
| Tulare | 3.1 | 880,604 | 859,991 | -20,613 | 434,047 | 440,042 | 5,995 |

Sources: CDOC 2013; Fresno County 2000; Kern County 2004; Kings County 2009; Madera County 1995; Merced County 2012; San Joaquin 2009; Stanislaus County 2010; Tulare County 2010

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

### 12.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas.

Crops grown in the San Francisco Bay Area Region include berries, vegetables, orchards, nursery plants, and irrigated and non-irrigated pasture. Permanent crops (orchards, vineyards, and berries) cover the largest acreage in this region with around 60,000 acres planted, as summarized in Table 12.10. Field and forage crops and vegetables also cover substantial acreage. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be substantially higher in this region. In total, the San Francisco Bay Area Region contains about 150,000 acres planted, creating over one billion dollars per year in value of production.

**Table 12.10 San Francisco Bay Area Average Annual Agricultural Acreage and Value from 2007 through 2012**

| | Orchards, Vineyards, Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 60,239 | 50,715 | N/A | 942 | 41,564 | 153,460 |
| Value[b] | $589 | $22 | $62 | $145 | $329 | $1,148 |

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the San Francisco Bay Area Region counties are summarized in Table 12.11.

**Table 12.11 Farmland Mapping and Monitoring Program Acreages in the San Francisco Bay Area Region in 2000 and 2010**

| | | Important Farmland[b] | | | Grazing Land | | |
|---|---|---|---|---|---|---|---|
| **County** | **Total[a]** | **2000** | **2010** | **Change** | **2000** | **2010** | **Change** |
| Alameda | 0.47 | 10,346 | 7,566 | -2,780 | 247,218 | 244,033 | -3,185 |
| Contra Costa | 0.52 | 102,294 | 90,148 | -12,146 | 172,053 | 168,646 | -3,407 |
| Napa | 0.51 | 78,406 | 76,210 | -2,196 | 180,920 | 179,029 | -1,891 |
| San Benito | 0.89 | 81,701 | 57,460 | -24,241 | 595,537 | 614,821 | 19,284 |
| Santa Clara | 0.84 | 44,025 | 27,751 | -16,274 | 389,210 | 392,777 | 3,567 |

Sources: Alameda County 2000; CDOC 2013; Contra Costa County 2005; Napa County 2007; San Benito County 2013; Santa Clara County 1994

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

### 12.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP.

Crops grown in this region include orchards and vineyards, berries, vegetables, and irrigated pasture. Permanent crops and vegetables dominate the irrigated acreage in this region, accounting for about eighty percent of both the acres planted and the annual value of production, as summarized in Table 12.12. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be higher in this region. On average, the Central Coast Region contains almost 230,000 acres planted and almost two billion dollars per year in value of production.

**Table 12.12 Central Coast Region Average Annual Agricultural Acreage and Value from 2007 through 2012**

| | Orchards, Vineyards, Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 86,394 | 43,078 | N/A | 1,749 | 97,17 | 228,397 |
| Value[b] | $874 | $22 | $98 | $268 | $641 | $1,904 |

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the Central Coast Region between 2000 and 2010 are summarized in Table 12.13.

**Table 12.13 Farmland Mapping and Monitoring Program Acreages in the Central Coast and Southern California Regions in 2000 and 2010**

| | | Important Farmland[b] | | | Grazing Land | | |
|---|---|---|---|---|---|---|---|
| County | Total[a] | 2000 | 2010 | Change | 2000 | 2010 | Change |
| San Luis Obispo | 2.3 | 496,116 | 409,726 | -86,390 | 1,105,169 | 1,181,015 | 75,846 |
| Santa Barbara | 1.8 | 139,810 | 125,292 | -14,518 | 583,709 | 581,642 | -2,067 |

Sources: CDOC 2013; San Luis Obispo County 2013; Santa Barbara County 2009

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

### 12.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

Two crop categories, orchards, vineyards, and berries; and field and forage, account for more than three quarters of the irrigated acreage and about sixty percent of the annual value of production in the Southern California Region, as summarized in Table 12.14). Vegetables account for about one fifth of the irrigated acreage and production value. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be higher in parts of this region. In total, the Southern California Region contains almost 380,000 acres irrigated and generates over five billion dollars per year in value of production.

**Table 12.14 Southern California Average Annual Agricultural Acreage and Value from 2007 through 2012**

| | Orchards, Vineyards, Berries | Field and Forage | Livestock, Dairy, Poultry | Nursery, Other | Vegetable | Total |
|---|---|---|---|---|---|---|
| Acreage[a] | 141,447 | 143,747 | N/A | 10,143 | 81,306 | 376,642 |
| Value[b] | $1,693 | $161 | $809 | $1,851 | $925 | $5,439 |

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the Southern California Region between 2000 and 2010 are summarized in Table 12.15.

**Table 12.15 Farmland Mapping and Monitoring Program Acreages in the Southern California Region in 2000 and 2010**

| | | Important Farmland[b] | | | Grazing Land | | |
|---|---|---|---|---|---|---|---|
| **County** | **Total[a]** | **2000** | **2010** | **Change** | **2000** | **2010** | **Change** |
| Los Angeles | 2.6 | 60,617 | 39,812 | -20,805 | 216,795 | 231,475 | 14,680 |
| Orange | 0.61 | 16,953 | 7,264 | -9,689 | 37,963 | 37,639 | -324 |
| Riverside | 4.7 | 484,821 | 428,989 | -55,832 | 124,714 | 110,841 | -13,873 |
| San Bernardino | 12.9 | 44,738 | 22,761 | -21,977 | 936,090 | 902,590 | -33,500 |
| San Diego | 2.9 | 193,103 | 218,921 | 25,818 | 137,619 | 126,496 | -11,123 |
| Ventura | 1.2 | 131,512 | 119,683 | -11,829 | 208,752 | 197,278 | -11,474 |

Sources: CDOC 2013; Los Angeles County 2011; Orange County 2005; RCIP 2000; San Bernardino County 2007; San Diego County 2011; Ventura County 2005

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

# 12.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in agricultural resources; results of the impact analysis; potential mitigation measures; and cumulative effects.

## 12.4.1 Potential Mechanisms for Change in Agricultural Resources

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in agricultural resources related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change irrigated acreage and total production value in areas that use CVP and SWP water supplies under long-term conditions (based upon the 81-year model simulation period) and dry and critical dry years.

This chapter only includes the analysis of economic changes in agricultural revenues. Chapter 19, Socioeconomics, includes economic changes related to municipal and industrial water supplies and changes in regional economics.

#### *12.4.1.1 Changes in Irrigated Agricultural Acreage and Total Production Value*

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and total production value over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison.

The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

Agricultural impacts were evaluated using a regional agricultural production model developed for large-scale analysis of irrigation water supply and cost changes. The Statewide Agricultural Production (SWAP) model is a regional model of irrigated agricultural production and economics that simulates the decisions of producers (farmers) in 27 agricultural subregions in the Central Valley Region, as described in Appendix 12A. The model selects the crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs.

The SWAP model incorporates CVP and SWP water supplies, other local water supplies represented in the CalSim II model, and groundwater. As conditions change within a SWAP subregion (e.g., the quantity of available project water supply declines), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. The model also fallows land when that appears to be the most cost-effective response to resource conditions.

SWAP was used to compare the long-run agricultural economic responses to potential changes in CVP and SWP irrigation water delivery and to changes in groundwater conditions associated with the alternatives. Results from the surface water analysis that used the CalSim II model, as described in Chapter 5, Surface Water Resources and Water Supplies, were provided as inputs into SWAP through a standardized data linkage procedure. Results from the groundwater analysis that used the CVHM model, as described in Chapter 7, Groundwater Resources and Groundwater Quality, were used to develop changes in pumping lift in SWAP. SWAP produces estimates of the change in value and costs of agricultural production.

The analysis only reduces groundwater withdrawals based upon an optimization of agricultural production costs. The analysis does not restrict groundwater withdrawals based upon groundwater overdraft or groundwater quality conditions. As described in Chapter 7, Groundwater Resources and Groundwater Quality, the Sustainable Groundwater Management Act requires preparation of Groundwater Sustainability Plans (GSPs) by 2020 or 2022 for most of the groundwater basins in the Central Valley Region. The GSPs will identify methods to implement measures that will achieve sustainable groundwater operations by 2040 or 2042. The analysis in this chapter is focused on conditions that would occur in 2030. If local agencies fully implement GSPs prior to the regulatory deadline, increasing groundwater use would be less of an option for agricultural water users. However, to achieve sustainable conditions, some measures could require several years to design and construct new water supply facilities, and sustainable groundwater conditions are not required until the 2040s. Therefore, it was assumed that Central Valley agriculture water users would not reduce groundwater use by 2030, and that groundwater use would change in response to changes in CVP and SWP water supplies.

#### *12.4.1.2 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur in drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento

Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future agricultural resources conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in agricultural resources conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 12.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to agricultural resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *12.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would result in disruption of agricultural resources; however, the development of general plans includes preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources.

Under the No Action Alternative and the Second Basis of Comparison, development of future water resources management projects by 2030 which would result in improved water supply flexibility and availability, including water supplies for agricultural resources, as described in Chapter 3, Description of Alternatives.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass. The restoration programs could disrupt agricultural resources depending upon the location of the restoration.

### 12.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C, Revised Second Basis of Comparison, includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected.

Chapter 7, Groundwater Resources and Groundwater Quality, includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

#### *12.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 12.4.3.1.1 Trinity River Region

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under the No Action Alternative as compared to the Second Basis of Comparison.

##### 12.4.3.1.2 Central Valley Region

*Potential Changes in Irrigated Agriculture.*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar (less than 5 percent change) under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.16 and 12.17.

**Table 12.16 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 154 | 1 |
| **Rice** | 548 | 548 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 199 | 200 | -1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 457 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.17 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 544 | 548 | -4 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 197 | 198 | -1 |

| Crops | No Action Alternative (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 457 | -1 |
| **Total** | 1,529 | 1,536 | -7 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar (less than 5 percent change) under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years due to increased use of groundwater, as summarized in Tables 12.18 and 12.19.

**Table 12.18 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 149 | 0.8 |
| **Rice** | 1,114 | 1,115 | -0.9 |
| **Field Crops** | 77 | 77 | 0.1 |
| **Forage Crops** | 246 | 246 | -0.7 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,193 | -0.9 |
| **Total** | 5,745 | 5,747 | -1.6 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.19 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | -0.5 |
| **Rice** | 1,107 | 1,114 | -7.3 |

| Crops | No Action Alternative ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Field Crops** | 77 | 77 | -0.1 |
| **Forage Crops** | 243 | 245 | -1.4 |
| **Vegetables and Truck Crops** | 967 | 967 | -0.2 |
| **Orchards and Vineyards** | 3,191 | 3,193 | -1.7 |
| **Total** | 5,735 | 5,746 | -11.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under the No Action Alternative as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.20 and 12.21.

**Table 12.20 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.21 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,010 | 1,024 | -14 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 827 | 828 | 0 |
| **Forage Crops** | 735 | 735 | -1 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,154 | 2,156 | -2 |
| **Total** | 5,375 | 5,392 | -17 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years due to increased use of groundwater, as summarized in Tables 12.22 and 12.23.

**Table 12.22 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | -0.2 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,437 | -0.4 |
| **Forage Crops** | 1,426 | 1,426 | -0.1 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.1 |
| **Orchards and Vineyards** | 16,547 | 16,547 | 0.0 |
| **Total** | 25,437 | 25,438 | -0.5 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.23 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Crops | No Action Alternative ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,359 | 1,373 | -14.4 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,437 | -0.9 |
| **Forage Crops** | 1,426 | 1,426 | -0.4 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | -0.2 |
| **Orchards and Vineyards** | 16,542 | 16,547 | -4.4 |
| **Total** | 25,417 | 25,437 | -20.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Cross Delta Water Transfers*

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to agricultural resources were identified as reduced cultivation of agricultural lands over the term of the transfer in the seller's service area. However, the amount of land effected by the water transfers would be relatively small as compared to the total cultivated acreage within a region. Beneficial changes would occur related to agricultural resources in the purchaser's service areas. The analysis indicated that these potential impacts would not be substantial.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 12.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### *12.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because agricultural resource conditions under Alternative 1 are identical to agricultural resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 12.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 1 as compared to the No Action Alternative.

*Central Valley Region*

*Potential Changes in Irrigated Agricultural*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.24 and 12.25.

**Table 12.24 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 154 | 155 | -1 |
| **Rice** | 549 | 548 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 200 | 199 | 1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 457 | 456 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.25 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 548 | 544 | 4 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 198 | 197 | 1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 457 | 456 | 1 |
| **Total** | 1,536 | 1,529 | 7 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar (less than 5 percent change) under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.26 and 12.27.

**Table 12.26 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 149 | 150 | -0.8 |
| **Rice** | 1,115 | 1,114 | 0.9 |
| **Field Crops** | 77 | 77 | -0.1 |
| **Forage Crops** | 246 | 246 | 0.7 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,193 | 3,192 | 0.9 |
| **Total** | 5,747 | 5,745 | 1.6 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.27 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | 0.5 |
| **Rice** | 1,114 | 1,107 | 7.3 |
| **Field Crops** | 77 | 77 | 0.1 |
| **Forage Crops** | 245 | 243 | 1.4 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.2 |
| **Orchards and Vineyards** | 3,193 | 3,191 | 1.7 |
| **Total** | 5,746 | 5,735 | 11.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.28 and 12.29.

**Table 12.28 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.29 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,010 | 14 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 827 | 0 |
| **Forage Crops** | 735 | 735 | 1 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,154 | 2 |
| **Total** | 5,392 | 5,375 | 17 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the San Joaquin Valley would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.30 and 12.31.

**Table 12.30 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | 0.2 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,437 | 1,436 | 0.4 |
| **Forage Crops** | 1,426 | 1,426 | 0.1 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | -0.1 |
| **Orchards and Vineyards** | 16,547 | 16,547 | 0.0 |
| **Total** | 25,438 | 25,437 | 0.5 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.31 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative**

| Crops | Alternative 1 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,359 | 14.4 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,437 | 1,436 | 0.9 |
| **Forage Crops** | 1,426 | 1,426 | 0.4 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.2 |
| **Orchards and Vineyards** | 16,547 | 16,542 | 4.4 |
| **Total** | 25,437 | 25,417 | 20.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Water Transfers*

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on agricultural resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### 12.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *12.4.3.3 Alternative 2*

The agricultural resources under Alternative 2 would identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 12.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to agricultural resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 12.4.3.1, No Action Alternative.

### *12.4.3.4 Alternative 3*

The CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.

#### 12.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the No Action Alternative.

*Central Valley Region*

*Potential Changes in Irrigated Agricultural*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.32 and 12.33.

**Table 12.32 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 154 | 155 | -1 |
| **Rice** | 548 | 548 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 200 | 199 | 1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |

| Crops | Alternative 3 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Orchards and Vineyards** | 457 | 456 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.33 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 547 | 544 | 3 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 197 | 197 | 1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 456 | 1 |
| **Total** | 1,533 | 1,529 | 4 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.34 and 12.35.

**Table 12.34 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 149 | 150 | -0.7 |
| **Rice** | 1,115 | 1,114 | 0.6 |
| **Field Crops** | 77 | 77 | -0.1 |

| Crops | Alternative 3 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Forage Crops** | 246 | 246 | 0.5 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,192 | 0.9 |
| **Total** | 5,746 | 5,745 | 1.2 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.35 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | 0.2 |
| **Rice** | 1,112 | 1,107 | 5.8 |
| **Field Crops** | 77 | 77 | 0.1 |
| **Forage Crops** | 244 | 243 | 0.8 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.1 |
| **Orchards and Vineyards** | 3,193 | 3,191 | 2.2 |
| **Total** | 5,744 | 5,735 | 9.2 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

#### *San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.36 and 12.37.

**Table 12.36 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.37 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,021 | 1,010 | 11 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 827 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,154 | 2,154 | 0 |
| **Total** | 5,387 | 5,375 | 12 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the San Joaquin Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.38 and 12.39.

**Table 12.38 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | 0.1 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,437 | 1,436 | 0.3 |
| **Forage Crops** | 1,426 | 1,426 | 0.1 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | -0.1 |
| **Orchards and Vineyards** | 16,547 | 16,547 | -0.1 |
| **Total** | 25,437 | 25,437 | 0.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.39 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative**

| Crops | Alternative 3 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,370 | 1,359 | 11.5 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,436 | 0.4 |
| **Forage Crops** | 1,426 | 1,426 | -0.1 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.0 |
| **Orchards and Vineyards** | 16,542 | 16,542 | -0.3 |
| **Total** | 25,428 | 25,417 | 11.4 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Water Transfers*

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on agricultural resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### 12.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Potential Changes in Irrigated Agricultural*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 3 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.40 and 12.41.

**Table 12.40 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 154 | 154 | 0 |
| **Rice** | 548 | 548 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 200 | 200 | 0 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 457 | 457 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.41 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 547 | 548 | -1 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 197 | 198 | -1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 457 | -1 |
| **Total** | 1,533 | 1,536 | -3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry conditions would be similar under Alternative 3 and Second Basis of Comparison, as summarized in Tables 12.42 and 12.43, primarily due to a decrease in groundwater pumping.

**Table 12.42 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 149 | 149 | 0.1 |
| **Rice** | 1,115 | 1,115 | -0.3 |
| **Field Crops** | 77 | 77 | 0.0 |
| **Forage Crops** | 246 | 246 | -0.1 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,193 | -0.1 |
| **Total** | 5,746 | 5,747 | -0.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.43 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | -0.3 |
| **Rice** | 1,112 | 1,114 | -1.5 |
| **Field Crops** | 77 | 77 | 0.0 |
| **Forage Crops** | 244 | 245 | -0.6 |
| **Vegetables and Truck Crops** | 967 | 967 | -0.1 |
| **Orchards and Vineyards** | 3,193 | 3,193 | 0.4 |
| **Total** | 5,744 | 5,746 | -2.1 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

### *San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 3 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.44 and 12.45.

**Table 12.44 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.45 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,021 | 1,024 | -3 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | -1 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,154 | 2,156 | -2 |
| **Total** | 5,387 | 5,392 | -5 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions would be similar under Alternative 3 and the Second Basis of Comparison, as summarized in Tables 12.46 and 12.47, primarily due to an increase in groundwater pumping.

**Table 12.46 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | -0.1 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,437 | 1,437 | -0.1 |
| **Forage Crops** | 1,426 | 1,426 | 0.0 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.0 |
| **Orchards and Vineyards** | 16,547 | 16,547 | -0.1 |
| **Total** | 25,437 | 25,438 | -0.3 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.47 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Crops | Alternative 3 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,370 | 1,373 | -2.9 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,437 | -0.6 |
| **Forage Crops** | 1,426 | 1,426 | -0.5 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | -0.2 |
| **Orchards and Vineyards** | 16,542 | 16,547 | -4.7 |
| **Total** | 25,428 | 25,437 | -8.9 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Water Transfers*

It is anticipated that water would be transferred between subbasins in the same manner under Alternative 3 as compared to the Second Basis of Comparison. If the water to be transferred is made available through crop idling, there would be a reduction in irrigated acreage. If the water is used to reduce crop idling in dry and critical dry years, there would be an increase in irrigated acreage. Therefore, the changes in agricultural resources would need to be determined for each water transfer program.

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 as compared to the Second Basis of Comparison, and that impacts on agricultural resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### *12.4.3.5 Alternative 4*

The agricultural resources under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 12.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in agricultural resources under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 12.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *12.4.3.6 Alternative 5*

The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations.

##### 12.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the No Action Alternative.

*Central Valley Region*

*Potential Changes in Irrigated Agricultural*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 5 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.48 and 12.49.

**Table 12.48 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 548 | 548 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 199 | 199 | 0 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 456 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.49 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | 0 |
| **Rice** | 544 | 544 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 197 | 197 | 0 |

| Crops | Alternative 5 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 456 | 0 |
| **Total** | 1,529 | 1,529 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry conditions would be similar under Alternative 5 and the No Action Alternative, as summarized in Tables 12.50 and 12.51.

**Table 12.50 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | 0.0 |
| **Rice** | 1,114 | 1,114 | 0.1 |
| **Field Crops** | 77 | 77 | 0.0 |
| **Forage Crops** | 246 | 246 | 0.0 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,192 | 0.1 |
| **Total** | 5,745 | 5,745 | 0.1 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.51 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | -0.1 |
| **Rice** | 1,107 | 1,107 | 0.2 |
| **Field Crops** | 77 | 77 | 0.0 |
| **Forage Crops** | 243 | 243 | 0.1 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,191 | 0.7 |
| **Total** | 5,736 | 5,735 | 0.8 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 5 as compared to the No Action Alternative over long-term average conditions and dry and critical dry years, as summarized in Tables 12.52 and 12.53.

**Table 12.52 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.53 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 (1000s acres) | No Action Alternative (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,010 | 1,010 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 827 | 827 | 0 |
| **Forage Crops** | 734 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,153 | 2,154 | -1 |
| **Total** | 5,374 | 5,375 | -1 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry year conditions would be similar under Alternative 5 and the No Action Alternative, as summarized in Tables 12.54 and 12.55.

**Table 12.54 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | 0.0 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,436 | 0.0 |
| **Forage Crops** | 1,426 | 1,426 | 0.0 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.0 |
| **Orchards and Vineyards** | 16,547 | 16,547 | -0.1 |
| **Total** | 25,437 | 25,437 | -0.1 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.55 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative**

| Crops | Alternative 5 ($ millions) | No Action Alternative ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,359 | 1,359 | -0.1 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,435 | 1,436 | -0.2 |
| **Forage Crops** | 1,426 | 1,426 | -0.1 |
| **Vegetables and Truck Crops** | 4,622 | 4,623 | -0.2 |
| **Orchards and Vineyards** | 16,540 | 16,542 | -2.0 |
| **Total** | 25,414 | 25,417 | -2.7 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Water Transfers*

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on agricultural resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### 12.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Irrigated Agricultural*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Potential Changes in Irrigated Agricultural*

*Sacramento Valley*

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 5 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.56 and 12.57.

**Table 12.56 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 154 | 1 |
| **Rice** | 548 | 549 | 0 |
| **Field Crops** | 59 | 59 | 0 |
| **Forage Crops** | 199 | 200 | -1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 457 | 0 |
| **Total** | 1,537 | 1,537 | 0 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.57 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 155 | 155 | -1 |
| **Rice** | 544 | 548 | -4 |
| **Field Crops** | 59 | 59 | 0 |

| Crops | Alternative 5 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Forage Crops** | 197 | 198 | -1 |
| **Vegetables and Truck Crops** | 119 | 119 | 0 |
| **Orchards and Vineyards** | 456 | 457 | -1 |
| **Total** | 1,529 | 1,536 | -7 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and in dry and critical dry conditions would be similar under Alternative 5 and Second Basis of Comparison, as summarized in Tables 12.58 and 12.59.

**Table 12.58 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 149 | 0.8 |
| **Rice** | 1,114 | 1,115 | -0.8 |
| **Field Crops** | 77 | 77 | 0.1 |
| **Forage Crops** | 246 | 246 | -0.6 |
| **Vegetables and Truck Crops** | 967 | 967 | 0.0 |
| **Orchards and Vineyards** | 3,192 | 3,193 | -0.9 |
| **Total** | 5,745 | 5,747 | -1.5 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.59 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 150 | 150 | -0.6 |
| **Rice** | 1,107 | 1,114 | -7.1 |
| **Field Crops** | 77 | 77 | -0.1 |
| **Forage Crops** | 243 | 245 | -1.3 |
| **Vegetables and Truck Crops** | 967 | 967 | -0.3 |
| **Orchards and Vineyards** | 3,192 | 3,193 | -1.1 |
| **Total** | 5,736 | 5,746 | -10.5 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*San Joaquin Valley*

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 5 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.60 and 12.61.

**Table 12.60 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,024 | 1,024 | 0 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 828 | 828 | 0 |
| **Forage Crops** | 735 | 735 | 0 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,156 | 2,156 | 0 |
| **Total** | 5,392 | 5,392 | -1 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

**Table 12.61 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as compared to the Second Basis of Comparison**

| Crops | Alternative 5 (1000s acres) | Second Basis of Comparison (1000s acres) | Changes (1000s acres) |
|---|---|---|---|
| **Grain Crops** | 1,010 | 1,024 | -14 |
| **Rice** | 17 | 17 | 0 |
| **Field Crops** | 827 | 828 | 0 |
| **Forage Crops** | 734 | 735 | -1 |
| **Vegetables and Truck Crops** | 633 | 633 | 0 |
| **Orchards and Vineyards** | 2,153 | 2,156 | -3 |
| **Total** | 5,374 | 5,392 | -18 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and in dry and critical dry conditions would be similar, as summarized in Tables 12.62 and 12.63, primarily due to an increase in groundwater pumping.

**Table 12.62 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,373 | 1,373 | -0.2 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,436 | 1,437 | -0.5 |
| **Forage Crops** | 1,426 | 1,426 | -0.1 |
| **Vegetables and Truck Crops** | 4,623 | 4,623 | 0.2 |
| **Orchards and Vineyards** | 16,547 | 16,547 | -0.1 |
| **Total** | 25,437 | 25,438 | -0.7 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

**Table 12.63 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison**

| Crops | Alternative 5 ($ millions) | Second Basis of Comparison ($ millions) | Changes ($ millions) |
|---|---|---|---|
| **Grain Crops** | 1,359 | 1,373 | -14.5 |
| **Rice** | 31 | 31 | 0.0 |
| **Field Crops** | 1,435 | 1,437 | -1.2 |
| **Forage Crops** | 1,426 | 1,426 | -0.5 |
| **Vegetables and Truck Crops** | 4,622 | 4,623 | -0.5 |
| **Orchards and Vineyards** | 16,540 | 16,547 | -6.4 |
| **Total** | 25,414 | 25,437 | -22.9 |

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

*Effects Related to Water Transfers*

Potential effects to agricultural resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on agricultural resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Irrigated Agricultural*

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

#### *12.4.3.7 Summary of Environmental Consequences*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 12.64 and 12.65. The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

**Table 12.64 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects on agricultural resources. | None needed |
| Alternative 2 | No effects on agricultural resources. | None needed |
| Alternative 3 | No effects on agricultural resources. | None needed |
| Alternative 4 | No effects on agricultural resources. | None needed |
| Alternative 5 | No effects on agricultural resources. | None needed |

**Table 12.65 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | No effects on agricultural resources. | Not considered for this comparison. |
| Alternative 1 | No effects on agricultural resources. | Not considered for this comparison. |
| Alternative 2 | No effects on agricultural resources. | Not considered for this comparison. |
| Alternative 3 | No effects on agricultural resources. | Not considered for this comparison. |
| Alternative 4 | No effects on agricultural resources. | Not considered for this comparison. |
| Alternative 5 | No effects on agricultural resources. | Not considered for this comparison. |

#### *12.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative, would not result in changes in agricultural resources. Therefore, there would be no adverse impacts to agricultural resources; and no mitigation measures are required.

### *12.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Agricultural Resources are summarized in Table 12.66.

**Table 12.66 Summary of Cumulative Effects on Agricultural Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Nimbus Fish Hatchery Fish Passage Project<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration | <u>These effects would be the same under all alternatives.</u><br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies as compared to past conditions.<br>Some future water quality and habitat projects could modify surface water conditions; however, water supplies are not anticipated to be affected.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability.<br>Developments under the general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect agricultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to remaining agricultural resources. |
| Future Actions considered as Cumulative Effects Actions with All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- *Westlands Water District v. United States Settlement*<br>- Future water supply projects, including water recycling, | <u>These effects would be the same under all alternatives.</u><br>Most of the reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries.<br>Developments under the future projects are anticipated to potentially affect agricultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources.<br>Some of the reasonably foreseeable actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | beneficial impact to agricultural resources. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans.<br>Some of the reasonably foreseeable actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

## 12.5 References


AgAlert. 2010. "*'Rolling stumping' could be in future for avocado trees*". Written by Kate Campbell for April 14, 2010. Site Accessed June 24, 2014. http://www.agalert.com/story/?id=1513

Alameda County. 2000. *East County Area Plan (Revised by Initiative Nov. 2000).*

Ayers, R. S., and D. W. Westcot. Reprinted 1989, 1994. *Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29*, Rev. 1. Site accessed August 7, 2014. http://www.fao.org/docrep/003/t0234e/T0234E00.htm

Baldwin, K. R. 2006. *Crop Rotations on Organic Farms, North Carolina Cooperative Extension Service.* June.

Butte County. 2010. *General Plan Draft Environmental Impact Report*. April 8.

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://bvh2o.com/James.html

CALFED (CALFED Bay-Delta Program). 2000. *Final Programmatic Environmental Impact Statement/Environmental Impact Report*. July.

CDOC (California Department of Conservation). 2004. *A Guide to the Farmland Mapping and Monitoring Program, 2004 Edition*.

CDOC (California Department of Conservation). 2013. *California Department of Conservation, Farmland Mapping and Monitoring Program*. Site accessed February 7, 2013. http://www.conservation.ca.gov/dlrp/FMMP/Pages/Index.aspx.

Colusa County. 2011. *Public Draft Environmental Impact Report for the 2030 Colusa County General Plan Update*. November.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020*. January.

Dale et al. (Dale, L. L., and L. S. Dixon). 1998. *The Impact of Water Supply Reductions on San Joaquin Valley Agriculture During the 1986-1992 Drought*. RAND.

DWR (California Department of Water Resources). 2009. *California Water Plan, Update 2009, Integrated Water Management*. December.

DWR (California Department of Water Resources). 2012. *A Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use, Report to the Legislature by the DWR Water Use and Efficiency Branch*. May 8.

DWR (California Department of Water Resources). 2013a. *California Water Plan Update 2013, Public Review Draft*. October.

DWR (California Department of Water Resources). 2013b. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

Edinger-Marshall, S., and J. Letey. 1997. *Irrigation Shifts toward Sprinklers, Drip and Microsprinklers*. University of California Agricultural and Natural Resources. California Agriculture 51(3):38-40.

El Dorado County. 2003. *El Dorado County General Plan Draft Environmental Impact Report*. May.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Fresno Bee. 2014. *San Joaquin Valley farmers take drastic measures to deal with drought*. Written by Robert Rodriguez. January 18.

Fresno County. 2000. *Fresno County General Plan Background Report*. October.

Glenn County. 1993. *Glenn County General Plan*. June 15.

Grattan, Stephen. 2002. *Irrigation Water Salinity and Crop Production, University of California, Agricultural and Natural Resources, University of California, Davis, Publication 8066*.

Howitt et al. (R. Howitt, D. MacEwan, C. Garnarche, J.M Azuara, P. Marchand, and D. Brown). 2012. *Yolo Bypass Flood Date and Flow Volume Agricultural Impact Analysis, Prepared for Yolo County*. May 15.

Kern County. 2004. *Revised Update of the Kern County General Plan and Amendment of the Kern County and Incorporated Cities Integrated Waste Management Plan Siting Element, Recirculated Draft Program Environmental Impact Report*. January.

Kings County. 2009. *2035 Kings County General Plan Draft Environmental Impact Report*. June.

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP).*

Los Angeles County (County of Los Angeles). 2011. *Public Review Draft 4/5/11 Text-Only Version, Los Angeles County General Plan 2035*. April.

Madera County. 1995. *Madera County General Plan Background Report*. October.

Maas and Hoffman (Maas, E. V. and Hoffman, G.J.). 1977. *Crop Salt Tolerance: Current Assessment*. Journal of the Irrigation and Drainage Division, American Society of Civil Engineers 103(2):115–134. Proceeding Paper 12993.

Merced County. 2012. *2030 Merced County General Plan Draft Program Environmental Impact Report*. November.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

Napa County. 2007. *Draft General Plan Environmental Impact Report*. February.

NCWA (Northern California Water Association). 2011. *Final Draft, Efficient Water Management for Regional Sustainability in the Sacramento Valley*. July.

Nevada County (County of Nevada). 1995. *Nevada County General Plan, Final Environmental Impact Report*. March.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

Orange County. 2005. *2005 Orange County General Plan*.

Panuska, J. 2011. Agricultural Drainage: Function and Value. Presentation to and Asbstract in the Proceedings of the Wisconsin Crop Management Conference, Vol. 50. 2011.

Placer County. 2011. *Placer County Conservation Plan, Western Placer County, Agency Review Draft Document*. February 1.

RCIP (Riverside County Integrated Project). 2000. *Existing Setting Report*. March.

Reclamation (Bureau of Reclamation). 2005. *San Luis Drainage Feature Re-evaluation, Draft Environmental Impact Statement*. May.

Reclamation (Bureau of Reclamation). 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Roel et al. (Roel, A., R.G. Mutters, J.W. Eckert, and R.E. Plant). 2005. *Effect of Low Water Temperature on Rice Yield in California*. Published online 13 May 2005, Agronomy Journal.

Sacramento County. 2010. *Final Environmental Impact Report, Sacramento County General Plan Update*. April.

San Benito County (County of San Benito). 2013. *2035 San Benito County General Plan Update Draft Program Environmental Impact Report*. November.

San Bernardino County (County of San Bernardino). 2007. *County of San Bernardino 2006 General Plan Program, Final Environmental Impact Report and Appendices*. February.

San Diego County (County of San Diego). 2011. *San Diego County General Plan Update, Final Environmental Impact Report*. August.

San Joaquin County. 2009. *General Plan Update Background Report*. July.

San Luis Obispo County (County of San Luis Obispo). 2013. *County of San Luis Obispo, Land Use and Circulation Elements*. August.

Santa Barbara County (County of Santa Barbara). 2009. *Santa Barbara County Comprehensive Plan*. May.

Santa Clara County (County of Santa Clara). 1994. *Santa Clara County General Plan Draft Environmental Impact Report*. September.

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

Shasta County. 2004. *Shasta County General Plan, as amended through September 2004*. September.

SJVDP (San Joaquin Valley Drainage Program). 1990. *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. Final Report of the San Joaquin Valley Drainage Program*. September.

SJVDIP (San Joaquin Valley Drainage Implementation Program). 1998. *Drainage Management in the San Joaquin Valley, A Status Report*. February.

Solano County. 2008. *Solano County General Plan, Draft Environmental Impact Report*. April.

Stanislaus County (County of Stanislaus County). 2010. *Stanislaus County General Plan Support Documentation, Revised April 2010*. April.

Sutter County. 2010. *General Plan Update Draft Environmental Impact Report*. September.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Tehama County. 2008. *Tehama County 2008-2028 General Plan Draft Environmental Impact Report*. September.

Tulare County. 2010. *Tulare County General Plan 2030 Update, Recirculated Draft Environmental Impact Report.* February.

UCCE (University of California Cooperative Extension). 2003. *Sample Costs to Establish and Produce Pasture, Sacramento Valley, Flood Irrigation*.

UCCE (University of California Cooperative Extension). 2011. *Sample Costs to Establish an Orchard and Produce Almonds, San Joaquin Valley North, Flood Irrigation*.

UCCE (University of California Cooperative Extension). 2012a. *Sample Costs to Establish a Vineyard and Produce Winegrapes, Cabernet Sauvignon, San Joaquin Valley North-Crush District 11 of San Joaquin and Sacramento Counties*.

UCCE (University of California Cooperative Extension). 2012b. *Sample Costs to Produce Corn Silage, San Joaquin Valley-South, Double Cropped Planting*.

UCCE (University of California Cooperative Extension). 2012c. *Sample Costs to Produce Rice, Sacramento Valley, Rice Only Rotation, Medium Grain*.

UCCE (University of California Cooperative Extension). 2013a. *Sample Costs to Establish and Produce Organic Alfalfa Hay, California-2013*.

UCCE (University of California Cooperative Extension). 2013b. *Sample Costs to Establish a Walnut Orchard and Produce Walnuts, San Joaquin Valley-North, Late leafing-lateral bearing*.

UCCE (University of California Cooperative Extension). 2013c. *Sample Costs to Produce Wheat for Grain, San Joaquin Valley-South, Irrigated*.

USDA (U. S. Department of Agriculture). 2010. *Impacts of Irrigation Water Quality on The Persistence and Transmission Of E. Coli O157:H7 from Soil To Plants, 2010 Annual Report*. Site accessed June 24, 2014. http://seprl.ars.usda.gov/research/projects/projects.htm?ACCN_NO=413282&fy=2010

USDA (U. S. Department of Agriculture). 2014b. *News Release: Obama Administration Announces Additional Assistance to Californians Impacted by Drought, February 14, 2014*. Site accessed August 10, 2014. http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2014/02/0022.xml.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2008. *California County Agricultural Commissioners' Data, 2007*. August 29.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2009. *California County Agricultural Commissioners' Data, 2008*. October 15.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2010. *California County Agricultural Commissioners' Data, 2009*. December.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2011a. *California County Agricultural Commissioners' Data, 2010*. December.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2011b. *California Agricultural Statistics, 2010 Crop Year*. October 28.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2012a. *California County Agricultural Commissioners' Reports, 2011*. December 17.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2012b. *California Agricultural Statistics, 2011 Crop Year*. October 31.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2013a. *California County Agricultural Commissioners' Reports, 2012*.

USDA-NASS (U. S. Department of Agriculture, National Agricultural Statistics Service). 2013b. *California Agricultural Statistics, 2012 Crop Year*.

USDOC (U.S. Department of Commerce). 2014. *Bureau of Economic Analysis. Gross Domestic Product Implicit Price Deflator. Annual Series. Washington, D.C.* Site accessed June 24, 2014. http://research.stlouisfed.org/fred2/series/A191RD3A086NBEA.

USGS (U.S. Geological Survey). 2008. *Technical Analysis of In-Valley Drainage Management Strategies for the Western San Joaquin Valley, California, Open File Report 2008-1210*.

Ventura County (County of Ventura). 2005. *Final Subsequent Environmental Impact Report for Focused General Plan Update*. June.

WRCD (Westside Resource Conservation District). 2004. *A Landowner's Manual -- Managing Agricultural Irrigation Drainage Water: A guide for developing Integrated On-Farm Drainage Management systems*.

WWD (Westlands Water District). 2008. *Water Management Plan, 2007*. April 19.

WWD (Westlands Water District). 2013a. *Water Management Plan, 2012*. April 19.

WWD (Westlands Water District). 2013b. *Water Management Handbook.* June 17.

WWD (Westlands Water District). 2014a. *Annual Water Supply and Use*. Site accessed March 24, 2014. http://www.westlandswater.org/resources/watersupply/supply.asp?title=Annual%20Water%20Use%20and%20Supply&cwide=1920

WWD (Westlands Water District). 2014b. *Westlands Water District 2012 Crop Acreage Report*. Site accessed June 28, 2014. http://wwd.ca.gov/wp-content/uploads/2014/04/croprpt2012.pdf.

WWD (Westlands Water District). 2014c. *Westlands Water District 2013 Crop Acreage Report*. Site accessed June 28, 2014. http://wwd.ca.gov/wp-content/uploads/2014/04/croprpt13.pdf.

WWD (Westlands Water District). No Date-a. *Westlands Water District Annual Report 2000/2001*.

WWD (Westlands Water District). No Date-b. *Westlands Water District Annual Report 2001-2002*.

WWD (Westlands Water District). No Date-c. *Westlands Water District Annual Report 2004/2005*.

Yolo County. 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report Public Review Draft*. April.

Yuba County. 2011. *Final Yuba County 2030 General Plan Environmental Impact Report*. May.

This page left blank intentionally.

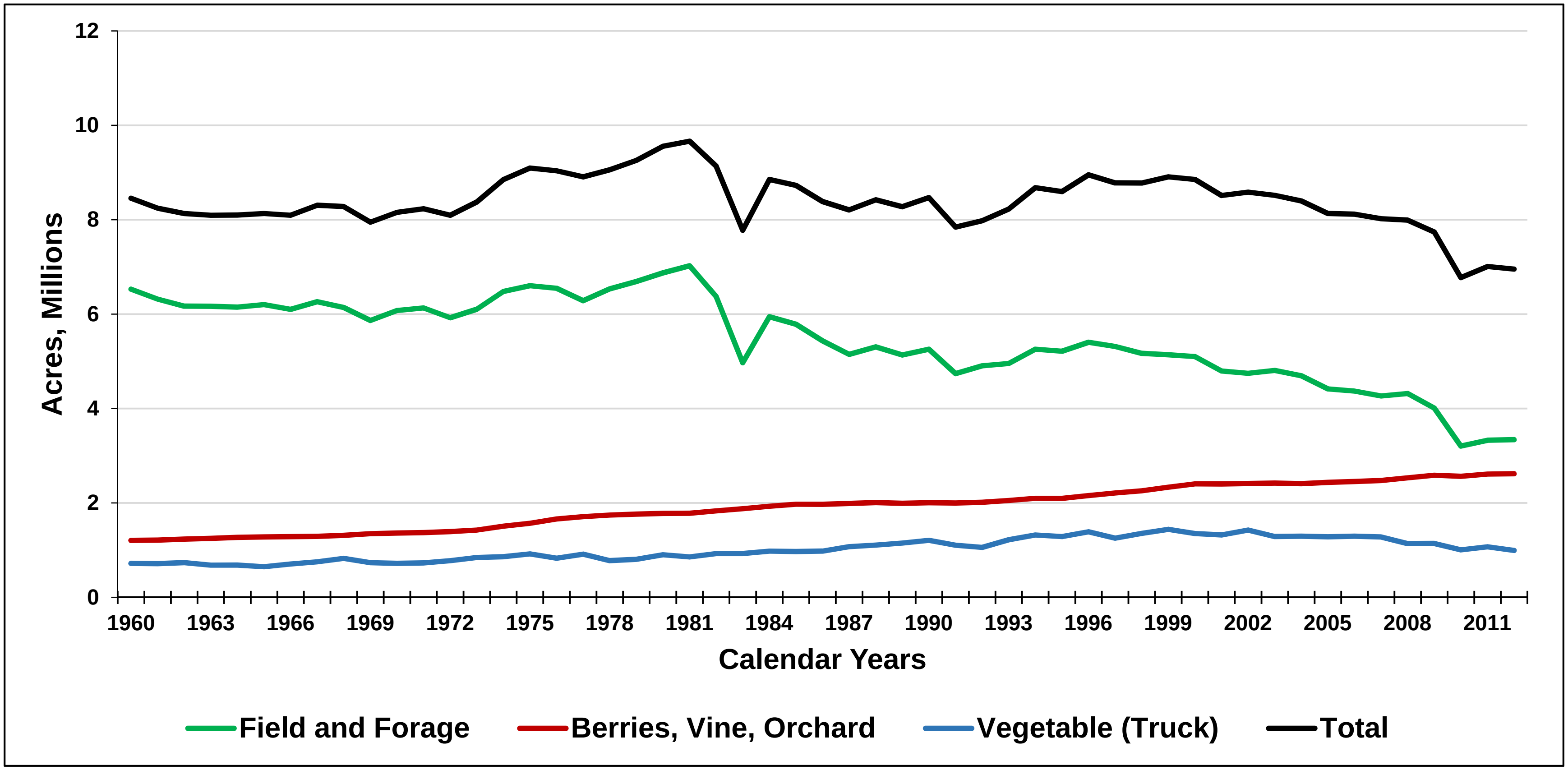



**Figure 12.1 California Agricultural Production Acreage, 1960 to 2012**

Source: USDA-NASS 2011, 2012a, 2012b, 2013b

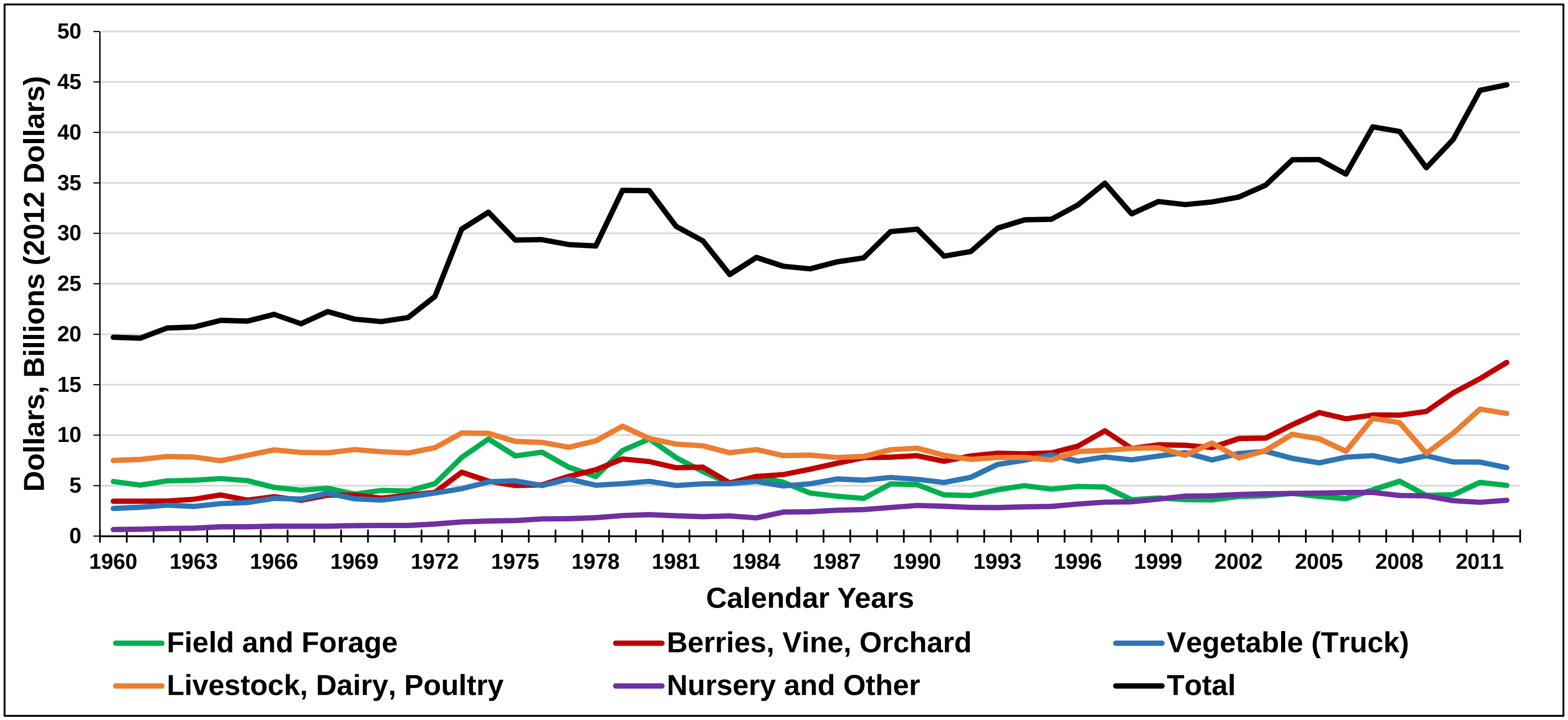



**Figure 12.2 Total Value of California Agricultural Production, 1960 to 2012**

Source: USDA 2014b; USDA-NASS 2008, 2009, 2010, 2011a, 2011b, 2012a, 2012b, 2013a, 2013b

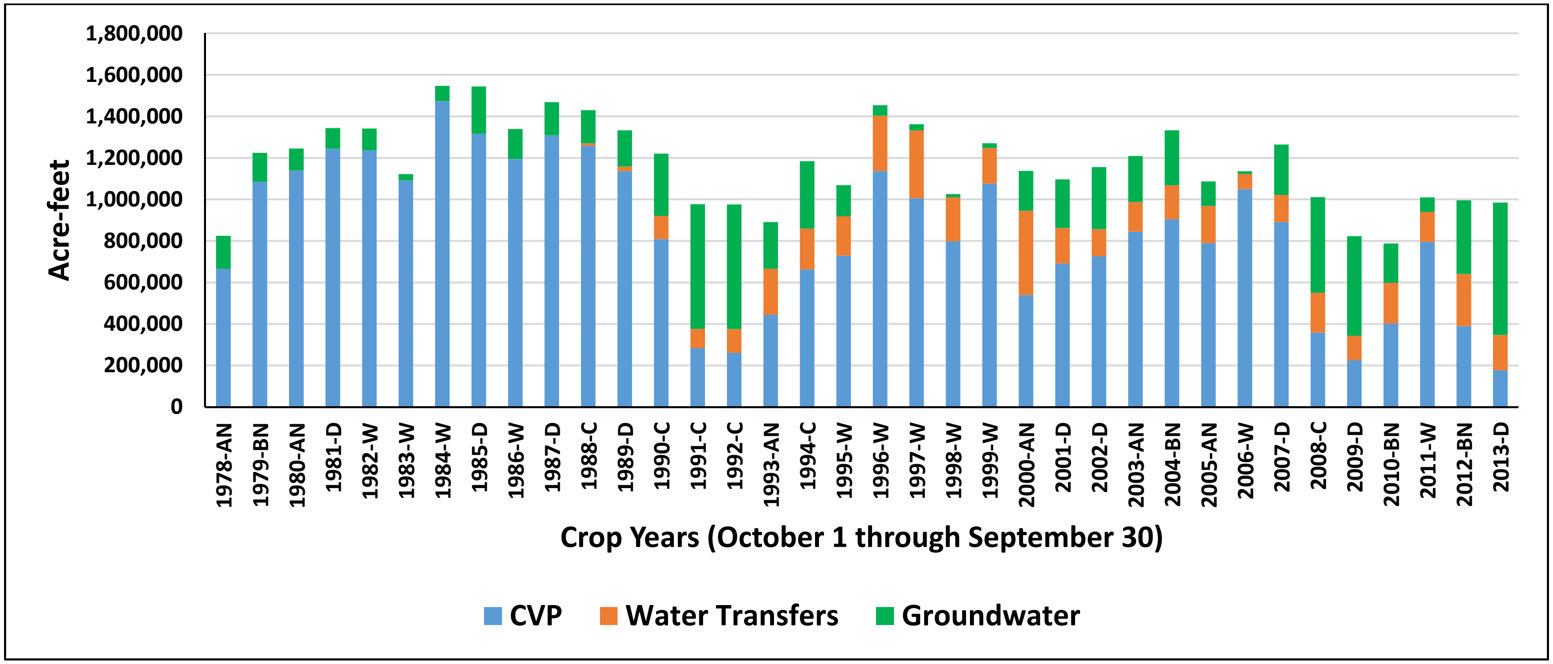



**Figure 12.3 Historical Surface Water and Groundwater Supply Sources in Westlands Water District**

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014a

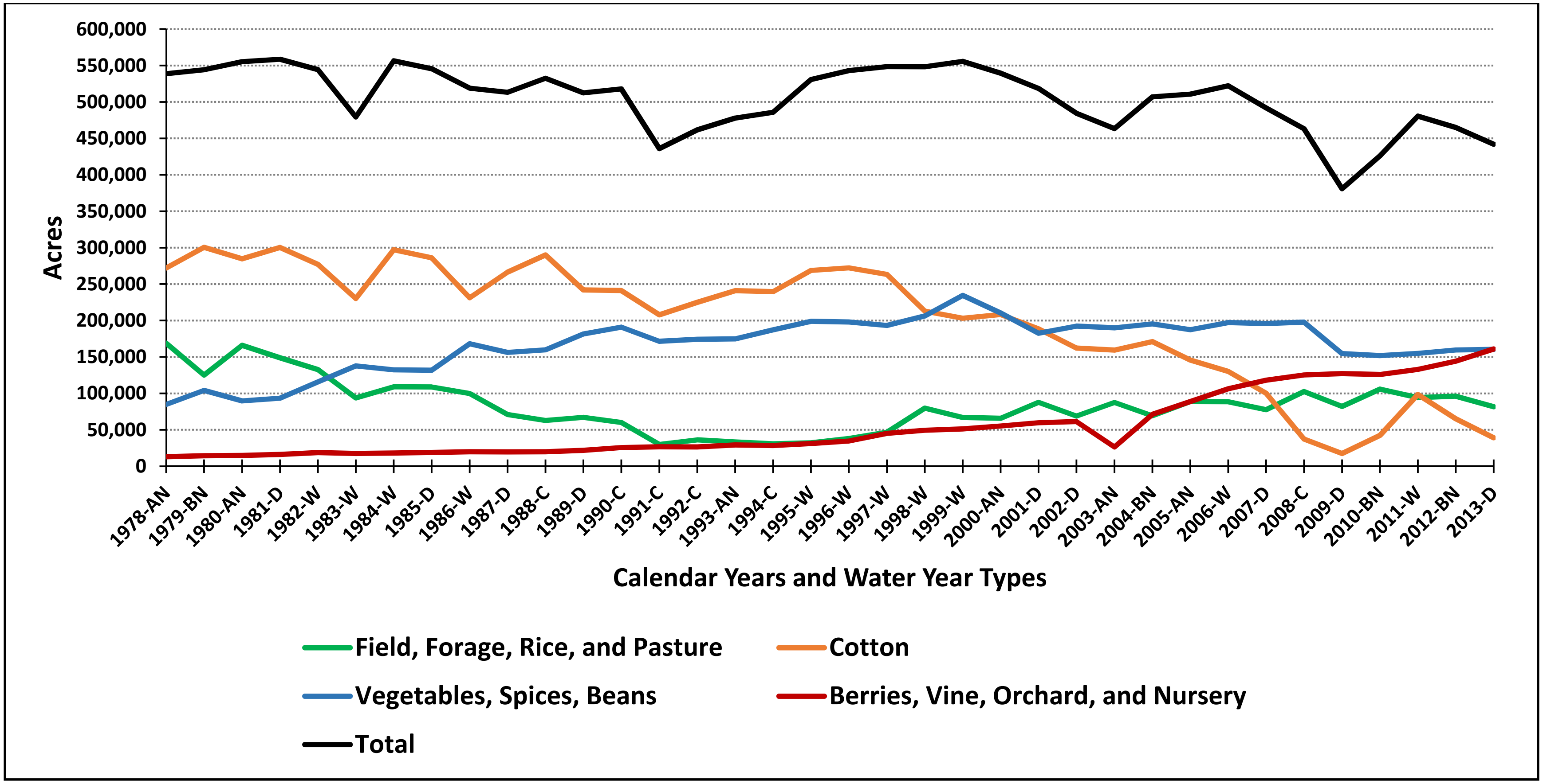



**Figure 12.4 Historical Cropping Patterns in Westlands Water District**

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014b, 2014c

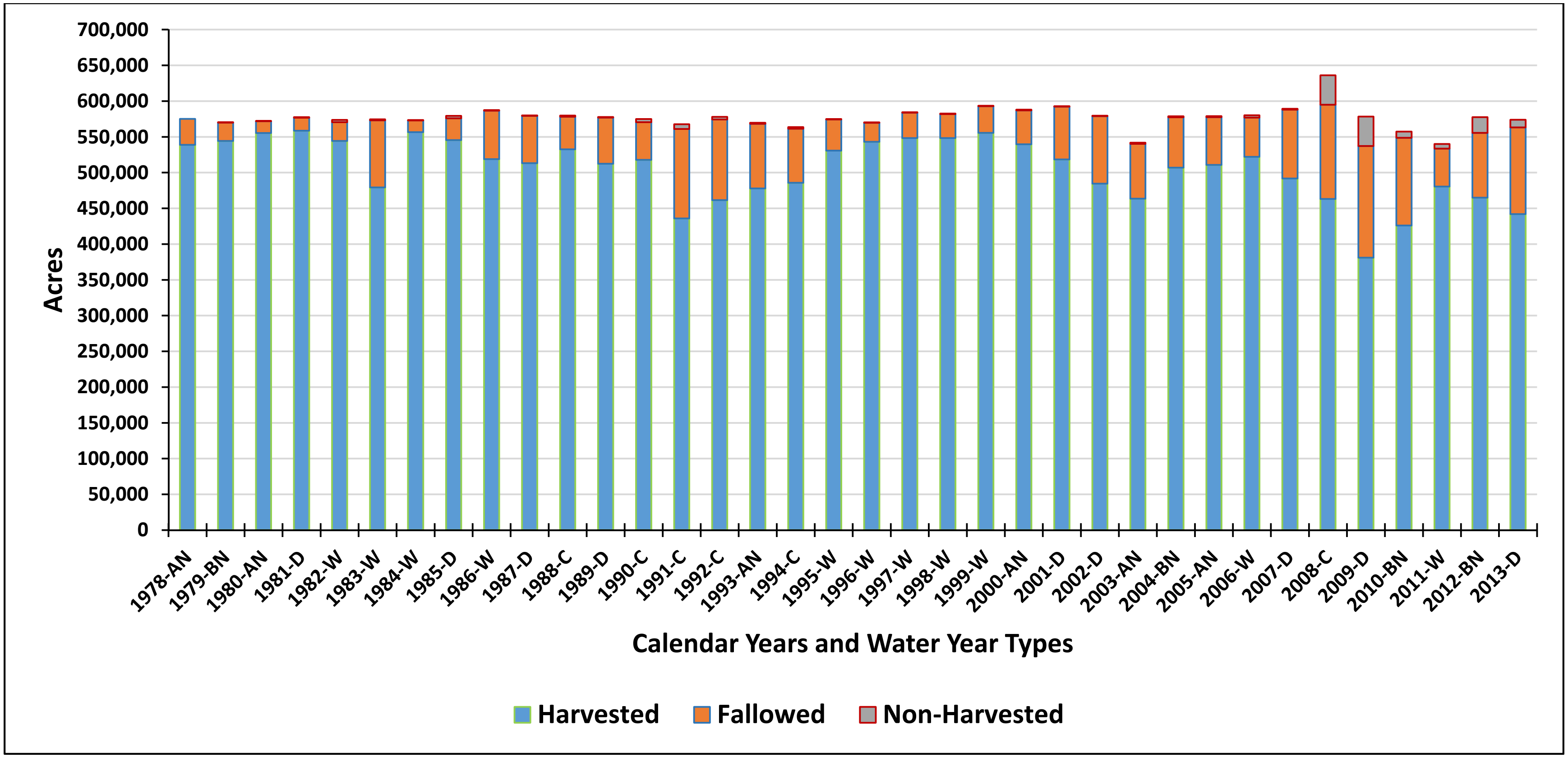



**Figure 12.5 Historical Harvested, Fallowed, and Non-Harvested Acreage in Westlands Water District**

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014b, 2014c

This page left blank intentionally.

**Chapter 13**

# Land Use

## 13.1 Introduction

This chapter describes non-agricultural land use in the study area, and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect municipal and industrial land uses through potential changes in the Central Valley Project (CVP) and State Water Project (SWP) operation.

Changes in agricultural land use and resources are described in Chapter 12, Agricultural Resources. Changes to population are described in Chapter 19, Socioeconomics.

## 13.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect land uses served by CVP and SWP water supplies. Actions done on public agency lands, or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations (summarized in Chapter 4, Approach to Environmental Analysis).

## 13.3 Affected Environment

This section describes land use conditions potentially affected by the implementation of the alternatives considered in this EIS. Changes in land uses from changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

An extensive range of land uses are within this study area. However, direct or indirect land use effects from implementing the alternatives analyzed in this EIS are related to changes in agricultural, municipal, and industrial land uses from the availability and reliability of CVP and SWP water supplies. The following description of the affected environment is presented at the county-level for agricultural and municipal and industrial land uses. More detailed agricultural land use information is presented in Chapter 12, Agricultural Resources.

### 13.3.1 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean. Tribal lands are also included for the entire Trinity River Region.

#### *13.3.1.1 Trinity County*

Trinity County encompasses approximately 3,206 square miles in northwestern California. It is bounded on the north by Siskiyou County, on the east by Shasta and Tehama Counties, on the south by Mendocino County, and on the west by Humboldt County. About 76 percent of the land area is within a national forest (Shasta-Trinity, Six Rivers, and Mendocino) and in four wilderness areas (Yolla Bolly-Middle Eel Reserve, Trinity Alps, Chanchellula, and North Fork). Another 14 percent is zoned for timber use or held in agriculture land conservation contracts (Trinity County 2012).

The headwaters of the Trinity River are in the northeastern part of the County at an elevation of 6,200 feet, in the southern Siskiyou Mountains. Trinity Lake and Lewiston Reservoir are located along the middle reach of the mainstem Trinity River. Downstream of Lewiston Dam, the river flows northwest to join the Klamath River in Humboldt County (Trinity County 2012).

Development of communities is relatively limited in Trinity County because much of the land is within national forests and tribal lands or is characterized by steep slopes. The largest communities in Trinity County include Lewiston, Weaverville, and Hayfork (Trinity County 2012).

Trinity County's primary industries are tourism and timber and is the sixth largest timber producer in the state, with substantial acreage in National Forest and private holdings. There is one operating mill in the County. Recreational opportunities are also important in this area, as described in Chapter 15, Recreation Resources (Trinity County 2012).

The portion of Trinity County in the Trinity River Region that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes areas in the vicinity of CVP facilities (Trinity Lake and Lewiston Reservoir) and areas along the Trinity River that use the river.

#### *13.3.1.2 Humboldt County*

Humboldt County encompasses approximately 3,570 square miles in northwestern California. It is bounded on the north by Del Norte County, on the east by Siskiyou and Trinity counties, on the south by Mendocino County, and on the west by the Pacific Ocean. About 25 percent of the land area is within the Six Rivers National Forest, Trinity Alps Wilderness Area, Redwood National and State National Park, national wildlife refuges, or other public land. About 3 percent of the land area is within state park lands. The Yurok and Hoopa tribal lands represent about 5.6 percent of the land within Humboldt County boundaries (Humboldt County 2012).

Most of the population and developed areas are located in western Humboldt County along U.S. Highway 101 (Humboldt County 2012). Incorporated cities and residential lands in unincorporated portions of Humboldt County represent less than 1 percent of the county. Development of communities is relatively limited in Humboldt County because much of the land is within national forests and tribal lands, characterized by steep slopes, or within the coastal zone where new large scale developments are minimized. Timber and agricultural lands are located on over 60 percent of unincorporated areas of Humboldt County.

Humboldt County's primary industries are lumber manufacturing, retail, and services (Humboldt County 2012). Humboldt County provides over 25 percent of the lumber in the state.

The portion of Humboldt County in the Trinity River Region evaluated in this EIS is located along the Trinity and Klamath rivers. Most of this area is located within the Hoopa Valley Indian Reservation and Yurok Indian Reservation. This portion of the county includes the communities of Willow Creek and Orleans within Humboldt County; Hoopa in the Hoopa Valley Indian Reservation; and the communities of Weitchpec, Cappell, Pecwan, and Johnson's in the Yurok Tribe Indian Reservation (Humboldt County 2012).

#### *13.3.1.3 Del Norte County*

Del Norte County encompasses 1,070 square miles in northwestern California. It is bounded on the north by the State of Oregon, on the east by Siskiyou County, on the south by Humboldt County, and on the west by the Pacific Ocean. Del Norte County includes lands within national forests (Six Rivers and Rogue River-Siskiyou), Smith River National Recreation Area, Redwood National and State Park, or other federally owned land. State lands include units of the Redwoods State Park and the Lake Earl Wildlife Area. The Yurok tribal lands are located along the lower Klamath River between the Del Norte and Humboldt county boundaries to the Pacific Ocean (Del Norte County 2003).

Del Norte County's primary industries are retail and services (Del Norte County 2003).

The portion of Del Norte County in the Trinity River Region evaluated in this EIS is located along the lower Klamath River. Most of this area is within the Yurok Indian Reservation. This portion of the County includes the communities of Requa and Klamath in the Yurok Tribe Indian Reservation (Del Norte County 2003).

#### *13.3.1.4 Tribal Lands in Trinity River Region*

The major federally recognized tribes and tribal lands in the Trinity River Region include the tribal lands of the Hoopa Valley Tribe, Yurok Tribe of the Yurok Reservation, Resighini Rancheria, and Karuk Tribe. Aquatic and wildlife resources associated with the Trinity and Klamath rivers and the surrounding lands are very important to these tribes (NCRWQCB et al. 2009; Yurok Tribe 2005; Karuk Tribe 2010).

The Hoopa Valley Indian Reservation includes 93,702.73 acres (Hoopa Valley Tribe 2008). The Trinity River flows through the Hoopa Valley Indian Reservation.

The Yurok Indian Reservation includes about 55,890 acres within Tribal trust, Tribal fee, allotment, Tribal member fee, nonmember fee, Federal, state, and county lands (Yurok Tribe 2012). The Tribe employs over 250 in the government agency, as well as seasonal workers for fisheries, forestry, fire prevention, and other programs.

The Resighini Rancheria includes about 435 acres of land along the south bank of the lower Klamath River and extends from an inland area to the U.S. Highway 101 bridge along the western boundary of the Rancheria (Reclamation 2010). The Rancheria is surrounded by the Yurok Indian Reservation (Reclamation 2010; Resighini Rancheria 2014). The community includes tribal offices, a casino, campground, residences, agricultural lands, and open space.

The Karuk Ancestral Territory is located to the north of the Trinity River in the vicinity of Trinity County and east of the Trinity River in the vicinity of Humboldt County (Karuk Tribe 2010). The western boundary of the Karuk Ancestral Territory is relatively concurrent with the western boundary of the Six Rivers National Forest. Therefore, changes in the Trinity River flow or water quality that could be affected by changes in CVP and/or SWP operations considered in the alternatives in this EIS would not occur within the Karuk Ancestral Territory.

## 13.3.2 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

### *13.3.2.1 Sacramento Valley*

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, and Sacramento counties. Yolo and Solano counties are also located within the Sacramento Valley; however, these counties are discussed as part of the Delta and Suisun Marsh subsection because potential changes in land use because of changes in CVP and SWP long-term operations would primarily occur within the Delta and Suisun marsh geography. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties. Tribal lands are also described for the entire Sacramento Valley.

#### 13.3.2.1.1 Shasta County

Shasta County encompasses approximately 3,793 square miles in northern California. It is bounded on the north by Siskiyou County, on the east by Lassen County, on the south by Tehama County, and on the west by Trinity County. Shasta County includes lands within national forests (Shasta-Trinity, Whiskeytown-Shasta-Trinity, and Lassen), Lassen Volcanic National Park, or other federally owned land. State lands include state forest and state parks (Shasta County 2004).

The Shasta County General Plan identifies four major categories of land use: urban, rural, agricultural, and timber (Shasta County 2004). Of Shasta County's 2,416,440 acres, 613,495 acres (25 percent) are designated as timber preserve zones pursuant to California's Forest Taxation Reform Act of 1976 (Shasta County 2004). Approximately 169,127 acres (7 percent), are designated as agricultural preserve lands.

Approximately 1.2 percent of the lands in the County are within incorporated areas (Shasta County 2004). Urban development is concentrated in the southern central portion of the county in the cities of Redding, Anderson, and Shasta Lake (Reclamation 2005a).

The portion of the Central Valley Region, Sacramento Valley in Shasta County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (Shasta Lake, Keswick Reservoir, and Whiskeytown Lake), areas along the Sacramento River and Clear Creek that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.2 Plumas County

Plumas County encompasses approximately 2,610 square miles in northern California. It is bounded on the north by Shasta County, on the east by Lassen County, on the west by Tehama and Butte counties, and on the south by Sierra County. Plumas County includes lands within national forests (Plumas, Lassen, Toiyabe, and Tahoe), Lassen Volcanic National Park, or other federally owned land. State lands include Plumas-Eureka State Park (Plumas County 2012).

Prominent landscape features in Plumas County are the Sierra Valley, the Lake Almanor Basin, and the Upper Feather River watershed which includes three SWP lakes (Antelope Lake, Lake Davis, and Frenchman Lake). The largest land uses in the county are agricultural and timber resource lands. Rural and semi-rural development is scattered throughout the County, with most growth concentrated in several designated planning areas. The county’s only incorporated area is the City of Portola.

The most recent Plumas County General Plan was adopted in 1984. The county is in the process of updating its General Plan through 2030 (Plumas County 2012). Approximately 76 percent of the land in Plumas County is National Forest land owned and managed by the U.S. Forest Service. The U.S. Forest Service prepared the Plumas National Forest Land and Resource Management Plan in 1988, to guide management and land use planning decisions in the forest. The National Forest Land and Resource Management Plan provides a designation for areas based on established priorities for various resources, including wilderness, recreation, wildlife, timber, and visual resources (Plumas County 2012).

The portion of the Central Valley Region, Sacramento Valley in Plumas County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS is located at the SWP Antelope Lake, Lake Davis, and Frenchman Lake and along the Feather River downstream of Frenchman Lake.

#### 13.3.2.1.3 Tehama County

Tehama County encompasses approximately 2,951 square miles in northern California. It is bounded on the north by Shasta County, on the east by Plumas County, on the west by Trinity and Mendocino counties, and on the south by Glenn and Butte counties. Tehama County includes lands within national forests (Lassen, Mendocino, and Shasta-Trinity), Lassen Volcanic National Park, or other federally owned land (Tehama County 2008).

Tehama County is predominantly rural, with populations primarily concentrated in the incorporated cities of Corning, Red Bluff, and Tehama or along the major transportation corridors. The incorporated areas include less than 1 percent of the total land area in the county. The primary incorporated and unincorporated developed areas in the county are adjacent to major transportation centers, with most adjacent to Interstate 5 and State Route 99. Clustered commercial land uses are located primarily along the major state and county roadways, most of which are near Red Bluff, Corning, and the unincorporated community of Los Molinos. Residential land uses in the developed portions of the county tend to be located behind or beyond the commercial and service uses adjacent to the major street network (Tehama County 2008).

Ranches, timber company holdings, and government land dominate the county. Much of the land use is resource-based, such as cropland, rangeland, pasture land, and timber land (Tehama County 2008). The majority of land within the CVP water service area in Tehama County is designated for agricultural use (Tehama County 2008; Reclamation 2005b).

The portion of the Central Valley Region, Sacramento Valley in Tehama County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.4 Glenn County

Glenn County encompasses 1,317 square miles in northern California. It is bounded on the north by Tehama County, on the east by Butte County, on the west by Lake and Mendocino counties, and on the south by Colusa County. Glenn County includes lands within the Mendocino National Forest, Sacramento National Wildlife Refuge, and other federally owned land (Glenn County 1993).

Approximately two-thirds (583,974 acres) are croplands and pasture. The two incorporated towns in the county are Willows, the County seat, and Orland (Reclamation 2004). Intensive agriculture provides a major segment of the county’s economic base (Glenn County 1993; Reclamation 2005b).The portion of the Central Valley Region, Sacramento Valley in Glenn County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), and CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.5 Colusa County

Colusa County encompasses approximately 1,132 square miles in northern California. It is bounded on the north by Glenn County, on the east by Butte and Sutter counties, on the west by Lake County, and on the south by Yolo County. Colusa County includes lands within the Mendocino National Forest, Sacramento National Wildlife Refuge complex (Colusa, Delevan, and Sacramento national wildlife refuges); East Park Reservoir; and other federally owned land (Colusa County 2011). State lands in Colusa County include Willow Creek-Lurline, North Central Valley, Colusa Bypass, and Sacramento River wildlife management areas.

Existing land uses in Colusa County are predominantly agricultural. Approximately 76 percent of the county's total land area is cropland or undeveloped rangeland. Twelve percent is national forest and national wildlife refuge land. Less than 1 percent is covered by urban and rural communities. Colusa and Williams are the only incorporated cities in the county and they encompass about 2,574 acres (Colusa County 2011). Arbuckle is the largest unincorporated town of the unincorporated communities, which includes Arbuckle, College City, Century Ranch, Grimes, Maxwell, Princeton, and Stonyford. Together, these established incorporated and unincorporated towns cover a total area in "urban" uses of about 5,451 acres (Colusa County 2011). The majority of land within the CVP water service area in Colusa County is designated for agricultural use (Colusa County 2011; Reclamation 2005b).

The portion of the Central Valley Region, Sacramento Valley in Colusa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources) and CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.6 Butte County

Butte County encompasses 1,680 square miles in northern California. It is bounded on the north by Tehama County, on the east by Plumas County, on the west by Glenn and Colusa counties, and on the south by Sutter and Yuba counties. Butte County includes lands within national forests (Plumas and Lassen), Sacramento National Wildlife Refuge (Butte County 2010). State lands in Butte County include Big Chico Creek and Butte Creek ecological preserves; Table Mountain Reserve; Gray Lodge, Sacramento River, and Oroville wildlife areas; SWP facilities at Lake Oroville and Thermalito Reservoir; and more than 750 miles of rivers and streams.

The county comprises three general topographical areas: valley region, foothills east of the valley, and mountain region east of the foothills. Each of these regions contains distinct environments with unique wildlife and natural resources.

The U.S. Forest Service manages 135,427 acres (12 percent) within Butte County, including portions of the Plumas and Lassen National Forests. The Bureau of Land Management owns and manages 16,832 acres (1.5 percent) in the county

(Butte County 2010). Agriculture is the dominant land use within unincorporated Butte County, accounting for approximately 599,040 acres (60 percent of the county area) (Butte County 2010).

Butte County contains five incorporated municipalities: Biggs, Chico, Gridley, Oroville, and Paradise. Each has a general plan that guides development within its limits and larger planning area (Butte County 2010).

The portion of the Central Valley Region, Sacramento Valley, in Butte County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), SWP facilities (Lake Oroville and Thermalito Afterbay), CVP facilities, areas along the Feather River that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

#### 13.3.2.1.7 Sutter County

Sutter County encompasses approximately 607 square miles in northern California. It is bounded on the north by Butte County, on the east by Yuba and Placer counties, on the west by Colusa and Yolo counties, and on the south by Sacramento County. Sutter County includes lands within the Sutter National Wildlife Refuge. State lands in Sutter County include Butte Slough, Feather River, Gray Lodge, Sutter Bypass, and Butte Sink wildlife management areas; and Sutter Buttes State Park (Sutter County 2010).

Sutter County's General Plan was updated in 2011. Approximately 98 percent of the land in the County is unincorporated, and approximately 98 percent of the unincorporated land is zoned for agricultural use (Reclamation 2004). The two incorporated cities within the county, Yuba City and Live Oak, encompass approximately 10,600 acres.

Existing land use in Sutter County is rural and dominated by agricultural areas. The county has significant natural and recreational resources, and a relatively low population density. Existing land uses in Yuba City and Live Oak contain the bulk of the county's urban land uses, such as residences, commercial and industrial uses, parks, and public facilities (Sutter County 2010). The county includes several incorporated rural communities: Meridian, Sutter, Robbins, Rio Oso, Trowbridge, Nicolaus, East Nicolaus, and Pleasant Grove (Sutter County 2010).

The portion of the Central Valley Region, Sacramento Valley in Sutter County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

#### 13.3.2.1.8 Yuba County

Yuba County encompasses approximately 634 acres in northern California. It is bounded on the north by Butte County, on the east by Sierra and Nevada counties, on the west by Sutter County, and on the south by Placer County. Federally owned lands in Yuba County include Tahoe and Plumas National Forests, and the 22,944-acre Beale Air Force Base (Yuba County 2011). The Department of Fish and Wildlife administers the state Spenceville Wildlife Area.

Yuba County is predominantly rural. Over 189,500 acres (46 percent of the county), are designated for agricultural land uses. Most of the population lives in the two incorporated cities in the county (Marysville and Wheatland); and the major unincorporated communities including Brown's Valley, Brownsville, Camptonville, Dobbins, Linda/Olivehurst, Log Cabin, Loma Rica, Oregon House, Rackerby, and River Highlands (Yuba County 2011).

The portion of the Central Valley Region, Sacramento Valley in Yuba County that could be affected by changes evaluated in this EIS includes areas within Yuba County Water Agency facilities that provide water for environmental and water supply purposes within the Central Valley.

#### 13.3.2.1.9 Nevada County

Nevada County encompasses approximately 634,880 acres in northern California. It is bounded on the north by Sierra County, on the northwest by Yuba County, on and on the south by Placer County. Federally owned lands in Nevada County include 169,686 acres in the Tahoe National Forest; 2,574 acres in the Toiyabe National Forest; and approximately 11,000 acres administered by the Bureau of Land Management (Nevada County 1995). The State Lands Commission manages approximately 4,600 acres; State Parks administers 6,300 acres at several locations, including Malakoff Diggins State Historical Park and Empire Mine State Park; and the Department of Fish and Wildlife administers approximately 11,000 acres at the Spenceville Wildlife Management and Recreation Area.

Nevada County is predominantly rural (Nevada County 2012). Approximately 91 percent of the county is used for agriculture, timber, or open space. Most of the population lives in the three incorporated cities in the county (Grass Valley, Nevada City, and Truckee).

#### 13.3.2.1.10 Placer County

Placer County encompasses approximately 1,506 square miles in northern California. It is bounded on the north by Nevada County, on the east by the California-Nevada boundary, on the west by Yuba and Sutter counties, and on the south by Sacramento and El Dorado counties. Placer County includes lands within the El Dorado and Tahoe National Forests and other federally owned land (Placer County 2011).

Placer County is predominantly rural. Most of the population lives in the area along Interstate 80 from the City of Auburn to the Sutter and Sacramento county boundaries. Incorporated cities and towns include Roseville, Rocklin, Lincoln, Colfax, Loomis, and Auburn (Placer County 2011; Reclamation 2005c; SACOG 2007). Residential land uses range from rural residential areas to medium and high-density dwelling units in urbanized areas. Commercial land uses are primarily located in the urbanized portions of the county; although a large concentration of commercial development occurs outside existing urban areas along Interstate 80. Non-urban land uses include agriculture, resource extraction (timber and mining), and public lands and open space uses. The largest amount of public lands within Placer County is located in the eastern half of the county, and is under the jurisdiction of the Bureau of Land Management, U.S. Forest Service, or the Bureau of Reclamation. The CVP water service area within Placer County primarily includes the communities and agricultural areas in the western portion of the county. The portion of the Central Valley Region, Sacramento Valley in Placer County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Folsom Lake), areas along the American River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.11 El Dorado County

El Dorado County encompasses approximately 1,790 square miles in northern California along the American River. It is bounded on the north by Placer County, on the east by California-Nevada boundaries, on the west by Sacramento County, and on the south by Amador and Alpine counties. El Dorado County includes about 521,210 acres (45.5 percent of the total county), under Federal ownership or trust, including lands within the El Dorado and Tahoe national forests. About 9,751 acres (8.5 percent of the county), is under the State jurisdiction (El Dorado County 2003).

The county includes two specific regions: the Lake Tahoe Basin and the western slopes of the Sierra Nevada (El Dorado County 2003). The CVP water service area provides water to a large portion of the communities and some agricultural areas along the western slope. El Dorado County includes two incorporated cities, Placerville and South Lake Tahoe, which cover 621 acres of land. Other major communities include El Dorado Hills, Cameron Park, Shingle Springs, Rescue, Diamond Springs, Camino, Coloma and Gold Hill, Cool and Pilot Hill, Georgetown and Garden Valley, Pollock Pines, Pleasant Valley, Latrobe, Somerset, and Mosquito. The rural land uses in the county include over 259,000 acres of private production forests, 153,472 acres of agricultural lands, and 35,282 acres within the waters of Folsom Lake and Lake Tahoe. The county's two largest crops are wine grapes and apples.

The portion of the Central Valley Region, Sacramento Valley in El Dorado County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Folsom Lake), areas along the American River that use the surface waters, and CVP water service areas.

#### 13.3.2.1.12 Sacramento County

Sacramento County encompasses approximately 1,769 square miles in northern California. It is bounded on the north by Sutter and Placer counties, on the east by El Dorado and Amador counties, on the south by Contra Costa and San Joaquin counties, and on the west by Yolo and Solano counties. Sacramento County includes federally owned lands within Folsom Lake and Lake Natoma.

Residential areas in Sacramento County primarily occur in northern and central Sacramento County. Sacramento County includes areas within the Delta, including the southwestern portion of the City of Sacramento, City of Isleton and the communities of Locke, Ryde, Courtland, Freeport, Hood, and Walnut Grove; and areas located to the east of the Delta (Sacramento County 2011). Sacramento County has seven incorporated cities located in about 56 percent of the county: Sacramento, Elk Grove, Citrus Heights, Folsom, Galt, Isleton, and Rancho Cordova. The County includes several unincorporated communities including Antelope, Arden-Arcade, Carmichael, Cordova, Elverta, Foothill Farms, Fair Oaks, Herold, Natomas, North Highlands, Orangevale, Rancho Murieta, Rio Linda, Sloughhouse, and Wilton.

The leading agricultural crops in Sacramento County include dairy, wine grapes, Bartlett pears, field corn, and turkeys (Sacramento County 2010). Agricultural acreage has declined as urban development has continued. Between 1989 and 2004, the portion of the county designated as agriculture declined from 40 percent to 34 percent. The southeastern portion of the county remains primarily rural with smaller communities, such as Herald (Sacramento County 2011).

The portion of the Central Valley Region, Delta, in Sacramento County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (Folsom Lake and Lake Natoma), areas along the American and Sacramento rivers and Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.1.13 Tribal Lands in Sacramento Valley

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries.

*Tribal Lands within the Boundaries of Shasta County*

Major federally recognized tribes and tribal lands within the boundaries of Shasta County include the Pit River Tribe and the Redding Rancheria, which is a federal reservation of Wintun, Pit River, and Yana Indians near Redding (SDSU 2013).

*Tribal Lands within the Boundaries of Tehama County*

There are approximately 2,000 acres within the total acreage of Tehama County within tribal trust, including land near Corning owned by the Paskenta Band of Nomlaki Indians of California (Paskenta 2014).

*Tribal Lands within the Boundaries of Glenn County*

Major federally recognized tribes and tribal lands within the boundaries of Glenn County include the Grindstone Indian Reservation near Elk Creek at the Grindstone Indian Rancheria of Wintun-Wailaki Indians of California, and lands of the Paskenta Band of Nomlaki Indians of California.

*Tribal Lands within the Boundaries of Colusa County*

Major federally recognized tribes and tribal lands within the boundaries of Colusa County include the Cachil Dehe Band of Wintun Indians of the Colusa Indian

Community of the Colusa Rancheria, and the Cortina Indian Rancheria of Wintun Indians of California (Colusa County 2011).

*Tribal Lands within the Boundaries of Butte County*

Major federally recognized tribes and tribal lands within the boundaries of Butte County include the Tyme Maidu of Berry-Creek Rancheria on approximately 90 acres, and the Concow Maidu of Mooretown Rancheria on approximately 300 acres (Butte County 2010).

*Tribal Lands within the Boundaries of Nevada County*

Major federally recognized tribes and tribal lands within the boundaries of Nevada County include tribal trust lands of the Shingle Springs Band of Miwok Indians.

*Tribal Lands within the Boundaries of Placer County*

Major federally recognized tribes and tribal lands within the boundaries of Placer County include tribal trust lands of the United Auburn Indian Community of the Auburn Rancheria of California.

*Tribal Lands within the Boundaries of El Dorado County*

Major federally recognized tribes and tribal lands within the boundaries of El Dorado County include the Shingle Springs Band of Miwok Indians.

*Tribal Lands within the Boundaries of Sacramento County*

Major federally recognized tribes and tribal lands within the boundaries of Sacramento County include lands of the Wilton Miwok Indians of the Wilton Rancheria near Elk Grove (SACOG 2007).

#### *13.3.2.2 San Joaquin Valley*

The San Joaquin Valley includes Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here. They include Calaveras, Mariposa, and Tuolumne counties. Tribal lands are also described for the entire San Joaquin Valley.

##### 13.3.2.2.1 Stanislaus County

Stanislaus County encompasses approximately 1,521 square miles in central California. It is bounded on the north by San Joaquin County, on the east by Calaveras and Tuolumne counties, on the west by Santa Clara County, and on the south by Merced County. Stanislaus County includes lands within the San Joaquin River National Wildlife Refuge (Stanislaus Council of Governments 2007).

Land use in the county is primarily agricultural, with nearly 80 percent of the land zoned for general agriculture or in agricultural production (Stanislaus Council of Governments 2007). Over the past 40 years, some portions of the county have been changing from a rural agricultural region to semi-urbanized, especially along major highways and freeways. There are nine incorporated cities in the county, including Ceres, Hughson, Modesto, Newman, Oakdale, Patterson, Riverbank, Turlock, and Waterford. Stanislaus County has adopted community plans for most of its unincorporated towns, including Crows Landing, Del Rio, Denair, Hickman, Keyes, Knights Ferry, La Grange, Westley, and Salida (Stanislaus County 2010, 2012).

The portion of the Central Valley Region, San Joaquin Valley, in Stanislaus County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP water facilities (New Melones Reservoir, Delta-Mendota Canal, and San Luis Canal/California Aqueduct), areas along the Stanislaus and San Joaquin rivers that use the surface waters (including agricultural lands), and CVP water service areas.

**13.3.2.2.2 Merced County**

Merced County encompasses approximately 1,977 square miles in central California. It is bounded on the north by Stanislaus County, on the east by Mariposa County, on the south by Fresno and Madera counties, and on the west by Santa Clara and San Benito counties. Merced County includes federally owned lands within the San Luis National Wildlife Refuge (Merced County 2013). State lands within the county include San Luis Reservoir State Recreation Area; Great Valley Grasslands State Park; and the Los Banos, North Grasslands, and Volta wildlife areas.

Merced County includes the six incorporated cities of Atwater, Dos Palos, Gustine, Livingston, Los Banos, and Merced. The major unincorporated communities include Delhi, Fox Hills, Franklin, Hilmar, LeGrand, Planada, Santa Nella, Laguna San Luis, and Winton (Merced County 2013). Unincorporated land within the county includes approximately 1.2 million acres (98.1 percent of the land in the county). Agriculture is the primary land use, totaling just over 1 million acres (81.2 percent). Public and quasi-public land is the next largest use with 131,582 acres or 10.6 percent of the unincorporated County. Commercial land uses represent 3,025 acres (0.2 percent), industrial uses represent 2,488 acres (0.2 percent), and mining represents 3,375 acres (0.3 percent). Incorporated cities account for 24,138 acres (1.9 percent) (Merced County 2012a, 2013). The Merced County Local Agency Formation Commission policies discourage annexation of prime agricultural land when significant areas of non-prime agricultural land are already available. The policies also encourage development of vacant areas in cities before the annexation and development of outlying areas. Local Agency Formation Commission policies encourage city annexations that reflect a planned, logical, and orderly progression of urban expansion and promote efficient delivery of urban services (Merced County 2012b).

The portion of the Central Valley Region, San Joaquin Valley in Merced County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP and SWP water facilities (San Luis Reservoir, Delta-Mendota Canal, and San Luis Canal/California Aqueduct), areas along the San Joaquin

River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.2.3 Madera County

Madera County encompasses approximately 2,147 square miles in central California. It is bounded on the north by Merced and Mariposa counties, on the east by Mono County, and on the south and west by Fresno County. Madera County includes lands within the Sierra and Inyo national forests (Madera County 1995). State lands within the county include the Millerton Lake State Recreation Area.

Land elevations in Madera County range from 180 feet to over 13,000 feet above mean sea level. Madera County can be divided generally into three regions – the San Joaquin Valley in the west, the foothills between the Madera Canal and the 3,500-foot elevation contour, and the mountains from the 3,500-foot contour to the crest of the Sierra Nevada. The County has two incorporated cities, Madera and Chowchilla (Madera County 1995). Major unincorporated communities in the county include North Fork, South Fork, O'Neals, Oakhurst, Coarsegold, Gunner Ranch, and Rio Mesa.

The portion of the Central Valley Region, San Joaquin Valley, in Madera County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Millerton Lake and the Madera Canal), areas along the San Joaquin River that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.2.4 San Joaquin County

San Joaquin County encompasses approximately 1,426 square miles in central California. It is bounded on the north by Sacramento County, on the east by Calaveras and Amador counties, on the south by Stanislaus County, and on the west by Contra Costa and Alameda counties. San Joaquin County includes about 6,000 acres of federally owned lands (San Joaquin County 2009).

San Joaquin County is currently in the process of updating its General Plan. Most of the county's land is in agricultural production. Agriculture, the predominant land use, covers 686,109 acres (75 percent) of the county. Residential land is the second largest use in the unincorporated lands, encompassing 40,410 acres (4.4 percent of the county). Residential development in the county is concentrated in existing cities and in adjacent unincorporated communities. San Joaquin County has seven incorporated cities: Stockton, Tracy, Manteca, Escalon, Ripon, Lodi, and Lathrop. Stockton and Tracy are the largest cities in the county. The major unincorporated areas in the county include French Camp, Linden, Lockeford, Morada, Mountain House, New Jerusalem, Thornton, and Woodbridge (San Joaquin County 2009). The incorporated cities account for 90,191 acres (approximately 10 percent of the county).

The portion of the Central Valley Region, Delta in San Joaquin County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including facilities associated with Rock

Slough Pumping Plant, Jones Pumping Plant, Clifton Court, and Banks Pumping Plant), areas along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.2.5 Fresno County

Fresno County encompasses approximately 6,000 square miles in central California. It is bounded on the north by Merced and Madera counties, on the east by Mono and Inyo counties, on the south by Kings and Tulare counties, and on the west by San Benito and Monterey counties. Fresno County includes lands within Millerton Lake, Pine Flat Lake, the Sierra and Sequoia national forests, Sequoia National Monument, and Kings Canyon National Park (Fresno County 2000). State lands within the county include the Millerton Lake State Recreation Area, San Joaquin River Parkway, and Mendota Wildlife Area.

Fresno County is California's sixth-largest county. Agricultural land uses cover over 48 percent of the county, and resource conservation lands (e.g., forests, parks, and timber preserves) cover approximately 45 percent of the county. The 15 incorporated cities and unincorporated communities cover approximately 5 percent of the county (Fresno County 2000). Development constraints within the county are primarily caused by lack of funding for infrastructure improvement, availability of water supplies, air quality regulations, and physical limitations, especially in the mountains and eastern foothills. The incorporated communities include Clovis, Coalinga, Firebaugh, Fowler, Fresno, Huron, Kerman, Kingsburg, Mendota, Orange Cove, Parlier-West Parlier, Reedley, Sanger, San Joaquin, and Selma (Fresno County 2000). Major unincorporated communities include Biola, Caruthers, Del Rey, Friant, Lanare, Laton, Riverdale, Shaver Lake, and Tranquility.

The portion of the Central Valley Region, San Joaquin Valley in Fresno County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Millerton Lake and the Friant-Kern Canal), areas along the San Joaquin River that use the surface waters, and CVP water service areas (including agricultural lands), and CVP water service areas.

#### 13.3.2.2.6 Kings County

Kings County encompasses approximately 1,280 square miles in south central California. It is bounded on the north by Fresno County, on the east by Tulare County, on the south by Kern County, and on the west by Monterey County. Kings County includes lands within Naval Air Station Lemoore (Kings County 2009).

Land use is predominantly agricultural, with more than 90 percent of the county designated for agricultural uses. Incorporated cities in Kings County include Avenal, Corcoran, Hanford, and Lemoore. Residential land uses in unincorporated areas and special districts cover less than 1 percent of the county's total acreage including for the communities of Armona, Home Garden, Kettleman City, and Stratford (Kings County 2009).

The portion of the Central Valley Region, San Joaquin Valley, in Kings County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP water service areas.

#### 13.3.2.2.7 Tulare County

Tulare County encompasses approximately 4,840 square miles in south central California. It is bounded on the north by Fresno County, on the east by Inyo County, on the south by Kern County, and on the west by Kings County. Tulare County includes federally owned lands within the Sequoia National Forest, Sequoia and Kings Canyon National Parks, Sequoia National Monument, several wilderness areas, Lake Kaweah, Lake Success, and Pixley National Wildlife Refuge (Tulare County 2010).

Agricultural land uses cover more than 2,150 square miles (approximately 44 percent) of the county. Lands classified as open space (i.e., national forests, monuments, and parks; wilderness areas; and County parks) make up 25 percent of the land use in the county. Less than 3 percent of the county lands are in the incorporated cities of Dinuba, Exeter, Farmersville, Lindsay, Porterville, Tulare, Visalia, and Woodlake (Tulare County 2010). Less than 2 percent of the county is designated for unincorporated residential areas, including the major communities of Alpaugh, Cutler, Ducor, Earlimart, East Oros, Goshen, Ivanhoe, Lemoncove, London, Oros, Pixley, Plainview, Poplar-Cotton Center, Richgrove, Springville, Strathmore, Terra Bella, Three Rivers, Tipton, Traver, and Woodville.

The portion of the Central Valley Region, San Joaquin Valley, in Tulare County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water service areas.

#### 13.3.2.2.8 Kern County

Kern County encompasses approximately 8,202 square miles in south central California. It is bounded on the north by Kings, Tulare, and Inyo counties; on the east by San Bernardino County, on the south by Ventura and Los Angeles counties; and on the west by San Luis Obispo County. Kern County includes lands within the Sequoia National Forest, Kern and Bitter Creek national wildlife refuges, Lake Isabella, China Lake Naval Air Weapons Station, and Edwards Air Force Base (Kern County 2004). State lands within the county include the Tule Elk State Reserve.

The county's geography includes mountainous regions, agricultural lands, and deserts. There are 11 incorporated cities in the county, including Arvin, Bakersfield, California City, Delano, Maricopa, McFarland, Ridgecrest, Shafter, Taft, Tehachapi, and Wasco (Kern County 2009). The major unincorporated communities include Kernville, Lake Isabella, Inyokern, Mojave, Boron, Rosamond, Golden Hills, Stallion Springs, and Buttonwillow. Agricultural land uses are designated for approximately 85 percent of the unincorporated lands that are under the jurisdiction of the county (not including lands under the jurisdiction of the Federal, state, tribes, or incorporated cities). Less than 6 percent of the unincorporated lands under county jurisdiction are designated for residential uses.

The portion of the Central Valley Region, San Joaquin Valley, in Kern County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP water service areas.

##### 13.3.2.2.9 Tribal Lands in San Joaquin Valley

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

*Tribal Lands within the Boundaries of Madera County*

Major federally recognized tribes and tribal lands within the boundaries of Madera County include the Picayune Rancheria of the Chuckchansi Indians of California near the community of Coarsegold and the Northfork Rancheria of the Mono Indians of California near Northfork (SDSU 2013).

*Tribal Lands within the Boundaries of Fresno County*

Major federally recognized tribes and tribal lands within the boundaries of Fresno County include the lands of the Big Sandy Rancheria of the Western Mono Indians of California and Table Mountain Rancheria of California.

*Tribal Lands within the Boundaries of Kings County*

Major federally recognized tribes and tribal lands within the boundaries of Kings County includes the lands of the Santa Rosa Indian Community of Santa Rosa Rancheria near the town of Lemoore (SDSU 2013).

*Tribal Lands within the Boundaries of Tulare County*

Major federally recognized tribes and tribal lands within the boundaries of Tulare County includes the Tule River Indian Tribe of the Tule River Reservation of the Yokut Indians about 20 miles east of Porterville and covers 55,356 acres (SDSU 2013).

#### *13.3.2.3 Delta and Suisun Marsh*

The Delta and Suisun Marsh includes Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties. Sacramento County is discussed in the Sacramento Valley subsection because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the Sacramento Valley than in the Delta and Suisun Marsh geographical areas. San Joaquin County is discussed in the San Joaquin Valley subsection because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the San Joaquin Valley than in the Delta and Suisun Marsh geographical areas. Contra Costa County is discussed as part of the San Francisco Bay Region because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the San Francisco Bay Region than in the Delta and Suisun Marsh geographical areas.

#### 13.3.2.3.1 Yolo County

Yolo County encompasses approximately 1,021 square miles in northern California. It is bounded on the north by Colusa County, on the east by Sutter and Sacramento counties, on the south by Solano County, and on the west by Lake and Napa counties. Yolo County includes federally owned lands in the Yolo Bypass and Cache Creek areas and state lands within the Yolo Bypass.

Residential areas in Yolo County primarily occur in the county's four incorporated cities (Davis, West Sacramento, Winters, and Woodland) that comprise approximately 32,325 acres (5 percent) of county lands (Yolo County 2009). Yolo County includes areas within the Delta, including the City of West Sacramento and the community of Clarksburg. The unincorporated portion of the county encompasses 35 community areas, including Capay, Clarksburg, Dunnigan, Esparto, Guinda, Knights Landing, Madison, Monument Hills, Rumsey, Yolo, and Zamora.

Yolo County adopted its 2030 General Plan in 2011. The general plan designates more than 92 percent of the County area for agricultural and open space uses. The major crops are tomatoes, alfalfa, wine grapes, rice, seed crops, almonds, organic production, walnuts, cattle, and wheat (Yolo County 2009).

The 59,000-acre Yolo Bypass is primarily located within Yolo County and includes a portion of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies (CALFED et al. 2001). The upper section of the Yolo Bypass is defined as the area between Fremont Weir and Interstate 80 and is located within Yolo County. The lower section is defined as the area between Interstate 80 and the southern boundary of Egbert Tract at the Sacramento River. The portion of the southern area located to the north of the upper Holland Tract and upper Liberty Island is within Yolo County. In the northern area, agricultural crops include rice, corn, and safflower with melons and tomatoes planted in years when the bypass is not inundated with flood waters. The southern bypass crops include corn, milo, safflower, beans, and sudan grass. Approximately 16,770 acres in the southern Yolo Bypass is within the Yolo Bypass Wildlife Area (Yolo County 2009).

The portion of the Central Valley Region, Delta in Yolo County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes areas in the Yolo Bypass and along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.2.3.2 Solano County

Solano County encompasses approximately 910 square miles in northern California. It is bounded on the north by Yolo County, on the east by Sutter and Sacramento counties, on the south by Contra Costa County, and on the west by Napa County. Solano County includes federally owned lands within Travis Air Force Base (Solano County 2008). State lands include areas within Suisun Marsh and the Cache Slough area of Yolo Bypass.

Solano County's General Plan was adopted in 2008. Approximately 81,678 acres of the county (14 percent of the total land area), lies within seven incorporated cities: Benicia, Dixon, Fairfield, Rio Vista, Suisun City, Vacaville, and Vallejo. Urban development is generally concentrated within the incorporated cities or surrounding suburban communities. Travis Air Force Base is located on approximately 7,100 acres (1 percent of the land within the county). In 2006, agriculture accounted for 56.5 percent of the total land use in Solano County (Solano County 2008). The southern section of the Yolo Bypass, as described under the Yolo County subsection, is located within Solano County.

The portion of the Central Valley Region, Delta in Solano County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (North Bay Aqueduct intakes at Barker Slough), areas in the Yolo Bypass and along the Delta channels that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

#### 13.3.2.3.3 Tribal Lands in Delta and Suisun Marsh

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

*Tribal Lands within the Boundaries of Yolo County*

Major federally recognized tribes and tribal lands within the boundaries of Yolo County include lands of the Yocha Dehe Wintun Nation (previously called the Rumsey Indian Rancheria of Wintun Indians of California) (Yolo County 2009).

### 13.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas.

#### 13.3.3.1.1 Napa County

Napa County encompasses approximately 793 square miles in northern California. It is bounded on the north by Lake County, on the east by Yolo County, on the south by Solano County, and on the west by Sonoma County. Napa County includes 62,865 acres of federally owned and 40,307 acres of state-owned lands throughout the county, including approximately 28,000 acres related to Lake Berryessa and the State Cedar Rough Wilderness and Wildlife Area (Napa County 2007).

Approximately 479,000 acres (95 percent) of the county, are unincorporated. The five incorporated cities include American Canyon, Calistoga, Napa, and St. Helena, and the town of Yountville. Land use in the county is predominantly agricultural (Napa County 2007, 2008).

The portion of the San Francisco Bay Area Region in Napa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP water service areas.

#### 13.3.3.1.2 Contra Costa County

Contra Costa County encompasses approximately 805 square miles in northern California. It is bounded on the north by Solano and Sacramento counties, on the east by San Joaquin County, on the south by Alameda County, and on the west by San Francisco Bay. Contra Costa County includes federally owned and state-owned lands throughout the county, including approximately 20,000 acres within Mount Diablo State Park (Contra Costa County 2005).

Over 40 percent of the county's land is in agricultural production, or about 200,370 acres. Residential land is the second largest use in the county, encompassing approximately 122,100 acres (25.4 percent of the county). Approximately 46,700 acres (9 percent of the land within the county), are within surface waters (Contra Costa County 2005).

Residential development is concentrated in existing cities and adjacent unincorporated communities. The Contra Costa County incorporated cities include Antioch, Brentwood, Clayton, Danville, El Cerrito, Hercules, Lafayette, Martinez, Moraga, Oakley, Orinda, Pinole, Pleasant Hill, Pittsburg, Richmond, San Pablo, San Ramon, and Walnut Creek. The major unincorporated areas in the county include Alamo, Bethel Island, Byron, Crockett, Discovery Bay, Kensington, Knightsen, North Richmond, Pacheco, Port Costa, and Rodeo (Contra Costa County 2005). Portions of the cities of Pittsburg, Antioch, Oakley, and Brentwood and eastern Contra Costa County are located within the Delta.

The portion of the San Francisco Bay Area Region in Contra Costa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (including facilities associated with Rock Slough), areas along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

#### 13.3.3.1.3 Alameda County

Alameda County encompasses approximately 738 square miles in northern California. It is bounded on the north by Contra Costa County, on the east by San Joaquin County, on the south by Santa Clara County, and on the west by San Francisco Bay. Alameda County includes federally owned and state-owned lands throughout the county (Alameda County 2009).

Western Alameda County and the portions of the Livermore-Amador Valley are heavily urbanized. The incorporated cities include Oakland, which is the County seat; Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Piedmont, Pleasant, San Leandro, and Union City. The unincorporated area of the County covers approximately 277,760 acres (59 percent) of the total land area, includes the unincorporated areas of Castro Valley, Eden Area, and (Alameda County Community Development Agency 2010; Alameda County 2000, 2009). Large portions of the unincorporated areas located to the east of Castro Valley and within the Livermore-Amador Valley hills include agricultural and open space lands which are not served by the CVP or SWP water supplies.

The portion of the San Francisco Bay Area Region in Alameda County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including the SWP South Bay Aqueduct), reservoirs that store CVP or SWP water, and CVP and SWP water service areas.

#### 13.3.3.1.4 Santa Clara County

Santa Clara County encompasses approximately 1,306 square miles in northern California. It is bounded on the north by Alameda County, on the east by Stanislaus and Merced counties, on the south by San Benito County, and on the west by San Mateo and Santa Cruz counties. Santa Clara County includes federally owned and state-owned lands throughout the county, including approximately 87,000 acres within Henry W. Coe State Park (Santa Clara County 1994, 2012).

Approximately 83 percent of the county's population resides in the 15 incorporated cities. The incorporated cities include Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Morgan Hill, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, and Sunnyvale. The southern portion of the county near Gilroy and Morgan Hill is predominantly rural, with low-density residential developments scattered though the valley and foothill areas (Santa Clara County 1994, 2012).

The portion of the San Francisco Bay Area Region in Santa Clara County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including the SWP South Bay Aqueduct and CVP facilities that convey water from San Luis Reservoir) and CVP and SWP water service areas.

#### 13.3.3.1.5 San Benito County

San Benito County encompasses approximately 1,386 square miles in central California. It is bounded on the north by Santa Clara County, on the east by Merced and Fresno counties, and on the south and west by Monterey County. San Benito County includes federally owned and state-owned lands throughout the county, including approximately 26,000 acres within Pinnacles National Monument, over 105,403 acres owned by Bureau of Land Management, and over 8,800 acres associated with the Hollister Hills State Vehicular Recreation Area and San Juan Bautista State Historic Park (San Benito County 2010, 2013).

San Benito County has approximately 882,675 acres of unincorporated lands (nearly 99.5 percent of the total land area). The incorporated cities of Hollister and San Juan Bautista account for approximately 4,044 acres (0.5 percent of the county land area). Agriculture is the predominant land use, totaling 747,409 acres (84 percent of the county) (San Benito County 2010, 2013).

The portion of the San Francisco Bay Area Region in San Benito County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including San Justo Reservoir and other facilities to convey water from San Luis Reservoir) and CVP water service areas.

## 13.3.4 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. Tribal lands are also described for the Central Coast Region.

### *13.3.4.1 San Luis Obispo County*

San Luis Obispo County encompasses approximately 3,594 square miles in central California, including over 200,000 acres of surface waters (San Luis Obispo County 2013). It is bounded on the north by Monterey County, on the east by Kern County, on the south by Santa Barbara County, and on the west by the Pacific Ocean. Federally owned land in San Luis Obispo County includes Los Padres National Forest, Carizzo Plain National Monument, several wilderness areas, and Guadalupe-Nipomo Dunes National Wildlife Refuge. State-owned lands include Hearst-San Simeon State Historical Monument, Montano de Oro State Park, and state beaches and marine conservation areas.

Land uses in the County are predominantly rural and agricultural with over 1,672,000 acres in agricultural and rural land uses (83 percent of the total county lands). Incorporated cities include Arroyo Grande, Atascadero, Grover Beach, Morro Bay, Paso Robles, Pismo Beach, and San Luis Obispo. Major unincorporated communities include Avila, California Valley, Creston Village, Edna Village, Heritage Ranch, Los Ranchos, Nipoma, Oak Shores, Oceano, San Miguel, Santa Margarita, and Templeton (San Luis Obispo County 2013).

The portion of the Central Coastal Region in San Luis Obispo County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (including facilities associated with the Central Coast Water Authority) and SWP water service areas.

### *13.3.4.2 Santa Barbara County*

Santa Barbara County encompasses approximately 2,744 square miles in central California. It is bounded on the north by San Luis Obispo, on the east by Ventura County, and on the south and west by the Pacific Ocean. Federally owned land in Santa Barbara County includes 629,120 acres in the Los Padres National Forest, 98,560 acres in the Vandenberg Air Force Base, Channel Islands National Park, and Guadalupe-Nipomo Dunes National Wildlife Refuge. The state-owned lands include the University of California at Santa Barbara, Sedgwick Reserve, La Purisima Mission State Park and other state parks, and Burton Mesa Ecological Reserve (Santa Barbara County 2009; SBCAG 2013).

Agricultural is the predominant land use in the county with over 1,440,000 acres (82 percent of the land) (Santa Barbara County 2009; SBCAG 2013). Santa Barbara County includes eight incorporated cities, Buellton, Carpinteria, Goleta, Guadalupe, Lompoc, Santa Barbara, Santa Maria, and Solvang. Less than 3 percent of the County is within incorporated cities. The major unincorporated communities include Cuyuama, Los Alamos, Los Olivos, Mission Hills, Montecito, New Cayamu, Orcutt, Summerland, and Vandendberg Village. The portion of the Central Coastal Region, in Santa Barbara County, that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (including facilities associated with the Central Coast Water Authority), recreation facilities at Cachuma Lake that stores SWP water, and SWP water service areas.

#### *13.3.4.3 Tribal Lands in Central Coast Region*

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

*Tribal Lands within the Boundaries of Santa Barbara County*

Major federally recognized tribes and tribal lands within the boundaries of Santa Barbara County include the Santa Ynez Reservation, which is home to the Santa Ynez Band of Chumash Mission Indians of the Santa Ynez Reservation near Santa Barbara (SDSU 2013).

### 13.3.5 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. Tribal lands are also described for the Southern California Region.

#### *13.3.5.1 Ventura County*

Ventura County encompasses approximately 1,873 square miles in southern California. It is bounded on the north by Kern County, on the east and south by Los Angeles County, and on the west by Santa Barbara County and the Pacific Ocean. Ventura County includes federally owned and state-owned lands throughout the county, including 550,211 acres in Los Padres National Forest, Chumash and Sespe wilderness area, 4,331 acres at the Point Mugu Naval Air Station, 670 acres at the California State University Channel Islands, and over 410 acres in state beach parks (Ventura County 2013).

Ventura County has 10 incorporated cities, including Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, Santa Paula, San Buenaventura, Simi Valley, and Thousand Oaks (Ventura County 2013). Major unincorporated communities within the county include Bell Canyon, Box Canyon, Camarillo Heights, Del Norte, El Rio, Hidden Valley, Lake Sherwood, Matilija Canyon, Montalvo, Oak Park, Ojai Valley, Piru, Saticoy, and Somis (Ventura County 2005).

The portion of the Southern California Region in Ventura County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes recreation at Lake Piru that stores SWP water, and SWP water service areas.

#### *13.3.5.2 Los Angeles County*

Los Angeles County encompasses approximately 4,083 square miles in northern California. It is bounded on the north by Kern County, on the east by San Bernardino County, on the south by Orange County, and on the west by Ventura

County and the Pacific Ocean. Los Angeles County includes federally owned and state-owned lands throughout the county, including nearly 650,000 acres in Los Padres and Angeles national forests, portions of Edwards Air Force Base, over 29,000 acres of other federally owned open space (including wilderness areas), and approximately 50,893 acres of state-owned land, including Hungry Valley State Vehicular Recreation Area (Los Angeles County 2011).

More than half of Los Angeles County's 1,698,240 acres of unincorporated land area is designated a natural resources land use category. The next highest land use is rural, which accounts for 39 percent of the unincorporated areas, followed by residential, which accounts for 3 percent of the unincorporated areas. The remaining land area is in the county's 88 incorporated cities, the most populous of which is the City of Los Angeles (Los Angeles County 2012). The County has approximately 140 unincorporated areas (Los Angeles County 2014).

The portion of the Southern California Region in Los Angeles County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities and SWP water service areas.

#### *13.3.5.3 Orange County*

Orange County encompasses 948 square miles in southern California. It is bounded on the north by Los Angeles County, on the east by San Bernardino and Riverside counties, on the south by San Diego County, and on the west by the Pacific Ocean. Orange County includes federally owned lands, including lands in the Cleveland National Forests.

Orange County has 34 incorporated cities in Orange County. The unincorporated lands cover approximately 192,758 acres (Orange County 2005). Land zoned as open space forms the largest land use type (143,313 acres).

The portion of the Southern California Region in Orange County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities and SWP water service areas.

#### *13.3.5.4 San Diego County*

San Diego County encompasses approximately 4,525 square miles in southern California. It is bounded on the north by Orange and Riverside counties, on the east by Imperial County, on the south by Mexico, and on the west by the Pacific Ocean. San Diego County includes federally owned land, including Camp Pendleton Marine Corps Base, Cleveland National Forest, and San Diego and San Diego national wildlife refuges. State-owned lands throughout the county, includes Cuyamaca Rancho State Park, Anza-Borrego Desert State Park, Felipe Wildlife Area, and Ocotillo Wells State Vehicular Recreation Area (San Diego County 2011).

The incorporated cities include Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Marcos, Santee, Solano Beach, and Vista San Diego (San Diego County 2011). The unincorporated communities include Lakeside, Ramona, San Dieguito, Spring Valley, and Valle de Oro.

The portion of the Southern California Region in San Diego County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities, non-SWP reservoirs that store SWP water (including Dixon Lake; and San Vicente, Lower Otay, and Sweetwater Reservoir), and CVP water service areas.

#### *13.3.5.5 Riverside County*

Riverside County encompasses approximately 7,295 square miles in southern California. It is bounded on the north by San Bernardino County, on the east by the state of Nevada, on the south by San Diego and Imperial counties, and on the west by Orange County. Riverside County includes federally owned lands throughout the county, including March Air Reserve Base, Chocolate Mountains Naval Gunnery Range, Joshua Tree National Park, San Bernardino and Cleveland national forests, numerous wilderness areas, and Coachella Valley National Wildlife Refuge; and state-owned lands including San Jacinto and Santa Rose wildlife areas and Mount San Jacinto State Park (RCIP 2000).

Residential land use accounts for approximately 184,000 acres, nearly 57 percent of which are within incorporated cities. Approximately 1,313,000 acres (28 percent) is in open space, recreation, agriculture, and wildland preservation (RCIP 2000).

Most of the population is concentrated in the 24 incorporated cities of Banning, Beaumont, Calimesa, Canyon Lake, Cathedral City, Coachella, Corona, Desert Hot Springs, Hemet, Indian Wells, Indio, Lake Elsinore, La Quinta, Moreno Valley, Murrieta, Norco, Palm Desert, Palm Springs, Perris, Rancho Mirage, Riverside, San Jacinto, and Temecula. The major unincorporated communities in the county include Banning Bench, Bermuda Dunes, Cabazon, Cherry Valley, Cleveland Ridge, Desert Center, Eagle Mountain, El Cerrito, Lakeview/Nuevo, Meadowbrook, Mecca, Menifee Valley, North Palm Springs, Ripley, Sun City, Temescal Canyon, Tenaja, Thermal, Thousand Palms, Warm Springs, and Wildomar.

The portion of the Southern California Region in Riverside County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities, reservoirs that store SWP water (including Diamond Valley Lake and Lake Skinner), and SWP water service areas.

#### *13.3.5.6 San Bernardino County*

San Bernardino County encompasses approximately 20,106 square miles in southern California. It is bounded on the north by Inyo County, on the east by the state of Nevada, on the south by Riverside County, and on the west by Kern, Los Angeles, and Orange counties. Most of the land in San Bernardino County is federally owned and state-owned lands, including approximately 10,500,000 acres (81 percent of the county) (San Bernardino County 2007, 2012). The federally owned lands include 28 Bureau of Land Management wilderness areas (approximately 47 percent of the total county), San Bernardino and Angeles National Forests (676,666 and 655,387 acres, respectively), Mojave National

Preserve, Joshua Tree and Death Valley National Parks, and four military bases (Edwards Air Force Base, Twentynine Palms Marine Corps Air Ground Combat Training Center, Fort Irwin, and China Lake Naval Weapons Center). State-owned lands include Silverwood Lake State Recreation Area at the SWP reservoir, Wildwood Canyon State Park, and Providence Mountain and Chino Hills state recreation areas.

San Bernardino County includes 24 incorporated cities, including Adelanto, Apple Valley, Barstow, Big Bear Lake, Chino, Chino Hills, Colton, Fontana, Grand Terrace, Hesperia, Highland, Loma Linda, Montclair, Needles, Ontario, Rancho Cucamonga, Redlands, Rialto, San Bernardino, Twentynine Palms, Upland, Victorville, Yucaipa, and Yucca Valley. Major unincorporated communities in the county include Amboy, Baker, Bear Valley, Bloomington, Crest Forest, Earp, Essex, Fontana suburbs, Goffs, Harvard, Havasu Lake, Helendale, Hilltop, Hinckley, Homestead Valley, Joshua Tree, Kelso, Kramer Junction, Lake Arrowhead, Landers, Lucerne Valley, Ludlow, Lytle Creek, Mentone, Moronga Valley, Muscoy, Newberry Springs, Nipton, Oak Glen, Oak Hills, Parker, Phelan/Pinon Hills, Pioneertown, Red Mountain, Rimrock, Silver Lake, Trona, Vidal, and Yerno.

The portion of the Southern California Region in San Bernardino County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP water service areas.

#### 13.3.5.7 Tribal Lands in Southern California Region

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

*Tribal Lands within the Boundaries of San Diego County*

Major federally recognized tribes and tribal lands within the boundaries of San Diego County includes lands of the Capitan Grande Band of Diegueno Mission Indians of California (Barona Reservation and Viejas Reservation), Cahuilla Band of Mission Indians of the Cahuilla Reservation, Campo Band of Diegueno Mission Indians of the Campo Indian Reservation, Ewiiaapaayp Band of Kumeyaay Indians, Inaja Band of Diegueno Mission Indians of the Inaja and Cosmit Reservation, Jamul Indian Village of California, La Jolla Band of Luiseno Indians, La Posta Band of Diegueno Mission Indians of the La Posta Indian Reservation, Los Coyotes Band of Cahuilla and Cupeno Indians, Manzanita Band of Diegueno Mission Indians of the Manzanita Reservation, Mesa Grade Band of Diegueno Mission Indians of the Mesa Grande Reservation, Pala Band of Luiseno Mission Indians of the Pala Reservation, Pauma Band of Luiseno Mission Indians of the Pauma & Yuima Reservation, Rincon Band of Luiseno Indians of the Rincon Reservation, San Pasqual Band of Diegueno Mission Indians of California, Iipay Nation of Santa Ysabel, and Sycuan Band of Kumeyaay Nation.

*Tribal Lands within the Boundaries of Riverside County*

Major federally recognized tribes and tribal lands within the boundaries of Riverside County include lands of the Agua Caliente Band of Cahuilla Indians of the Agua Caliente Reservation, Augustine Band of Cahuilla Indians, Cabazon Band of Mission Indians, Cahuilla Band of Mission Indians of the Cahuilla Reservation, Morango Band of Mission Indians, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Ramona Band of Cahuilla, Santa Rosa Band of Cahuilla Indians, Soboba Band of Luiseno Indians, Torres-Martinez Desert Cahuilla Indians, Twenty-Nine Palms Band of Mission Indians of California, and Colorado River Indian Tribes of the Colorado River Indian Reservation (RCIP 2000).

*Tribal Lands within the Boundaries of San Bernardino County*

Major federally recognized tribes and tribal lands within the boundaries of San Bernardino County include the lands of the San Manual Band of Mission Indians and the Twenty-Nine Palms Band of Mission Indians of California (SDSU 2013). The Chemehuevi Indian Tribe of the Chemehuevi Reservation is also located in San Bernardino County near the Colorado River.

## 13.4 Impact Analysis

This section describes the potential mechanisms for change in non-agricultural land uses and analytical methods; results of the impact analysis; potential mitigation measures; and potential cumulative effects.

### 13.4.1 Potential Mechanisms for Change and Analytical Tools

As described in Chapter 4, Approach to Environmental Analysis, the environmental consequences assessment considers changes in non-agricultural land uses related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

#### *13.4.1.1 Changes in Land Uses*

Land uses in 2030 are assumed to be consistent with the future projections included in existing general plans. The general plans were developed assuming adequate water supplies to support the projected lands uses. Changes in CVP and SWP operations under the No Action Alternative and Alternatives 1 through 5 could change the availability of CVP and SWP water supplies. If the CVP and SWP water supplies were reduced as compared to the No Action Alternative and Second Basis of Comparison to a level that would not support planned municipal and industrial water demands, development of future land uses may not occur. Potential changes to agricultural land uses are described in Chapter 12, Agricultural Resources.

Availability of CVP and SWP water supplies were analyzed using CalSim II model output (see Chapter 5, Surface Water Resources and Water Supplies). Most of the CVP and SWP municipal and industrial water users prepared Urban

Water Management Plans (UWMPs) that project availability of water supplies to support land uses in 2030. That information was used with projected CVP and SWP water supply availability under each of the alternatives to determine if projected municipal and industrial water demands could be met in 2030 using the CWEST model, as described in Chapter 19, Socioeconomics. The results of the CWEST model indicated that municipal and industrial water demands of CVP and SWP water users in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions would be met through a combination of water conservation, available CVP and SWP water supplies, local and regional surface water supplies, groundwater, recycled water, and, in some cases, desalination.

Alternative 4 includes provisions for floodway development regulations. It is assumed that under the No Action Alternative and Alternatives 1 through 5, existing programs to protect floodways would continue to be implemented, including Federal and state requirements as implemented by the U.S. Army Corps of Engineers (USACE), Central Valley Flood Protection Board, and Department of Water Resources (DWR). Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways, including the Delta Stewardship Council's recently adopted Delta Plan. These regulations would continue to be implemented in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, future development would be prevented from occurring within the Delta floodplains and floodways; and in the Sacramento, Feather, American, and San Joaquin river corridors upstream of the Delta. Provisions in Alternative 4 would require additional setbacks along the floodways as compared to other alternatives and the Second Basis of Comparison. The potential change in land use is analyzed qualitatively in this chapter.

The No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison include restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass; and continued delivery of refuge water supplies under the Central Valley Project Improvement Act, as described in Chapter 3, Description of Alternatives. Land uses in 2030 due to implementation of these programs would be consistent between all alternatives and the Second Basis of Comparison. Therefore, this EIS does not analyze changes due to these programs.

##### *13.4.1.2 Effects Related to Cross Delta Water Transfers*

Cross Delta water transfers involving the CVP and SWP facilities or water supplies would be required to be implemented in accordance with all existing regulations and requirements, including not causing adverse impacts to other water users in accordance with the requirements of Reclamation, DWR, and the State Water Resources Control Board. It is anticipated that water transfers would continue under all alternatives to provide water supplies to agricultural, municipal and industrial, and wildlife refuges under all alternatives and the Second Basis of

Comparison in a similar manner. Transfers for municipal and industrial water users would be one of several water supply sources to meet the future water demands in Year 2030. If the availability of transferred water is reduced, it is anticipated that other water supplies (e.g., recycled water and desalination) would be increased, as described in the UWMPs for 2030 water demands.

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison. The analysis indicated that water transfers would not result in changes to non-agricultural land uses.

Under all of the alternatives and Second Basis of Comparison, it is assumed that these transfers would continue to occur each year to meet the water demands in the existing general plans. It is not anticipated that water transfers would change municipal and industrial land uses as defined in the existing general plans. If a water transfer program was implemented for the purposes of changing existing general plan land uses, separate environmental documentation would be required for the changes to the general plan and the water transfer. Potential effects due to Cross Delta water transfers on in agricultural land uses are described in Chapter 12, Agricultural Resources. Therefore, this chapter does not include separate analyses of changes in municipal and industrial land uses due to cross Delta water transfers.

### 13.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison (described in Chapter 3, Description of Alternatives): the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions.

#### *13.4.2.1 No Action Alternative*

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison (e.g., climate change, sea level rise, projected development under existing general plans, and implementation of reasonable and foreseeable projects). Due to these changes, especially climate change and sea level rise, it is anticipated that CVP and SWP water supply availability would be less than under recent conditions (described in Chapter 5, Surface Water Resources and Water Supplies). However, it is anticipated that projected land uses would occur by 2030 with implementation of water conservation programs and the development of other water supplies, including ongoing recycled water programs, desalination, and groundwater use.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with the general plans for counties and cities within the Central Valley Region; tribal lands; and regulations of state and regional agencies, including Central Valley Flood Protection Board, Delta Protection Commission, and Delta Stewardship Council.

Development along the river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways. The Central Valley Flood Protection Board adopts floodway boundaries and approves uses within those floodways (DWR 2010). Various uses are permitted in the floodways, such as agriculture, canals, low dikes and berms, parks and parkways, golf courses, sand and gravel mining, structures that will not be used for human habitation, and other facilities and activities that will not be substantially damaged by the base flood event and will not cause adverse hydraulic impacts that will raise the water surface in the floodway.

Within the Delta, future development also is subject to the requirements of the Delta Protection Commission and Delta Stewardship Council. The general plans within the Delta are required by state laws to be consistent with the Delta Protection Commission's *Land Use and Resource Management Plan for the Primary Zone of the Delta* (DPC 2010; OAL 2010), which does not allow development within the Primary Zone of the Delta unless proponents can demonstrate that implementing their projects would preserve and protect natural resources of the Delta, promote protection of remnants of riparian and aquatic habitat, not result in loss of wetlands or riparian habitat, would not degrade water quality, would not interfere with migratory birds or public access, would not harm agricultural operations, and would not degrade levees or expose the public to increased flood hazards. Farmers are encouraged to implement management practices to maximize habitat values for migratory birds and wildlife.

The Delta Plan adopted by the Delta Stewardship Council in May 2013 included a policy that protects floodways within the entire Delta that are not regulated by other Federal or state agencies (23 California Code of Regulations Section 5014). This policy prevents encroachment into floodways that would impede the free flow of water in the floodway or jeopardize public safety.

### 13.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of the following alternative analysis:

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

### *13.4.3.1 No Action Alternative*

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

#### 13.4.3.1.1 Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under the No Action Alternative and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under the No Action Alternative and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be 6 percent less for the North of Delta water users and 10 percent less for the South of Delta users under the No Action Alternative, compared to the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be reduced by 18 percent throughout the SWP service area under the No Action Alternative, compared to the Second Basis of Comparison. However, as described in Chapter 19, Socioeconomics, 2030 municipal and industrial water demands would be met through a combination of available CVP and SWP water supplies and other water supplies, including water conservation, water transfers, local and regional surface water and groundwater, recycled water, and desalination. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under the No Action Alternative and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under the No Action Alternative and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

### *13.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because land use conditions under Alternative 1 are identical to land use conditions under the Second Basis of Comparison, Alternative 1 is only compared to the No Action Alternative.

##### 13.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Change in Land Use*

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 1 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 1 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be 7 percent greater for the North of Delta water users and 11 percent greater for the South of Delta users under Alternative 1 as compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be increased by 22 percent under Alternative 1 as compared to the No Action Alternative. The increased CVP and SWP water supply availability would allow water users to reduce other water supplies, including groundwater. It is anticipated that the additional water supplies would not result in changes in the general plan development plans without subsequent environmental documentation. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 1 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 1 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

##### 13.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *13.4.3.3 Alternative 2*

The land use conditions under Alternative 2 would be identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 13.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to land use under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 13.4.3.1, No Action Alternative.

#### *13.4.3.4 Alternative 3*

The CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.

Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 thousand acre feet (TAF)/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 13.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Changes in Land Use*

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 3 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 3 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and 9 percent greater for the South of Delta users under Alternative 3, compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be increased by 17 percent under Alternative 3, compared to the No Action Alternative. The increased CVP and SWP water supply availability would allow water users to reduce other water supplies, including groundwater. It is anticipated that the additional water supplies would not result in changes in the general plan development plans without subsequent environmental documentation. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 3 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 3 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

#### 13.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Changes in Land Use*

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 3 and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 3 and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and South of Delta users under Alternative 3 and the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be similar under Alternative 3 and the Second Basis of Comparison. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 3 and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under Alternative 3 and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

#### *13.4.3.5 Alternative 4*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway.

##### 13.4.3.5.1 Alternative 4 Compared to the No Action Alternative

*Changes in Land Use*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under Alternative 1. Therefore, the land use conditions influenced by availability of CVP and SWP water supplies under Alternative 4 would be the same as conditions under Alternative 1.

Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway. Development within floodways is currently prohibited in accordance with existing general plans and state and regional plans (e.g., requirements of the Delta Protection Commission and Delta Stewardship Council). Structures that either cannot be moved before flood events or that would reduce the flood management function of the floodway are not allowed. It is anticipated that these requirements would continue to be implemented in 2030, to protect the floodways. However, Alternative 4 would include additional restrictions on new development within 170 feet of the ordinary high water line of any floodway. It is anticipated that the provisions under Alternative 4 could result in site-specific parcel changes as compared to the No Action Alternative. However, the development that would have occurred on these parcels could be incorporated within the general plan development plans and guidelines. Therefore, land use conditions under Alternative 4 would be similar to conditions under the No Action Alternative; and would be the same as the impacts described in Section 13.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### 13.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

*Changes in Land Use*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under Second Basis of Comparison. Therefore, the land use conditions influenced by availability of CVP and SWP water supplies under Alternative 4 would be the same as conditions under the Second Basis of Comparison.

Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway. Development within floodways is currently prohibited in accordance with existing general plans and state and regional plans (e.g., requirements of the Delta Protection Commission and Delta Stewardship Council). Structures that either cannot be moved prior to flood events or that would reduce the flood management function of the floodway are not allowed. It is anticipated that these requirements would continue to be implemented in 2030 to protect the floodways. However, Alternative 4 would include additional restrictions on new development within 170 feet of the ordinary high water line of any floodway. It is anticipated that the provisions under Alternative 4 could result in site-specific parcel changes as compared to the Second Basis of Comparison. However, the development that would have occurred on these parcels could be incorporated within the general plan development plans and guidelines. Therefore, land use conditions under Alternative 4 would be identical to conditions under the Second Basis of Comparison.

### *13.4.3.6 Alternative 5*

The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations.

Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 13.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Changes in Land Use*

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 5 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 5 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta and South of Delta water users under Alternative 5, compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be similar under Alternative 5, compared to the No Action Alternative. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 5 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 5 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

##### 13.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Changes in Land Use*

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 5 and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under the No Action Alternative and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and 10 percent less for the South of Delta water users under Alternative 5 as compared to the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be reduced by 19 percent throughout the SWP service area under the Alternative 5, compared to the Second Basis of Comparison. However, as described in Chapter 19, Socioeconomics, 2030 municipal and industrial water demands would be met through a combination of available CVP and SWP water supplies and other water supplies, including water conservation, water transfers, local and regional surface water and groundwater, recycled water, and desalination. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 5 and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under Alternative 5 and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

#### *13.4.3.7 Summary of Impact Analysis*

The results of the environmental consequences of implementation of Alternatives 1 through 5, compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 13.1 and 13.2.

**Table 13.1 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 2 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 3 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 4 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 5 | No effects to municipal and industrial and regional land uses | None needed |

**Table 13.2 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 1 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 2 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 3 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 4 | No effects to municipal and industrial and regional land uses | None needed |
| Alternative 5 | No effects to municipal and industrial and regional land uses | None needed |

#### *13.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5, as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5, compared to the No Action Alternative, would not result in changes in municipal and industrial land uses or regional lands use plans. Therefore, there would be no adverse impacts to land use and no mitigation measures are required.

### *13.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, Description of Alternatives, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Land Use are summarized in Table 13.3.

**Table 13.3 Summary of Cumulative Effects on Land Use with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and all Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Nimbus Fish Hatchery Fish Passage Project<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish | <u>These effects would be the same under all alternatives.</u><br>Community development would occur in accordance with general plan projections for 2030. Development within the Delta would be subject to the requirements of the Delta Protection Commission and Delta Stewardship Council.<br>Restoration plans for the ongoing programs would be completed. Development along river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan(including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- San Luis Reservoir Low Point Improvement Project<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | These effects would be the same under all alternatives.<br>Most of the reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Community development would occur in accordance with general plan projections for 2030. Development within the Delta would be subject to the requirements of the Delta Protection Commission and Delta Stewardship Council.<br>Restoration plans for the ongoing programs would be completed. Development along river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways.<br>Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. |
| Alternative 1 reasonably foreseeable actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 2 reasonably foreseeable actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 reasonably foreseeable actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 4 reasonably foreseeable actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Increased restrictions for development within floodways. | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 reasonably foreseeable actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

## 13.5 References


Alameda County. 2000. *East County Area Plan (Revised by Initiative Nov. 2000)*.

______. 2009. *Initial Study and Negative Declaration, Alameda County Housing Element Update (2009-2014)*. December 2.

Alameda County Community Development Agency. 2010. *Demographic Map*. March.

Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan, Final, 2013 Update*.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html

Butte County. 2010. *General Plan Draft Environmental Impact Report*. April 8.

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://bvh2o.com/James.html

CALFED et al. (CALFED Bay-Delta Program, Yolo Bypass Working Group, and Yolo Basin Foundation). 2001. *A Framework for the Future: Yolo Bypass Management Strategy*. August.

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://www.lbwater.org/overview-long-beach-seawater-desalination-project

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

_____. 2010. *Water System Ten-Year Capital Improvement Program for the Fiscal Years 2010-2019*.

_____. 2013. *Initial Study, Los Angeles Groundwater Replenishment Project*. September.

City of Oceanside. 2012. *Oceanside Harbor Desalination Testing Project*.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2009a. *Mission Valley Basin*. September 11.

_____. 2009b. *San Pasqual Basin*. September 11.

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp

Colusa County. 2011. *Public Draft Environmental Impact Report for the 2030 Colusa County General Plan Update*. November.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020*. January.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2015a. *Status of the Central Valley Salt & Nitrate Management Plan, Central Valley Water Board Meeting, Agenda Item #14*. April 16.

_____. 2015b.CV-SALTS. No Date (n.d.). CV-SALTS, Central Valley Salinity Alternatives for Long-Term Sustainability. Site accessed April 29, 2015. http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html

Del Norte County. 2003. *Del Norte County General Plan*. January 28.

DPC (Delta Protection Commission). 2010. *Draft Land Use and Resource Management Plan for the Primary Zone of the Delta, Adopted February 25, 2010*, February 25.

DSC (Delta Stewardship Council). 2013. *The Delta Plan, Ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value*. May.

DWR (California Department of Water Resources). 2010. *Central Valley Flood Management Planning Program, State Plan of Flood Control Descriptive Document*. November.

_____. 2011. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

_____. 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR and Reclamation (California Department of Water Resources and Bureau of Reclamation). 2014. *Draft Technical Information for Preparing Water Transfer Proposals (Water Transfer White Paper) Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval*. November.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

EBMUD (East Bay Municipal Utility District). 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

El Dorado County. 2003. *El Dorado County General Plan Draft Environmental Impact Report*. May.

EMWD (Eastern Municipal Water District). 2014a. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

_____. 2014b. *Indirect Potable Reuse Program*. January 8.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Fresno County. 2000. *Fresno County General Plan Background Report*. October.

Glenn County. 1993. *Glenn County General Plan*. June 15.

Hoopa Valley Tribe. 2008. *Water Quality Control Plan, Hoopa Valley Indian Reservation*. February.

Humboldt County. 2012. *Humboldt 21st Century General Plan Update, Draft Environmental Impact Report*. April 2.

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

Karuk Tribe. 2010. *Karuk Tribe Department of Natural Resources Eco-Cultural Resources Management Plan*. June.

Kern County. 2004. *Revised Update of the Kern County General Plan and Amendment of the Kern County and Incorporated Cities Integrated Waste Management Plan Siting Element, Recirculated Draft Program Environmental Impact Report*. January.

_____. 2010. *Greater Tehachapi Area Specific Plan Draft Environmental Impact Report*. August.

Kings County. 2009. *2035 Kings County General Plan Draft Environmental Impact Report*. June.

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP).*

Los Angeles County (County of Los Angeles). 2010. *The County of Los Angeles Annual Report 2009-2010.*

_____. 2011. *Public Review Draft 4/5/11 Text-Only Version, Los Angeles County General Plan 2035*. April.

_____. 2012a. *Cities within the County of Los Angeles*. February.

_____. 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

Madera County. 1995. *Madera County General Plan Background Report*. October.

Merced County. 2012a. *Merced County General Plan Revised Background Report*. November.

_____. 2012b. *2030 Merced County General Plan Draft Program Environmental Impact Report*. November.

_____. 2013. *2030 Merced County General Plan Update Recirculated Draft Program Environmental Impact Report*. July.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

Napa County. 2007. *Draft General Plan Environmental Impact Report*. February.

Napa County. 2008. *Napa County General Plan*. June.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

Nevada County (County of Nevada). 1995. *Nevada County General Plan, Final Environmental Impact Report*. March.

_____. 2012. *Nevada County Demographic and Statistical Profile*.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

OAL (California Office of Administrative Law). 2010. *Notice of Approval of Regulatory Action, Delta Protection Commission*. October 7.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

Orange County. 2005. *2005 Orange County General Plan*.

Paskenta. 2014. *Winththunun Lewquit/About the Tribe, About our People*. Site accessed March 30, 2014. http://www.paskentaweb.com/about/

Placer County. 2011. *Placer County Conservation Plan, Western Placer County, Agency Review Draft Document*. February 1.

Plumas County. 2012. *2035 Plumas County General Plan Update Draft Environmental Impact Report*. November.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

RCIP (Riverside County Integrated Project). 2000. *Existing Setting Report*. March.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

_____. 2012. *Agricultural Water Management Plan*. December 13.

Reclamation (Bureau of Reclamation). 2004. *Sacramento River Settlement Contractors Environmental Impact Statement*. September.

_____. 2005a. *Final Environmental Assessment for the Long-term Contract Renewal, Shasta and Trinity Divisions*. March.

_____. 2005b. *Final Environmental Assessment for Renewal of Long-term Contracts for the Sacramento River Division Contractors*. February.

_____. 2005c. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

_____. 2006. *San Luis Drainage Feature Re-evaluation. Final Environmental Impact Statement*. May.

_____. 2009. *Record of Decision, Grassland Bypass Project, 2010-2019*. December.

_____. 2010. *Resighini Rancheria Water Resources Development Project*. July.

_____. 2011. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

_____. 2012. *Record of Decision San Joaquin River Restoration Program*. September 28.

_____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

_____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

_____. 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

_____.2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

_____.2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

_____. 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Resighini Rancheria. 2014. *Resighini Rancheria, About Us*. Site accessed April 25, 2014. http://resighin.ipower.com/about_us.html.

SACOG (Sacramento Area Council of Governments). 2007. *Draft Environmental Impact Report for the Metropolitan Transportation Plan for 2035*. October.

Sacramento County. 2010. *Final Environmental Impact Report, Sacramento County General Plan Update*. April.

_____. 2011. *General Plan of 2005-2030*. November 9.

San Benito County. 2010. *San Benito County General Plan Public Review Draft Background Report*. November.

_____. 2013. *2035 San Benito County General Plan Update Draft Program Environmental Impact Report*. November.

San Bernardino County (County of San Bernardino). 2007. *County of San Bernardino 2006 General Plan Program, Final Environmental Impact Report and Appendices*. February.

_____. 2012. *County of San Bernardino 2007 General Plan*. May.

San Diego County (County of San Diego). 2011. *San Diego County General Plan Update, Final Environmental Impact Report*. August.

San Joaquin County. 2009. *General Plan Update Background Report*. July.

San Luis Obispo County (County of San Luis Obispo). 2013. *County of San Luis Obispo, Land Use and Circulation Elements*. August.

Santa Barbara County (County of Santa Barbara). 2009. *Santa Barbara County Comprehensive Plan*. May.

Santa Clara County (County of Santa Clara). 1994. *Santa Clara County General Plan Draft Environmental Impact Report*. September.

_____. 2012. *Santa Clara Valley Habitat Plan, Final Environmental Impact Report/Environmental Impact Statement*. 2012.

SBCAG (Santa Barbara County Association of Governments). 2013. *2040 Santa Barbara County Regional Transportation Plan and Sustainable Communities Strategy, Draft Environmental Impact Report*. May.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

_____. 2015. *Seawater Desalination*. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination

SDSU (San Diego State University). 2013. Site accessed March 25, 2013. http://library.sdsu.edu/guides/sub2.php?id=195&pg=193.

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

Shasta County. 2004. *Shasta County General Plan, as amended through September 2004*. September.

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011. *Friant-Kern Canal Capacity Restoration, Draft*. June.

_____. 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://restoresjr.net/activities/site_specific/madera-canal/index.html

Solano County. 2008. *Solano County General Plan, Draft Environmental Impact Report*. April.

Stanislaus Council of Governments. 2007. *Final Supplemental Program Environmental Impact Report for the 2007-2030 Regional Transportation Plan of Stanislaus County*. May.

Stanislaus County (County of Stanislaus County). 2010. *Stanislaus County General Plan Support Documentation, Revised April 2010*. April.

_____. 2012. *Text Revisions to the Stanislaus County General Plan*.

Sutter County. 2010. *General Plan Update Draft Environmental Impact Report*. September.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

_____. 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

_____. 2015. *CV-SALTS Annual Report, State Water Board Meeting, Agenda Item #5*. January 20.

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Tehama County. 2008. *Tehama County 2008-2028 General Plan Draft Environmental Impact Report*. September.

Trinity County. 2012. *2009 Housing Element of the Trinity County General Plan*. December 4.

Tulare County. 2010. *Tulare County General Plan 2030 Update, Recirculated Draft Environmental Impact Report.* February.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

Ventura County (County of Ventura). 2005. *Final Subsequent Environmental Impact Report for Focused General Plan Update*. June.

_____. 2013. Ventura County Statistics. Assessor's Office. Site accessed February 5, 2013. http://assessor.countyofventura.org/generallyspeaking/CountyStatistics.html.

WBMWD (West Basin Municipal Water District). 2011. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

______. 2015. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview

Yolo County. 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report Public Review Draft*. April.

Yuba County. 2011. *Final Yuba County 2030 General Plan Environmental Impact Report*. May.

Yurok Tribe. 2005. *Tribal Park Concept Plan*. August.

______. 2012. *NPS Assessment and Management Program Plan*. December.

This page left blank intentionally.

**Chapter 14**

# Visual Resources

## 14.1 Introduction

This chapter describes the visual resources in the study area related to natural and artificial landscape features and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives considered in this EIS could affect visual resources through changes in surface water elevations at Central Valley Project (CVP) and State Water Project (SWP) reservoirs and changes in land use related to potential changes in operation of the CVP and SWP and ecosystem restoration.

Changes in reservoir surface water elevations, agricultural resources, and land use are described in more detail in Chapter 5, Surface Water Resources and Water Supplies; Chapter 12, Agricultural Resources; and Chapter 13, Land Use, respectively.

### 14.1.1 Visual Effects

Natural and artificial landscape features contribute to perceived visual images and aesthetic values of views. The values of views frequently are determined by contrasts of forms and textures related to geology, hydrology, vegetation and wildlife, agricultural crops, and other land uses. For example, a small water feature in a plain may be a significant visual feature; however, a small water feature within an area with vast rivers or larger ponds may be of less significance.

Visual effects are dependent upon the viewpoint of individuals because each person can respond differently to changes in the physical environment depending upon expectations, historical perspective, duration and frequency of the views, and extent of a viewshed. A viewshed is defined by the Federal Highway Administration (DOT 1981) as a surface area visible from a particular location. The character of a viewshed can also vary daily, seasonally, and with changing weather.

Visual effects also are affected by the general activities of the viewers. Passengers in automobiles and trains with relatively short exposure to views may have a different experience than recreationists or residents who view the area for longer periods of time. Residents and recreationists frequently select a location for their activities due to the views. Changes in views could affect the quality of their activities, including housing, camping, hiking, or boating locations. Therefore, changes in visual effects are dependent upon the visual quality of the landscape within the context of the setting (DOT 1981).

Visual quality, or scenic value, has been classified with respect to the lines, forms, colors, textures, and composition of landforms, vegetation, rocks, cultural features, and water features by the U.S. Department of Agriculture (USDA), Forest Service (USDA 1995). The classification system includes Class A, Distinctive; Class B, Typical (or ordinary or common features); and Class C, Indistinctive. This classification system also considers the scenic integrity, or the completeness of the landscape character.

# 14.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect visual resources at reservoirs and lands served by CVP and SWP water supplies. Actions located on public agency lands or implemented, funded, or approved by Federal and state agencies, would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analysis.

# 14.3 Affected Environment

This section describes visual resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in visual resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, and Central Coast and Southern California regions.

Physical form and visual character are the result of the interaction of natural and engineered elements. Natural elements, including topography, hydrology, vegetation, and climate create the physical context. Engineered elements, such as buildings, roads, infrastructure, and settlement patterns, are secondary elements that act on the natural physical context to establish a visual environment.

Both the natural and engineered landscape features contribute to perceived views and the aesthetic value of those views. In areas considered to have high resource value and scenic character, it is important to evaluate and protect the visual character and aesthetic value of landscapes that may to undergo alteration.

## 14.3.1 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River, and along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

### *14.3.1.1 Trinity River Watershed*

The Trinity River drains an area of the Coast Range, northwest of the Sacramento Valley. Dams on the river form Trinity Lake and Lewiston Lake, both of which are in the Whiskeytown-Shasta-Trinity National Recreation Area, as described in Chapter 15, Recreation Resources. The Trinity River flows through sparsely populated and heavily forested, mountainous terrain, jagged cliffs that can be viewed during numerous recreational opportunities, including fishing, rafting, kayaking, and canoeing. The forests offer visual resources which include snow-covered peaks, volcanoes, rock outcroppings, mountain creeks, lakes, meadows, and a wide variety of trees and vegetation. Downstream of Lewiston Dam, the Trinity River corridor is characterized by gravel bars, riparian vegetation, and human-built features (NCRWQCB et al. 2009). Artificial lights occur related to passing vehicles and local residential and commercial buildings. Glare related to the water surfaces may occur from some view locations.

##### 14.3.1.1.1 Wild and Scenic Rivers and Scenic Highways in the Trinity River Watershed

On January 19, 1981, the Secretary of the Interior designated portions of the Trinity River watershed as part of the National Wild and Scenic Rivers System, including the Trinity River downstream of Lewiston Dam, and portions of the South Fork, North Fork, and New River (BLM et al. 2012). The State of California adopted similar reaches as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

The Trinity River Region includes two highways in Trinity County and one highway in Humboldt County that are eligible for State Scenic Highway designations. The two highways in Trinity County are eligible for State Scenic Highway designation and include the Siskiyou-Trinity Scenic Byway (State Route 3, which extends from south of Hayfork to north of Trinity Lake to Interstate 5) and Trinity Scenic Byway (State Route 299, which extends from the Pacific Ocean to Redding) (CalTrans 2014a). In Humboldt County, State Route 96 along the Trinity River from Willow Creek to the confluence with the Klamath River is eligible for State Scenic Highways designation (CalTrans 2014b).

#### *14.3.1.2 Lower Klamath River Watershed*

The Klamath River from the confluence with the Trinity River to the Pacific Ocean is characterized by a forested river canyon with riparian vegetation along the river. Reduced flows in the summer have frequently resulted in algal blooms which has reduced water clarity and visual quality of the river corridor (DOI and DFG 2012).

##### 14.3.1.2.1 Wild and Scenic Rivers and Scenic Highways in the Klamath River Watershed

The portion of the Klamath River watershed within the Trinity River Region considered in this EIS (from the confluence with the Trinity River to the Pacific Ocean) was designated as part of the entire reach of the Klamath River from Iron Gate to the Pacific Ocean by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also adopted this reach of Klamath River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

Caltrans has not designated highways within the Klamath River watershed in the Trinity River Region as Scenic Highways or identified roadways to be eligible for Scenic Highways status (CalTrans 2014b, 2014c).

## 14.3.2 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

The Central Valley Region is predominantly made up of lowlands and plains surrounded by foothills and tall mountains of the Coast Range to the west, the Cascade Range to the north, the Sierra Nevada to the east, and the Tehachapi Mountains to the south. Communities and roadways of various sizes are located throughout the valley. Land use outside of the communities is primarily agricultural, with riparian, wetland and oak woodlands along the major waterways.

### *14.3.2.1 Sacramento Valley*

The Sacramento Valley extends from the northern mountainous areas to the less dramatic landscapes of the Central Valley at the lower elevations. The mountainous areas are characterized by rugged and deep river canyons and valleys that extend from jagged peaks to forested areas with pine and deciduous trees. Large rivers flow from the mountain areas through the foothills into the agricultural areas and communities along the valley floor. Oak woodlands are located at middle and lower elevations of the foothills and along riparian corridors on the valley floor.

The Sacramento Valley extends from Shasta Lake and Whiskeytown Lake to the Delta. The Sacramento Valley portion of the Central Valley Region considered in this EIS includes the middle and lower portions of the Feather River and American River watersheds that are influenced by CVP and SWP water supply facilities, respectively.

#### 14.3.2.1.1 Shasta Lake, Keswick Reservoir, and Whiskeytown Lake

Shasta Lake, Keswick Reservoir, and Whiskeytown Lake are in the Whiskeytown-Shasta-Trinity National Recreation Area, as described in Chapter 15, Recreation Resources. These watersheds provide opportunities for high quality visual attractions, such as mountains, forests, waterfalls, streams, open water, and vistas of the sky that can be experienced during numerous recreational activities such as boating, water skiing, swimming, fishing, camping, picnicking, hiking, hunting, and mountain biking. Panoramic views for travelers through the area can be seen from many locations, including State Route 151 vista point, Shasta Dam Visitor Center, and Interstate 5. The contrast between the open water bodies and surrounding mountains provides a wide diversity of views. The quality and diversity of visual resources at the lakes and the surrounding areas is influenced by human-built features such as highways, railroads, resorts, bridges, communities, and electrical transmission facilities. The visual quality of open waters also is influenced by fluctuating water levels. Typically, the water levels decline from an annual maximum in May to a minimum in October. In extremely dry years, exposed bare mineral soils in a “bathtub ring” are in substantial contrast to the open water and the upslope vegetation (Reclamation 2013a).

Between the lakes, pine and oak forests predominate, with intermittent chaparral and rock outcrops. The landscape includes mountain ranges, volcanoes, and waterways, opening below the reservoir to the agricultural vistas and communities of the Central Valley.

#### 14.3.2.1.2 Sacramento River Watershed: Keswick Reservoir to Feather River

The scenic qualities of the upper reaches of the Sacramento River watershed south of Keswick Reservoir are generally considered to be of high quality, especially in areas where little to no development has occurred. Varied topography, geologic formations, and natural and manmade water bodies provide striking vistas. Similar conditions are found in the Sierra Nevada Mountains and foothills near the upper and middle Feather, Yuba, American, Mokelumne, Calaveras, and Stanislaus rivers watersheds.

The foothills provide views of rolling hills, open grasslands, and scattered oak and pine woodlands. In the lower elevations of the Central Valley, the human-built environment becomes more dominant, and detracts from views of the natural landscape. Outside of the urban and suburban areas, land use is rural in character, with agricultural areas that include irrigated row crops, orchards, and grazing lands. Sporadically, flooded agricultural fields, especially rice fields managed for wetlands, are used heavily by migrating birds.

Between the Keswick Reservoir and Feather River confluence with the Sacramento River, the landscape also includes human-built reservoirs and canals. Black Butte Reservoir is operationally integrated with the CVP, and the canal system includes the CVP Corning Canal, Tehama-Colusa Canal, and Glenn-Colusa Irrigation District’s canal. The canals provide visual interest in localized areas with limited viewing opportunities (Reclamation 1997).

Visual resources that could be affected in the Feather River and American River watersheds are described below. The remaining portions of the Sacramento Valley between the Feather River and the San Francisco Bay Area Region includes the Delta (described in following subsections of this chapter) and areas located to the east and west of the Delta. Land uses located to the south of the Feather River and outside of the Delta include agricultural, open space, and major urban centers that all use SWP water supplies. The urban areas include the cities of Vacaville, Fairfield, and Vallejo in Solano County and unincorporated areas of Napa County.

*Scenic Highways in the Sacramento River Area*

In the Sacramento Valley portion of the Central Valley Region, there are several designated State Scenic Highways and several roads that are eligible for this designation, including the following roadways:

- Shasta County: State Route 151 from Shasta Dam to Lake Boulevard is designated as a State Scenic Highway due to views of the Sacramento River, Shasta Lake, and distant hills. State Routes 299, 44, and 89 are eligible for State Scenic Highway designation (CalTrans 2014a, 2014d).

- Tehama County: State Routes 89 and 36 are eligible for State Scenic Highway designation (CalTrans 2014e).
- Yolo County: A portion of State Route 16 is eligible for State Scenic Highways designation (CalTrans 2014f).
- Solano County: A portion of State Route 37 is eligible for State Scenic Highways designation (CalTrans 2014g).
- Napa County: Portions of State Routes 29 and 121 are eligible for State Scenic Highways designation (CalTrans 2014h).

#### 14.3.2.1.3 Feather River Watershed

Antelope Lake, Lake Davis, Frenchman Lake, Lake Oroville, and Thermalito Afterbay on the Feather River are human-built reservoirs providing visual contrast with surrounding terrain.

*Upper Feather River*

Antelope Lake, Lake Davis, and Frenchman Lake are located in the upper Feather River watershed (DWR 2013a; USFS 2006a, 2006b, 2011). Antelope Lake, located on Indian Creek, has the longest dam of the three reservoirs. This remote lake, surrounded by pine and fir trees, can be viewed from Fruit Growers Boulevard and Indian Creek Road. Lake Davis is formed by Grizzly Dam on Big Grizzly Creek, and is the largest of the three dams. It is located in the upper watershed surrounded by many trees, and can be viewed from Beckwourth-Taylorsville Road and Lake Davis Road. Frenchman Lake, located on Last Chance Creek, is formed by the tallest dam of the three dams. This lake also is surrounded by trees to the waterline and can be viewed from Little Last Chance Creek Road and Frenchman Lake Road.

*Lake Oroville and Thermalito Reservoir*

The terrain adjacent to Lake Oroville is generally quite steep with limited vehicular access. Most views of the water are from the bridges on State Route 162, State Route 70, and several county roads. Some residents live in the lands around Lake Oroville and Thermalito Afterbay. The residents can easily view the water and visitors can view the structures. As described above for Shasta Lake and other reservoirs in the upper Sacramento River watershed, Lake Oroville water levels decline as summer progresses, leaving a ring of bare soil along the water's edge. In extremely dry years at Lake Oroville, more than 200 vertical feet of bare mineral soils in a "bathtub ring" may be exposed when the surface water elevation approaches 710 feet above mean sea level (DWR 2007).

The Diversion Pool between Oroville Dam and Thermalito Diversion Dam extends about 4.5 miles along the Feather River and meanders through hillsides with substantial vegetation within widths ranging from 50 to 200 feet (DWR 2007). Vistas of the Diversion Pool are primarily viewed by recreationists on the water or along the adjacent trails. A 1.9-mile-long concrete Thermalito Power Canal appears as a contrast from State Route 70 and county roads to the undeveloped landscape between the Diversion Dam and the Thermalito Forebay.

The Thermalito Forebay is a 630-acre reservoir, approximately 3 miles in length that can be viewed by recreationists along or within the open water and travelers along State Route 70 as the roadway extends from the foothills to the valley floor. Water levels in these human-built features generally vary by 2 to 4 feet during a week. When the water levels are low, exposed bare soils create a "bathtub ring" effect.

Thermalito Afterbay is located in a more flat terrain than Lake Oroville and can be viewed from many locations and residences. The Thermalito Afterbay Dam is located parallel to State Route 99 and rises over 30 feet above the roadway (DWR 2007). The Thermalito Afterbay is approximately 4,300 acres and is visible from State Route 162, several county roads, recreation areas, and neighboring residences. Because the afterbay is located on flat lands with minimal foothills, vistas from the water or lands surrounding the afterbay extend from the Sierra Nevada foothills to the Feather River on the valley floor. Water levels in the afterbay generally vary by 2 to 6 feet during a week, but can decline by as much as 11 feet. When the water levels are low, exposed bare soils create a "bathtub ring" effect.

The low flow channel of the Feather River extends from the Diversion Dam through the community of Oroville (DWR 2007). Urban land uses and other buildings, including the Feather River Fish Hatchery, are located along the channel upstream of the State Route 70 bridge. The Oroville Wildlife Area extends from State Route 70 on the east, downstream of the bridge, and includes the Thermalito Afterbay area. Dredge tailings from hydraulic mining that occurred over 100 years ago occur along the low flow channel with some of the tailings reaching heights of more than 40 feet above the roadway.

*Wild and Scenic Rivers and Scenic Highways in the Feather River Watershed*

Within the Central Valley Region considered in this EIS, the Middle Fork Feather River (from Beckworth to Lake Oroville) was designated as part of Public Law 90-542 (Wild and Scenic Rivers Act) to be part of the National Wild and Scenic Rivers System on October 2, 1968.

In the Feather River watershed and adjacent Bear River watershed of the Central Valley Region, there is one designated State Scenic Highway and several roads that are eligible for this designation, including the following roadways.

- Butte County: State Route70 is eligible for State Scenic Highways designation (CalTrans 2014i).
- Plumas County: State Routes 70 and 89 are eligible for State Scenic Highways designation (CalTrans 2014j).
- Nevada County: State Route 20 from Skillman Flat Campground to half-mile east of Lowell Hill Road is designated as a State Scenic Highway and a U.S. Forest Service (USFS) Scenic Byway due to views of pine forests and results of hydraulic mining. Interstate 80 and State Routes 20, 49, and 174 are eligible for State Scenic Highways designation (CalTrans 2014k).

#### 14.3.2.1.4 Yuba River Watershed

The middle and lower Yuba River watershed extends through Nevada and Yuba counties. Upstream of New Bullards Bar Reservoir, the watershed is characterized by coniferous, mixed conifer/hardwood, and ponderosa pine forests along steep canyons. Most of the upper watershed is undeveloped with rural communities located along State Route 49 (DWR et al. 2007).

New Bullards Bar Reservoir, on the Yuba River and in Yuba County, is a human built reservoir providing visual contrast of the lake surface with mountainous landscape with conifers and mixed hardwood forests (DWR et al. 2007). There are many locations in the watershed to view the lake and the adjacent forests. Recreational developments are located near the marina and campgrounds near the shoreline.

Downstream of New Bullards Bar Reservoir along the Middle Yuba River and to Englebright Reservoir (located in Nevada and Yuba counties), the landscape is characterized by rolling hills with hardwood and coniferous trees and grasslands (DWR et al. 2007, USACE 2012). This portion of the watershed is rural with communities located along State Route 20.

Downstream of Englebright Reservoir, the landscape includes grasslands and agricultural fields with several small communities (USACE 2012). Along the river, the landscape is dominated by remnants of historic gold and gravel mining and ongoing gravel mining activities with minimal riparian vegetation. This portion of the watershed can be viewed from State Route 20.

#### 14.3.2.1.5 Middle and Lower American River Watershed

The middle and lower American River watershed extends through Placer, El Dorado, and Sacramento counties. Upstream of Folsom Dam, much of Placer and El Dorado counties are characterized by undeveloped rolling grasslands and oak woodlands with sporadic agricultural activities related to orchards, vineyards, ornamental flowers, and Christmas tree farms in the wooded foothills. Communities have been developed throughout the counties especially near Interstate 80, U.S. Highway 50, and State Routes 49 and 89.

Folsom Lake, on the American River, is a human built reservoir providing visual contrast with the foothill landscape. Views from the water surface provide panoramic vistas of the foothills with open grasslands, oak woodlands, and pine woodlands. Folsom Lake is generally considered to provide a pleasing visual setting for recreationists, residences, and from roadways along the foothills above the reservoir, especially from the Lake Overlook and the Folsom Dam Observation Point vista points. Increased population in the communities around the lake have provided more scenic view points, including increased vistas of human-built structures such as electric transmission facilities, roadways, dams, and residential subdivisions. Reservoir levels fluctuate and decline as summer progresses, leaving a “bathtub ring” of bare soil along the water’s edge. The visual quality also degrades because visitors drive vehicles onto the exposed soils which cause tire tracks and erosion (Reclamation et al. 2006).

Lake Natoma extends from Folsom Dam along the American River to Nimbus Dam. The land along the river is mostly undeveloped and includes wooded canyon areas, sheer bluffs, and dredge tailings from the gold mining era. Residential and community developments have been constructed along the foothills that overlook the canyon, and these structures can be seen by recreationists from the water or adjacent trails. Lake Natoma can be viewed from U.S. Highway 50 and local roads.

Downstream of Nimbus Dam to Gristmill Recreation Area (downstream of William B. Pond Recreation Area and approximately 2 miles upstream from the Watt Avenue Bridge), the American River flows through a landscape characterized by steep bluffs, terraces, mid-river sand and gravel bars, backwater areas along the edges, and riparian vegetation. This viewshed is seen from the recreational areas on the water and adjoining trails, from the bridge crossings, and from residences along the terraces and foothills. Downstream of the Gristmill Dam Recreation Area, the visual characteristics are less complex with an increased number of bridges, water treatment plant intake, and artificial bank protection. The communities along the American River corridor include the cities of Folsom, Roseville, Rancho Cordova, and Sacramento and unincorporated areas. The communities, transportation infrastructure, and water-river corridor are visible from multiple vantage points.

*Wild and Scenic Rivers and Scenic Highways in the American River Watershed*

Within the American River watershed, the Lower American River from Nimbus Dam to the confluence with the Sacramento River were designated by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also designated the Lower American River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545. In addition, the state designated the North Fork American River from the source to Iowa Hill Bridge as wild and scenic.

In the portion of the American River watershed in the study area of this EIS, there is one roadway designated as a State Scenic Highway and one road that is eligible for this designation. In El Dorado County, U.S. Highway 50 from Government Center Interchange in Placerville to South Lake Tahoe is designated as a State Scenic Highway due to vistas of the American River canyon, suburban foothills, granite peaks, and Lake Tahoe. Also in El Dorado County, State Route 49 is eligible for State Scenic Highways designation (CalTrans 2014l).

#### ***14.3.2.2 San Joaquin Valley***

The San Joaquin Valley land cover ranges from high alpine vegetation near the crest of the Sierra Nevada Mountains, through coniferous forest, mixed forest, oak woodlands and oak savanna, to grasslands and agricultural areas at the lower elevations (Reclamation 1997, 2005a, 2005b). Water bodies include reservoirs, natural lakes and ponds, rivers, and tributary streams. The human-built environment is more dominant at lower elevations, and includes roadways, communities, roadside businesses, and transmission lines, detracting from views of the natural environment. On the valley floor, the San Joaquin Valley is characterized by agricultural lands, including many that are irrigated with CVP and/or SWP water supplies. The valley is arid to semi-arid, and there are few natural lakes or streams on the valley floor.

Several wetlands have been established as wildlife refuges in the San Joaquin Valley (as described in Chapter 10, Terrestrial Biological Resources), providing views of water and vegetation, enhanced seasonally by waterfowl and seasonal wildflowers.

The predominant land use is agricultural, with sparse to moderate populations. Interstate 5 and major railroads pass along the western San Joaquin Valley at the base of the Coast Ranges foothills. State Route 99 and other railroads are located along the eastern San Joaquin Valley at the base of the Sierra Nevada foothills. Interstate 580 and State Routes 152, 198, and 46 cross the San Joaquin Valley from east to west between Interstate 5 and State Route 99. Larger cities have been established in the northern San Joaquin Valley, including Lodi, Stockton, Lathrop, Manteca, and Tracy; and along State Route 99, including Merced, Fresno, Visalia, and Bakersfield. Both Interstate 5 and State Route 99 are extensively traveled and provide numerous viewing opportunities.

#### 14.3.2.2.1 Northern San Joaquin Valley

In the northern San Joaquin Valley, the foothills range from rolling hills to mountainous terrain with riparian corridors that range from narrow canyons to alluvial plains. The San Joaquin, Stanislaus, Merced, and Tuolumne rivers are the principal water features that flow from the Sierra Nevada foothills. One or more reservoirs are located along each of these rivers, including the CVP New Melones Reservoir on the Stanislaus River and Millerton Lake on the San Joaquin River. Other reservoirs are owned and operated by local and regional water suppliers, as described in Chapter 5, Surface Water Resources and Water Supplies. Dredge tailings have been deposited along some of the rivers as the streams flow from the mountains into the foothills.

The CVP New Melones Reservoir is located in the western foothills of the Sierra Nevada along the Stanislaus River. The area is characterized by foothills, ridges, and small valleys with vegetated slopes and the open water surface (Reclamation 2010). The vegetation is primarily grasslands and oak woodlands with varying densities, with gray pine and low shrubs along some slopes. Views of the water are primarily from the water surface, adjacent recreation areas, and State Route 49. The surrounding lands are rural and undeveloped except for the infrastructure associated with the dam, canals, and power generation facilities and some minor structures associated with the recreation areas and utility lines. When the reservoir is drawn down, broad bands of bare soil are exposed.

Millerton Lake also is located in the western foothills of the Sierra Nevada along the San Joaquin River in an area that ranges from grasslands and rolling hills near Friant Dam to steep, craggy slopes in the upper reaches of the lake (Reclamation et al. 2011a). The lake, dam infrastructure, and surrounding hills can be viewed from the lake surface and adjacent county roads. Development has occurred along the hillsides that can be viewed from the lake surface and adjacent recreation areas; however; future development will be regulated by Madera and Fresno counties to protect visual and scenic resources. When the reservoir is drawn down, broad bands of bare soil are exposed. The Madera Canal and Friant-Kern Canal extend from Millerton Lake to the north and south, respectively. The canals are located along the Sierra Nevada foothills through mostly agricultural landscapes and limited residences (Reclamation et al. 2011, Reclamation 1997). The canals are only intermittently visible from county roads.

#### 14.3.2.2.2 Western San Joaquin Valley

The Coast Range foothills on the western side of the northern San Joaquin Valley are sparsely populated and characterized by mountainous to hilly terrain with grasslands and scattered oak woodlands along narrow streams. The CVP and SWP San Luis Reservoir complex is located within the western foothills; and the CVP and SWP water supply canals are located at the base of the foothills to the north and south of the San Luis Reservoir.

The CVP and SWP water supply facilities are prominent features in the viewshed of the San Joaquin Valley, including facilities at or near San Luis Reservoir, Delta-Mendota Canal, San Luis Canal-California Aqueduct, Cross Valley Canal, New Melones Reservoir, and Millerton Lake. The San Luis Reservoir, O'Neill Forebay, and Los Banos Creek Reservoir are located in northwestern San Joaquin Valley. State Route 152 is located along the northern and eastern rims of San Luis Reservoir and the western rim of O'Neill Forebay (Reclamation and State Parks 2013). O'Neill Forebay and Los Banos Creek Reservoir can be seen to the west from Interstate 5. The reservoirs are also part of the visual resources for the San Luis Reservoir State Recreation Area, Pacheco State Park, and Upper and Lower Cottonwood Wildlife Areas (which are described in Chapter 10, Terrestrial Biological Resources, and Chapter 15, Recreation Resources). The shorelines of the reservoirs are undeveloped, except for recreational facilities. Views included annual grassland, coastal sage, and riparian woodland. When the reservoirs are drawn down, broad bands of bare soil are exposed. Open water viewing opportunities also occur to the south of the San Luis complex at the Little Panoche Reservoir located to the west of Interstate 5.

The open water and canal infrastructure of the Delta-Mendota Canal, San Luis Canal-California Aqueduct, Cross Valley Canal, and irrigation district canals can be viewed from Interstate 5 and the railroad lines along the western San Joaquin Valley. The open water of Mendota Pool is located at the terminus of the Delta Mendota Canal and can be viewed from county roads.

#### 14.3.2.2.3 Southern San Joaquin Valley

In the southern portion of the San Joaquin Valley, the Kings, Kaweah, Tule, and Kern rivers are the principal water features along the eastern Sierra Nevada foothills. One or more reservoirs are located along each of these rivers. Riparian vegetation and oak woodlands occur along these river corridors. The western Coast Ranges foothills are characterized by distinct, folded foothills with grasslands and infrequent oak woodlands along small drainages. The Tehachapi Mountains rise abruptly along the southern boundary of the valley.

#### 14.3.2.2.4 Wild and Scenic Rivers and Scenic Highways in the San Joaquin Valley

In the San Joaquin Valley within or near the Central Valley Region considered in this EIS, four rivers were designated to be part of the National Wild and Scenic Rivers System. Portions of the Tuolumne River from the source waters to Don Pedro Reservoir were designated through Public Law 98-425 as wild and scenic. Portions of the Merced River were designated through Public Laws 100-149 and 102-432 as wild and scenic, including the entire South Fork and the mainstem from the source waters to Lake McClure. Portions of the Kings River were designated as wild and scenic through Public Law 100-150, including the Middle Fork and South Fork from their respective sources to the confluences with the mainstem; and the mainstem from these confluences to an elevation of 1595 feet above mean sea level (upstream of the confluence with the North Fork and Pine Flat Lake). Portions of the Kern River were designated as wild and scenic through Public Law 100-174, including the North Fork from the source to the Tulare County/Kern County boundary; and the South Fork from the source to the Domeland Wilderness. Most of these reaches are located outside of the Central Valley Region; however, the flows from these reaches could influence the visual resources of downstream reaches in the Central Valley Region.

In the San Joaquin Valley of the Central Valley Region, there are five roadway sections designated as a State Scenic Highway and seven roadway sections that are eligible for this designation.

- San Joaquin County and Alameda County: Interstate 580 from Interstate 5 to State Route 205 is designated as a State Scenic Highway due to vistas of the Coast Ranges and Central Valley. Interstate 5 from the Stanislaus County boundary to Interstate 580 is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014m, 2014n).
- Stanislaus County: Interstate 5 from the San Joaquin County boundary to the Merced County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014o).
- Merced County: Interstate 5 from State Route 152 to the Stanislaus County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014p). State Route 152 from Interstate 5 to the Santa Clara County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the San Luis Reservoir State Recreational Area.
- Fresno County: State Routes 168, 180, and 198 are eligible for State Scenic Highways designation (CalTrans 2014q).

- Tulare County: State Routes 190 and 198 are eligible for State Scenic Highways designation (CalTrans 2014s).
- Kern County: State Routes 14 and 58 are eligible for State Scenic Highways designation (CalTrans 2014t).

#### *14.3.2.3 Delta and Suisun Marsh*

Most of the Delta is used for agricultural purposes with major waterways and sloughs that connect the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers (CALFED 2000). Flood management and irrigation facilities include levees, impoundments, pumping plants, and control gate structures. Bodies of open water occur where historic levee failures were not repaired, including Franks Tract and Liberty Island. The Sacramento Deep Water Ship Channel is a larger water feature between levees that extends from the Sacramento River near Rio Vista to West Sacramento. Cities within the Delta include the southern portion of Sacramento, Isleton, West Sacramento, Rio Vista, Lathrop, western portions of Stockton and Manteca, Tracy, Brentwood, Oakley, Antioch, and Pittsburg. Small communities to serve the agriculture and recreation users include Freeport, Clarksburg, Hood, Courtland, Locke, Walnut Grove, Ryde, Thornton, Knightsen, and Collinsville. Vistas of the Delta can be seen from residences and agricultural areas in the Delta, open water areas used by recreationists, and from vehicles on roadways and railroads that cross the Delta. Waterfront industries are located along the rivers, especially along the San Joaquin River.

The Suisun Marsh is characterized by tidal and freshwater wetlands and riparian woodlands (Reclamation et al. 2010). The area is bounded by Interstate 80 and State Route 12 on the north; the Montezuma Hills and Sulphur Springs Mountains on the east and west, respectively; and on the south by the open waters of Suisun Bay, Grizzly Bay, and Honker Bay with adjoining wetlands, marshes, and riparian forests. The marsh is relatively flat and comprised primarily of tidal marsh and submerged lands. Upland areas serve as a backdrop with grasslands and nearby rolling foothills. Vistas of Suisun Marsh can be viewed from adjacent roadways railroads; roads and trails within the marsh; a few residences within the marsh; and open water that can be accessed by boats, kayaks, and canoes. Much of Suisun Marsh is managed wetlands and provides habitat for resident and migrating birds and waterfowl.

##### 14.3.2.3.1 Scenic Highways in the Delta

In the Delta and Suisun Marsh portion of the Central Valley Region, there two roadway sections designated as a State Scenic Highway and two roadway sections that are eligible for this designation.

- Sacramento County: State Route 160 between the southern limits of the City of Sacramento to the Contra Costa County boundary is designated as a State Scenic Highway due to the views of historic Delta agriculture and small towns along the Sacramento River (CalTrans 2014u).

- Contra Costa County: State Route 160 from the Antioch Bridge to State Route 4 and State Route 4 continuing on towards Brentwood are eligible for State Scenic Highways designation (CalTrans 2014v).

### 14.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. The San Francisco Bay Area Region ranges in topography from sea level to the East Bay and South Bay foothills that reach elevations of 3,500 feet and higher (CALFED 2000; WTA 2003; Reclamation 2005c). It offers a diverse physical and natural environment, and a wide range of visual resources. Typical views and landscapes include urban development, natural and altered open-space areas, major ridgelines, and scenic waterways. The terrain ranges from alluvial plains to gently sloping hills and wooded ravines. Striking views of iconic scenes are available throughout the area, of San Francisco Bay, the San Francisco skyline, Angel Island, Mount Tamalpais, Peninsula foothills, and the East Bay hills. Views to the east are dominated by Mount Diablo and adjacent Diablo Ridge and valleys. Views in the South Bay extend through the baylands that extend along the Contra Costa, San Mateo, Santa Clara, and Alameda counties shorelines; the river floodplains of the Guadalupe River and Coyote Creek in Santa Clara County; and towards the Santa Cruz Mountains (Santa Clara County 1994).

Urban and industrial areas are located throughout the San Francisco Bay Area Region, including along the San Francisco Bay shoreline. Smaller, localized scenic resources include wetlands, isolated hilltops, rock outcroppings, mature stands of trees, lakes, reservoirs, and other natural features. City parks and recreation areas, open-space areas adjacent to ravines, golf courses, and resource preserves provide visual opportunities in urban areas. The reservoirs that store CVP or SWP water or water from other surface water sources are human built reservoirs located in the foothills or at the edge of the foothills. The water can be viewed from roadways located at elevations higher than the reservoirs and by recreationists on the reservoirs. Agricultural areas that use CVP and SWP water are located within coastal valleys especially within the Livermore-Amador valleys of Alameda County, southern Santa Clara County, and northern San Benito County.

#### *14.3.3.1 Scenic Highways in the San Francisco Bay Area Region*

In the San Francisco Bay Area Region, there are four roadway sections designated as a State Scenic Highway and five roadway sections that are eligible for this designation.

- Contra Costa County: State Route 24 from the Alameda County boundary to Interstate 680, and Interstate 680 from State Route 24 to Interstate 580 at the Alameda County boundary are designated as State Scenic Highways due to the views of Mount Diablo and attractive residential and commercial areas (CalTrans 2014v).

- Alameda County: Interstate 580 between Interstate 80 and State Route 92 are designated as a State Scenic Highways (CalTrans 2014n). Portions of Interstate 680 from the Contra Costa County boundary to Mission Boulevard in Fremont and portions of State Route 84 are designated as State Scenic Highways due to vistas of wooded hillsides and valleys. Other portions of Interstate 580 are eligible for State Scenic Highways designation.
- Santa Clara County: Portions of State Routes 152 and 280 within the San Francisco Bay Area Region are eligible for State Scenic Highways designation (CalTrans 2014w).
- San Benito County: Portions of State Routes 156 and 25 within the San Francisco Bay Area Region are eligible for State Scenic Highways designation (CalTrans 2014x).

### 14.3.4 Central Coast and Southern California Regions

The Central Coast and Southern California Regions include portions of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

Areas along the Pacific Coast in San Luis Obispo, Santa Barbara, Ventura, portions of Los Angeles, portions of Orange, and San Diego counties are characterized by steep, craggy coastal mountains and coastal plains that can be viewed from the roadways, residences, and the Pacific Ocean. The visual resources include beaches, sand dunes, coastal bluffs, headlands, wetlands, estuaries, islands, hillsides, and canyons (Santa Barbara County 2009, SBCAG 2013). The foothills extend from the Pacific Ocean to more than 800 feet above mean sea level; and the mountains extend to more than 3,000 feet above mean sea level. The foothills are generally covered with mature trees and shrubs, including native oaks, deciduous trees, and eucalyptus. The coastal plains gradually slope towards the foothills with streams through the plains. Small to medium size communities occur along the coast and the coastal plains in San Luis Obispo, Santa Barbara, and Ventura counties and within portions of the coastline in Los Angeles, Orange and San Diego counties. Larger communities also are located along the coastline separated by large areas of undeveloped lands.

Inland from the Pacific Ocean, urban areas extend throughout large portions of the foothills and valleys of Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties. Reduced abundance of natural features, vistas, and non-urban land uses may diminish the visual resources for many viewers (SCAG 2010). However, in many inland areas urban areas are separated by areas of undeveloped or agricultural lands, especially in Riverside and San Bernardino counties. Minimal development has occurred within the higher elevations of the Central Coast and Southern California regions, as described in Chapter 13, Land Use. Therefore, the mountainous areas (such as the San Gabriel, Santa Monica, Santa Ana, Santa Rosa, and San Jacinto mountains) provide dramatic viewsheds from the valleys (Los Angeles 2011, RCIP 2000, San Bernardino County 2007). The mountains also are characterized by deep canyons, rock outcroppings, and sparse vegetation. In the Coachella Valley portion of Riverside County, the visual resources are dominated by dramatic vistas of the Santa Rosa, San Jacinto, San Bernardino, Cottonwood, and Chocolate mountains with high desert craggy rock outcroppings and sparse vegetation. The Salton Sea in the southern Coachella Valley provides dramatic vistas from the shoreline and highways that extend around the open water.

The inland areas also include major surface water resources that provide open water vistas, including Twitchell Reservoir, Silverwood Lake, Diamond Valley Lake, Lake Perris, Lake Skinner, Vail Lake, and Lake Mathews; and smaller water supply reservoirs. Many of these reservoirs store CVP and SWP water and are human built reservoirs located in the foothills or at the edge of the foothills. The water can be viewed from highways located at elevations higher than the reservoirs and by recreationists on the reservoirs.

#### *14.3.4.1 Wild and Scenic Rivers and Scenic Highways in the Central Coast and Southern California Regions*

The wild and scenic rivers in the Central Coast and Southern California areas are not located within the study area of this EIS.

In the Central Coast and Southern California regions, there are seven roadway sections designated as State Scenic Highways and several roadway sections that are eligible for this designation.

- San Luis Obispo County: U.S. Highway 1 from the Monterey County boundary to the City of San Luis Obispo is designated as a State Scenic Highway and an All American Road due to dramatic vista along the mountains and rocky headlands of the Pacific Ocean coastline (CalTrans 2014y). Portions of State Route 41 and Interstate 101 are eligible for State Scenic Highways designation.
- Santa Barbara County: U.S. Highway 1 from Interstate 101 near Las Cruces to near Lompoc is designated as a State Scenic Highway due to dramatic vista along the mountains and rocky headlands of the Pacific Ocean coastline (CalTrans 2014z). Portions of Interstate 101 are eligible for State Scenic Highways designation.
- Ventura County: State Route 33 from the Santa Barbara County boundary to the north of the junction with State Route 150 is designated as a State Scenic Highway and a USFS Scenic Byway due to dramatic vista along the mountains between the Coast Ranges and the Central Valley with landscapes that range from pine forests to semi-desert vegetation (CalTrans 2014aa). Portions of Interstate 101 and State Routes 33 and 1 are eligible for State Scenic Highways designation.
- Los Angeles County: State Route 2 from near La Cañada-Flintridge to the San Bernardino County boundary is designated as a State Scenic Highway and a U.S. Forest Service Scenic Byway due to dramatic vista along the San Gabriel Mountains with vistas of the Mojave Desert and the Los Angeles Basin (CalTrans 2014ab). Portions of Interstate 101, 210, and 110 and State

Routes 1, 23, 27, 39, 118, and 126 are eligible for State Scenic Highways designation.

- Orange County: State Route 91 from State Route 55 to the City of Anaheim is designated as a State Scenic Highway due vistas of the Santa Ana River and urban development with intermittent riparian and chaparral vegetation (CalTrans 2014ac). State Routes 1, 57, and 74 and portions of State Route 91 are eligible for State Scenic Highways designation.
- San Diego County: State Route 75 from the City of Imperial Beach to Coronado is designated as a State Scenic Highway due to vistas of the Pacific Ocean, San Diego Harbor, and the Coronado Bridge (CalTrans 2014ad). State Route 125 between State Routes 94 and 8 is designated as a State Scenic Highway due to vistas of Mt. Helix and attractive residential and commercial areas. Interstate 5 and 8 and portions of State Routes 52, 76, and 93 within the Southern California Region are eligible for State Scenic Highways designation.
- Riverside County: State Route 243 from the City of Banning to State Route 74 is designated as a State Scenic Highway and a U.S. Forest Service Scenic Byway due to the vistas of the San Bernardino Mountains and valley (CalTrans 2014ae). Interstate 15 and State Routes 71, 74, 91, and 111 are eligible for State Scenic Highways designation.
- San Bernardino County: State Routes 2, 18, 38, 138, 173, 189, and 247 are eligible for State Scenic Highways designation (CalTrans 2014af).

## 14.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in visual resources; results of the impact analysis; potential mitigation measures; and cumulative effects.

### 14.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in visual resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change the vistas at reservoirs that store CVP and SWP water during dry and critical dry water years and at irrigated agricultural lands during dry and critical dry water years when the crops are idled.

#### *14.4.1.1 Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Vistas at reservoirs that store CVP and SWP water provide a wide diversity of visual experiences related to the contrasts between the open water surface and surrounding foothills or mountains. By the end of September, the surface water elevations decline, and a bare "bathtub ring" appears in contrast to the open water and the upslope vegetation. Changes in CVP and SWP operations under the alternatives could change the extent of the "bathtub" ring over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison.

The CalSim II model output includes monthly reservoir elevations for CVP and SWP reservoirs in the Central Valley and Trinity Lake. The end-of-September reservoir elevations in dry and critical dry water years generally indicate low reservoir elevations. To assess changes in visual resources, changes in reservoir storage elevations for the end of September in dry and critical dry years were compared between alternatives and the No Action Alternative and Second Basis of Comparison.

Reservoirs in the San Francisco Bay Area, Central Coast, and Southern California regions store water from multiple water supplies including CVP and SWP water; however, these reservoirs are not included in the CalSim II model simulation. For the purposes of this EIS analysis, changes in surface water elevations in these reservoirs were assumed to be related to changes in CVP and SWP water deliveries to the areas located to the south of the Delta.

#### *14.4.1.2 Changes in Vista at Irrigated Agricultural Lands*

Agrarian vistas of irrigated row crops, orchards, and grazing lands intermixed within a landscape of grasslands, large water canals, isolated riparian corridors, and several small communities occur throughout the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions. Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and the associated vistas over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison. However, as described in Chapter 12, Agricultural Resources, the extents of irrigated acreage between Alternatives 1 through 5 are similar to irrigated acreage under the No Action Alternative and the Second Basis of Comparison. Therefore, changes in CVP and SWP operations would not change irrigated acreage and as a result they are not analyzed in this EIS.

#### *14.4.1.3 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water; pumping groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that use less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future visual conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 14.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to visual resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *14.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end-of-September storage would also reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop-idling.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change visual resources, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that would affect visual resources, including:

- Restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass
- Restoration of Battle Creek
- Implementation of Red Bluff Pumping Plant

### 14.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

#### *14.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 14.4.3.1.1 Trinity River Region

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations (changes within 5 percent) and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

##### 14.4.3.1.2 Central Valley Region

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be reduced by 6.2 percent in wet and critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to visual resources were identified as changes in reservoir surface water elevations, streams, irrigated acreage, and water elevations in canals that would convey transferred water. The analysis indicated that these potential impacts would not be substantial because the conditions with and without the water transfers would be similar.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

##### 14.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis. Monthly deliveries are not necessarily indicative of reservoir storage because all or a portion of the water deliveries could be directly conveyed to water users in any specific month. Therefore, annual deliveries are considered to be relatively proportional to the amount of water that could be stored over all water year types. In the San Francisco Bay Area Region, values for the CVP municipal and industrial water deliveries and the SWP south of the Delta water deliveries (without Article 21 deliveries) were considered; and SWP south of the Delta water deliveries (without Article 21 deliveries) were considered for the Central Coast and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison CVP water deliveries would be reduced by 10 percent and SWP water deliveries would be reduced by 18 percent. Therefore, for this EIS analysis, it is assumed that visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

#### *14.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because visual resource conditions under Alternative 1 are identical to visual resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 14.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be increased by 6.6 percent in wet and critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on visual resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 1 as compared to the No Action Alternative, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 11 to 21 percent in the San Francisco Bay Area Region and 21 percent in the Central Coast and Southern California regions.

#### 14.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *14.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 14.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative.  Therefore, changes to visual resources conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 14.4.3.1, No Action Alternative.

#### *14.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.  As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 14.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in below-normal, dry, and critical dry years, as described in Chapter 5, Surface Water Resources and Water Supplies.  Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be increased by 7.9 percent in wet years and 5.7 percent in above-normal years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of

Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on visual resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the No Action Alternative, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 9 to 17 percent in the San Francisco Bay Area Region and 17 percent in the Central Coast and Southern California regions.

#### 14.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on visual resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the Second Basis of Comparison, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be similar (changes within 5 percent).

#### *14.4.3.5 Alternative 4*

The visual resources conditions under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 14.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in visual resources conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 14.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *14.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle Rivers (OMR) flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 14.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on visual resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 5 as compared to the No Action Alternative, visual resources would be similar.

#### 14.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in wet, above-normal, and below-normal years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in dry year and critical dry years because the end-of-September surface water elevations would be decreased by 6.2 percent in dry years and 8.5 percent in critical dry years.

*Effects Related to Cross Delta Water Transfers*

Potential effects to visual resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on visual resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water*

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 5 as compared to the Second Basis of Comparison, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

#### *14.4.3.7 Summary of Impact Assessment*

The results of the impact assessment of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 14.1 and 14.2.

**Table 14.1 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be increased by 6 percent in wet and critical dry years at San Luis Reservoir, by 11 to 21 percent in the San Francisco Bay Area Region, and by 21 percent in the Central Coast and Southern California regions. | None needed. |
| Alternative 2 | No effects on visual resources. | None needed. |
| Alternative 3 | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be increased by 8 percent in wet years and 6 percent in above-normal years at San Luis Reservoir, by 9 to 17 percent in the San Francisco Bay Area Region, and by 17 percent in the Central Coast and Southern California regions. | None needed. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed. |
| Alternative 5 | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions. | None needed. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 14.2 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be reduced by 6 percent in wet and critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions. | Not considered for this comparison. |
| Alternative 1 | No effects on visual resources. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions. | Not considered for this comparison. |
| Alternative 4 | No effects on visual resources. | Not considered for this comparison. |
| Alternative 5 | Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be reduced by 6 percent in dry years and 9 percent in critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

#### *14.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5, as compared to the No Action Alternative, would not result in changes in visual resources. Therefore, there would be no adverse impacts to visual resources and no mitigation measures are required.

#### *14.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Visual Resources are summarized in Table 14.3.

**Table 14.3 Summary of Cumulative Effects on Visual Resources with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project | <u>These effects would be the same under all alternatives.</u><br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce end of September storage in CVP and SWP reservoirs compared to past conditions, and to reduce CVP and SWP water supply reliability which could result in less irrigated lands compared to past conditions.<br>General plans would be completed for projected conditions by 2030, as described in Chapter 13, Land Use. Restoration plans for the ongoing programs would be completed which would change visual resources of the restored lands. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- San Luis Reservoir Low Point Improvement Project<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same under all alternatives.</u><br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the future reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries and associated extent of irrigated lands. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce end of September CVP and SWP reservoir storage as compared to past conditions.<br>Community development would occur in accordance with general plan projections for 2030. Restoration plans for the ongoing programs would be completed.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with added actions. |

## 14.5 References


BCDC (San Francisco Bay Conservation and Development Commission). 1976. *Suisun Marsh Protection Plan*. Site accessed February 13 and March 25, 2013. http://www.bcdc.ca.gov/laws_plans/plans/suisun_marsh.shtml

BLM et al. (Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Forest Service). 2012. *River Mileage Classifications for Components of the National Wild and Scenic Rivers System*. September.

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://bvh2o.com/James.html

CALFED (CALFED Bay-Delta Program). 2000. *Final Programmatic Environmental Impact Report/Environmental Impact Statement.* July. Sacramento.

CalTrans (California Department of Transportation). 2014a. California Scenic Highway Program. Site accessed February 16, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_hi67ghways/trinity.htm.

CalTrans (California Department of Transportation). 2014b. California Scenic Highway Program. Site accessed February 16, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/humboldt.htm.

CalTrans (California Department of Transportation). 2014c. California Scenic Highway Program. Site accessed February 16, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/delnorte.htm.

CalTrans (California Department of Transportation). 2014d. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/shasta.htm.

CalTrans (California Department of Transportation). 2014e. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/Tehama.htm.

CalTrans (California Department of Transportation). 2014f. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/yolo.htm.

CalTrans (California Department of Transportation). 2014g. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/solano.htm.

CalTrans (California Department of Transportation). 2014h. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/napa.htm.

CalTrans (California Department of Transportation). 2014i. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/butte.htm.

CalTrans (California Department of Transportation). 2014j. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/plumas.htm.

CalTrans (California Department of Transportation). 2014k. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/nevada.htm.

CalTrans (California Department of Transportation). 2014l. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/el dorado.htm.

CalTrans (California Department of Transportation). 2014m. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/san joaquin.htm.

CalTrans (California Department of Transportation). 2014n. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/alameda.htm

CalTrans (California Department of Transportation). 2014o. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/stanislaus.htm.

CalTrans (California Department of Transportation). 2014p. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/merced.htm.

CalTrans (California Department of Transportation). 2014q. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/fresno.htm.

CalTrans (California Department of Transportation). 2014r. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/kings.htm

CalTrans (California Department of Transportation). 2014s. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/tulare.htm.

CalTrans (California Department of Transportation). 2014t. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014u. California Scenic Highway Program. Site accessed February 17, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/sacramento.htm.

CalTrans (California Department of Transportation). 2014v. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/contra costa.htm

CalTrans (California Department of Transportation). 2014w. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014x. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014y. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014z. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014aa. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/ventura.htm

CalTrans (California Department of Transportation). 2014ab. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014ac. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/orange.htm

CalTrans (California Department of Transportation). 2014ad. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

CalTrans (California Department of Transportation). 2014ae. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/riverside.htm

CalTrans (California Department of Transportation). 2014af. California Scenic Highway Program. Site accessed February 18, 2014. http://www.dot.ca.gov/hq/LandArch/scenic_highways/

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

DOT (U.S. Department of Transportation, Federal Highway Administration). 1981, Reprinted 1989. *Visual Impact Assessment for Highway Projects, Publication No. FHWA-HI-88-054.*

DWR (California Department of Water Resources). 2007. *Draft Environmental Impact Report Oroville Facilities Relicensing—FERC Project No. 2100.* May.

DWR (California Department of Water Resources). 2013a. *Upper Feather River Lakes*. April.

DWR (California Department of Water Resources). 2013b. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report.* December.

DWR, Reclamation, USFWS, and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

DWR et al. (California Department of Water Resources, Yuba County Water Agency, Bureau of Reclamation). 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord*. June.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

KRCD (Kings River Conservation District). 2012b. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP).*

Los Angeles County (County of Los Angeles). 2011. *Public Review Draft 4/5/11 Text-Only Version, Los Angeles County General Plan 2035*. April.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

National Wild and Scenic Rivers System. 2013. State Listings. California. Site accessed February 13 and March 25, 2013. http://www.rivers.gov/rivers/california.php.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NID (Nevada Irrigation District). n.d. (No date). *Combie Reservoir, Carrying Capacity and Safety Study.*

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

RCIP (Riverside County Integrated Project). 2000. *Existing Setting Report*. March.

Reclamation (Bureau of Reclamation). 1997. *Central Valley Project Improvement Act, Draft Programmatic Environmental Impact Statement*. September.

Reclamation (Bureau of Reclamation). 2005a. *Delta Mendota Canal Unit, Environmental Assessment, Long-Term Contract Renewal*. February.

Reclamation (Bureau of Reclamation). 2005b. *Central Valley Project Long-Term Water Service Contract Renewal San Luis Unit, Public Draft Environmental Impact Statement and Appendices*. September.

Reclamation (Bureau of Reclamation). 2005c. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2010. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

Reclamation (Bureau of Reclamation). 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2013. *San Luis Reservoir State Recreation*

*Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/ Environmental Impact Report*. June.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2010. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Draft Environmental Impact Statement/Environmental Impact Report*.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011b. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

San Bernardino County (County of San Bernardino). 2007. *County of San Bernardino 2006 General Plan Program, Final Environmental Impact Report and Appendices*. February.

Santa Barbara County (County of Santa Barbara). 2009. *Coastal Land Use Plan*. June.

Santa Clara County (County of Santa Clara). 1994. *Santa Clara County General Plan Draft Environmental Impact Report*. September.

SBCAG (Santa Barbara County Association of Governments). 2013. *2040 Santa Barbara County Regional Transportation Plan and Sustainable Communities Strategy, Draft Environmental Impact Report*. May.

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

SJRRP (San Joaquin River Restoration Program). 2011a. *Friant-Kern Canal Capacity Restoration, Draft Environmental Assessment, San Joaquin River Restoration Program*. June.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

USACE (U.S. Army Corps of Engineers). 2012. *Lower Yuba River Large Woody Material Management Plan Pilot Study, Yuba County, California, Final Environmental Assessment.* August.

USDA (U.S. Department of Agriculture, Forest Service). 1995. *Landscape Aesthetics, A Handbook for Scenery Management, Agriculture Handbook Number 701*. December.

USDA (U.S. Department of Agriculture, Forest Service). 2011. Shasta-Trinity National Recreation Area (NRA). Site accessed December 22, 2011. http://www.fs.usda.gov/detail/stnf/about-forest/?cid=fsm9_008651.

USFS (U.S. Department of Agriculture, Forest Service). 2006a. *Lake Davis Recreation Area*. May.

USFS (U.S. Department of Agriculture, Forest Service). 2006b. *Frenchman Lake Recreation Area*. May.

USFS (U.S. Department of Agriculture, Forest Service). 2011. *Antelope Lake Recreation Area*. July.

WTA (Water Transit Authority). 2003. *Final Program Environmental Impact Report Expansion of Ferry Transit Service in the San Francisco Bay Area*. June.

Chapter 15

# Recreation Resources

## 15.1 Introduction

This chapter describes recreational resources in the study area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect recreation resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 15.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect recreational resources at reservoirs and lands served by CVP and SWP water supplies. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 15.3 Affected Environment

This section describes recreational resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in recreation opportunities due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions. Recreational fishing in San Francisco Bay and along the Pacific Coast also may be affected by changes in CVP and SWP operations.

There are extensive recreational opportunities within this study area. However, the recreational opportunities that could be directly or indirectly affected through implementation of the alternatives analyzed in this EIS are related to water-related recreation activities at CVP and SWP reservoirs and in the rivers downstream of those reservoir, fishing opportunities in the Delta and the Pacific Ocean that are affected by the water flows managed by CVP and SWP operations, and bird watching, wildlife viewing, and hunting activities at wildlife refuges that use CVP water supplies. Therefore, the following description of the affected environment is limited to these recreational aspects. The wildlife refuges identified to receive CVP water supplies are shown on Figure 15.1.

### 15.3.1 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. Major recreational opportunities occur at Trinity Lake, Lewiston Reservoir, along the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

#### *15.3.1.1 Trinity Lake*

Trinity Lake is a CVP facility on the Trinity River that is located approximately 50 miles northwest of Redding, as described in Chapter 5, Surface Water Resources and Water Supplies. Trinity Lake is part of the Whiskeytown-Shasta-Trinity National Recreation Area and part of the Shasta-Trinity National Forest. Recreational facilities and activities at Trinity Lake are administered by the U.S. Forest Service (USFS). When the water storage in the reservoir is at full capacity (water elevation at 2370 feet mean sea level (msl), Trinity Lake has a surface area of 17,222 acres and 147 miles of shoreline (USFS 2014).

Boating, windsurfing, and fishing primarily occur in the northern part of the lake near Trinity Center. Houseboats, motorboats, water skiing primarily occur in the southern part of the lake. There are six public boat ramps on Trinity Lake as summarized in Table 15.1.

**Table 15.1 Trinity Lake Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Trinity Lake | Bowerman | – | 2,370 to 2,323 |
| Trinity Lake | Clark Spring | – | 2,370 to 2,313 |
| Trinity Lake | Fairview | – | 2,370 to 2,313 |
| Trinity Lake | Minersville | – | 2,305 to 2,170 |
| Trinity Lake | Stuart Fork | – | 2,370 to 2,338 |
| Trinity Lake | Trinity Center | – | 2,370 to 2,300 |

Source: USFS 2014

Three major marinas are located at Trinity Lake, as summarized in Table 15.2. The USFS can permit up to 1,000 boat slips at the Trinity Lake marinas (USFS 2014). Many commercial houseboats are available for rent at the marinas. Trinity Lake shoreline includes approximately 32 miles of prime houseboating areas and 18.5 miles of secondary houseboating areas. The USFS issues permits for houseboats and privately-owned recreational occupancy vehicles that use the water overnight. At Trinity Lake, up to 99 permits for privately-owned vessels and 85 permits for commercially-owned vessels may be issued each year.

**Table 15.2 Trinity Lake Marinas and Moorage Facilities**

| Location | Marina and Moorage Facility | Number |
|---|---|---|
| Trinity Lake | Cedar Stock Resort & Marina | 31 Commercial and 220 Private Slips, including 10 Commercial Houseboats |
| Trinity Lake | KOA Campground | 15 Commercial and 110 Private Slips |
| Trinity Lake | Pinewood Cove Docks | 52 Private Slips |
| Trinity Lake | Trinity Alps Marina | 31 Commercial and 63 Private Slips, including 25 Commercial Houseboats |
| Trinity Lake | Trinity Center Marina | 80 Private Slips |

Source: USFS 2014

The Trinity Unit of the Whiskeytown-Shasta-Trinity National Recreation Area includes many campground sites, including campgrounds for group camping opportunities (USFS 2014), as summarized in Table 15.3. There are other campgrounds within the upper elevations of the Trinity Lake watershed that are not directly or indirectly affected by changes in surface water elevations.

**Table 15.3 Trinity Lake Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Trinity Lake | Alpine View | – | 53 |
| Trinity Lake | Bushytail | – | 11 |
| Trinity Lake | Captain’s Point | Boat-In Campground | 3 |
| Trinity Lake | Clark Springs | – | 21 |
| Trinity Lake | Fawn | Group Campground | 60 |
| Trinity Lake | Hayward Flat | – | 98 |
| Trinity Lake | Jackass Springs | – | 10 |
| Trinity Lake | Mariner’s Roost | Boat-In Campground | 7 |
| Trinity Lake | Minersville | – | 14 |
| Trinity Lake | Ridgeville | Boat-In Campground | 10 |
| Trinity Lake | Ridgeville Island | Boat-In Campground | 3 |
| Trinity Lake | Stoney Creek | Group Campground | 10 |
| Trinity Lake | Stoney Point | – | 15 |
| Trinity Lake | Tannery Gulch | – | 82 |

Source: USFS 2014

Trinity Lake recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.4. The locations for shoreline day use areas are limited due to the steep and rocky elevations at the shorelines. To develop two swimming beaches at Trinity Lake, the rocky shorelines were covered with sand and/or decomposed granite at a specific elevation. Uses of these locations are less desirable when the water elevations decline.

**Table 15.4 Trinity Lake Major Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Trinity Lake | Clark Springs Day Use and Beach | Picnic and Swimming | 34 picnic sites |
| Trinity Lake | North Shore Vista | Vistas and Interpretative Site | – |
| Trinity Lake | Osprey Info Site | Vistas and Interpretative Site | – |
| Trinity Lake | Stoney Creek | Picnic and Swimming | 4 picnic sites |
| Trinity Lake | Tanbark Picnic | Picnic and Swimming | 8 picnic sites |
| Trinity Lake | Trail of Trees | Interpretative Trail at Tannery Gulch Campground | 0.5 miles |
| Trinity Lake | Trinity Lakeshore Trail | Trail | 4 miles |
| Trinity Lake | Trinity Vista | Vistas and Interpretative Site | – |

Source: USFS 2014

Trinity Lake fishing opportunities include Smallmouth Bass, Largemouth Bass, Rainbow Trout, Brown Trout, Chinook Salmon, and Kokanee Salmon (USFS 2014). White Catfish, Brown Bullhead, Green Sunfish, Bluegill, Klamath Smallscale Sucker, and Pacific Lamprey also are present but are not generally considered as part of the recreational fishing opportunities. Wildlife viewing opportunities extend throughout the Trinity Lake area, including viewing of Bald Eagles, Black-tailed Deer, Black Bear, Gray Squirrel, rabbit, turkey, and California Quail.

#### *15.3.1.2 Lewiston Reservoir*

Lewiston Reservoir is a CVP facility on the Trinity River that is located immediately downstream of the Trinity Dam, as described in Chapter 5, Surface Water Resources and Water Supplies. Lewiston Reservoir is part of the Whiskeytown-Shasta-Trinity National Recreation Area and part of the Shasta-Trinity National Forest. Recreational facilities and activities are administered by the USFS. When the water storage in the reservoir is at full capacity (water elevation at 1,874 feet msl), the reservoir has a surface area of 759 acres and 15 miles of shoreline (USFS 2014).

The water elevation is generally stable in Lewiston Reservoir because it is used as regulating reservoir for releases to downstream uses. Water is diverted from the lower outlets in Trinity Lake to Lewiston Reservoir to provide cold water to Trinity River and Whiskeytown Lake. Therefore, recreational opportunities in Lewiston Reservoir include boating and fishing; however, there are fewer opportunities for swimming and water skiing. Lewiston Reservoir does not support houseboats. There is one primary boat ramp and two marinas in Lewiston Reservoir, as summarized in Tables 15.5 and 15.6.

**Table 15.5 Lewiston Reservoir Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Lewiston Lake | Pine Cove | Open all year | Around 1870 |

Source: USFS 2014

**Table 15.6 Lewiston Lake Marinas and Moorage Facilities**

| Location | Marina and Moorage Facility | Number |
|---|---|---|
| Lewiston Lake | Lakeview Terrace Docks | 14 Commercial and 7 Private Slips |
| Lewiston Lake | Pine Cove Marina | 20 Commercial and 34 Private Slips |

Source: USFS 2014

The Whiskeytown-Shasta-Trinity National Recreation Area includes campground sites near the Lewiston Reservoir shoreline, including campgrounds for group camping opportunities (USFS 2014), as summarized in Table 15.7. Lewiston Reservoir recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.8. Because the water surface elevations are more stable in Lewiston Reservoir than Trinity Lake, the day use areas have more vegetation along the shoreline.

**Table 15.7 Lewiston Lake Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Lewiston Lake | Ackerman | – | 51 |
| Lewiston Lake | Cooper Gulch | – | 5 |
| Lewiston Lake | Mary Smith | – | 17 |
| Lewiston Lake | Tunnel Rock | – | 6 |

Source: USFS 2014

**Table 15.8 Lewiston Major Lake Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Lewiston Lake | Baker Gulch Trail | Trail | 0,2 miles |
| Lewiston Lake | Lewiston Vista | Vistas and Interpretative Site | – |
| Lewiston Lake | North Lakeshore Trail | Trail | 2 miles |
| Lewiston Lake | Pine Cove | Picnic | 2 picnic sites |
| Lewiston Lake | South Lakeshore Trail | Trail | 1 mile |

Source: USFS 2014

Lewiston Reservoir fishing opportunities include Smallmouth Bass, Rainbow Trout, Brown Trout, Three-spine Stickleback, Golden Shiner, and Kokanee Salmon (USFS 2014). Klamath Smallscale Sucker, and Pacific Lamprey also are present but are not generally considered as part of the recreational fishing opportunities. Wildlife viewing opportunities extend throughout the Lewiston Reservoir area, including viewing of Bald Eagles, Black-tailed Deer, River Otter, ring-tailed cats, raccoon, and California Quail. Waterfowl use Lewiston Reservoir throughout the year with increased populations in the winter.

#### *15.3.1.3 Trinity River from Lewiston Dam to the Klamath River*

The Trinity River flows approximately 112 miles from Lewiston Dam to the Klamath River (NCRWQCB et al. 2009) through Trinity, Humboldt, and Del Norte counties.

The first mile of the river below the Lewiston Dam is located within the Whiskeytown-Shasta-Trinity National Recreation Area. Portions of the Trinity River downstream of Lewiston Dam and Junction City to the confluence with North Fork Trinity River are under the jurisdiction of the Department of the Interior, Bureau of Land Management (BLM) (USFWS et al. 1999). Between the confluence with the North Fork Trinity River and the confluence of New River, the area along the Trinity River is located within the USFS Shasta-Trinity National Forest. Between the confluence with the New River and the Hoopa Indian Reservation, most of the area along the Trinity River is located within the USFS Six Rivers National Forest. The remaining portions of the Trinity River to the confluence with the Klamath River are located within the Hoopa Indian Reservation.

On January 19, 1981, the Secretary of the Interior designated the Trinity River starting 100 yards downstream of the Lewiston Dam to the confluence with the Klamath River as part of the National Wild and Scenic Rivers System. The designation also included portions of the South Fork, North Fork, and New River (BLM et al 2012). However, because the flows in the South Fork, North Fork, and New River are not affected by the alternatives considered in this EIS, these rivers are not evaluated in this EIS.

There are approximately 35 developed recreation sites and more than 200 access points along the Trinity River corridor within a half mile of the river, and numerous river access sites between Lewiston Dam and Weitchpec (NCRWQCB et al. 2009; USFWS et al. 1999).

Recreation occurs year-round in the Trinity River area. Water-related activities include boating, kayaking, canoeing, whitewater rafting, inner tubing, fishing, swimming, wading, gold panning, camping, and picnicking (NCRWQCB et al. 2009). Fishing opportunities include steelhead, Rainbow Trout, Brown Trout, and Chinook Salmon.

#### *15.3.1.4 Lower Klamath River from Trinity River Confluence to the Pacific Ocean*

The Klamath River continues for 43.5 miles from the Trinity River confluence to the Pacific Ocean (NCRWQCB et al. 2009).

Downstream of the Trinity River, the Klamath River flows through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation as well as lands owned by local agencies and private entities (DOI and DFG 2012). Near the confluence with the Pacific Ocean, the Klamath River flows through the Redwood National Park. These reaches are primarily within Humboldt and Del Norte counties.

The portion of the Klamath River from the confluence with the Trinity River to the Pacific Ocean is part of the Klamath River designated by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also designated this reach of Klamath River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

Recreation along the Klamath River downstream of the Trinity River is limited (DOI and DFG 2012). Canoeing, kayaking, and whitewater boating occurs along this reach. Whitewater rafting generally requires a minimum flow of 1,800 cfs in this portion of the Klamath River. Four campgrounds, picnic areas, and water access at public lands are located along the Klamath River near the confluence with the Pacific Ocean. Fishing opportunities in the lower Klamath River are primarily related to Chinook Salmon. Del Norte County operates two public boat ramps along the Klamath River. The Redwood National and State Parks operate Lagoon Creek near the confluence of the Klamath River and the Pacific Ocean (RNSP 2013; Del Norte County 2003). There are other trails near the Pacific Ocean, including the California Coastal Trail which is generally located along the northern and eastern banks of the Klamath River at the Pacific Ocean (California Coastal Trail 2014).

### 15.3.2 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

#### *15.3.2.1 Sacramento Valley*

Recreational opportunities in the Sacramento Valley upstream of the Delta that are influenced by CVP and SWP operations occur at Shasta Lake, Keswick Reservoir, Whiskeytown Lake, Clear Creek, Sacramento River between Keswick Dam and the Delta, Lake Oroville and Thermalito Afterbay, Yuba River from between New Bullards Bar and Feather River, Bear River between Camp Far West Reservoir and Feather River, Feather River between Thermalito Dam and the Sacramento River, Folsom Lake and Lake Natoma, American River between Nimbus Dam and the Sacramento River, and refuges that use CVP water supplies.

##### 15.3.2.1.1 Shasta Lake

Shasta Lake is a CVP facility on the Sacramento River that is located near Redding, as described in Chapter 5, Surface Water Resources and Water Supplies. Shasta Lake is part of the Whiskeytown-Shasta-Trinity National Recreation Area and part of the Shasta-Trinity National Forest. Recreational facilities and activities at Shasta Lake are administered by the USFS. When the water storage in the lake is at full capacity (water elevation at 1067 feet msl), Shasta Lake has a surface area of approximately 30,000 acres and 365 miles of shoreline (Reclamation 2013a; USFS 2014).

Boating, water skiing, other water sports, and fishing occur in many locations in the lake. Many types of boats are used, including fishing boats, deck boats, houseboats, cabin cruisers, pontoon boats, personal watercraft, runabouts, and ski boats (Reclamation 2013a; USFS 2014). There are seven public boat ramps on Shasta Lake, as summarized in Table 15.9.

**Table 15.9 Shasta Lake Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Shasta Lake | Antlers | – | 1,067 to 992 |
| Shasta Lake | Bailey Cove | – | 1,067 to 1,017 |
| Shasta Lake | Centimudi | – | 1,067 to 857 |
| Shasta Lake | Hirz Bay | – | 1,067 to 972 |
| Shasta Lake | Jones Valley | – | 1,067 to 857 |
| Shasta Lake | Packers Bay | – | 1,067 to 952 |
| Shasta Lake | Sugar Loaf | – | 992 to 907 |

Source: USFS 2014

A boating safety issue that arises with fluctuations in water level is the associated fluctuation of the pattern of submerged obstacles. When the water level decreases, many rocks, shoals, and islands are much closer to the water surface, and can be easily struck by boats. When the water level rises, debris and obstacles that were previously easily visible may be dangerously out of sight and struck by boats (Reclamation 2013a).

Nine major marinas are located at Shasta Lake, as summarized in Table 15.10. The USFS can permit up to 3,000 boat slips at the Shasta Lake marinas (USFS 2014). Many commercial houseboats are available for rent at the marinas. Shasta Lake shoreline includes approximately 109 miles of prime houseboating areas and 153 miles of secondary houseboating areas. The USFS issues permits for houseboats and privately-owned recreational occupancy vehicles that use the water overnight. At Shasta Lake, up to 613 permits for privately-owned vessels and 450 permits for commercially-owned vessels may be issued each year.

**Table 15.10 Shasta Lake Marinas and Moorage Facilities**

| Location | Marina and Moorage Facility | Number |
|---|---|---|
| Shasta Lake | Antlers Resort and Marina | 101 Commercial and 200 Private Slips, including 35 Commercial Houseboats |
| Shasta Lake | Bridge Bay Resort | 140 Commercial and 7,773 Private Slips, including 92 Commercial Houseboats |
| Shasta Lake | Digger Bay Marina | 75 Commercial and 145 Private Slips, including 50 Commercial Houseboats |
| Shasta Lake | Holiday Harbor | 95 Commercial and 330 Private Slips, including 70 Commercial Houseboats |
| Shasta Lake | Jones Valley Marina | 90 Commercial and 99 Private Slips, including 64 Commercial Houseboats |
| Shasta Lake | Packers Bay Marina | 51 Commercial Slips, including 26 Commercial Houseboats |
| Shasta Lake | Shasta Lake RV Resort | 22 Private Slips |
| Shasta Lake | Shasta Marina | 54 Commercial and 139 Private Slips, including 24 Commercial Houseboats |
| Shasta Lake | Silverthorn Resort Marina | 59 Commercial and 113 Private Slips, including 35 Commercial Houseboats |
| Shasta Lake | Sugarloaf Cottages | 16 Private Slips |
| Shasta Lake | Sugarloaf Marina | 41 Commercial and 40 Private Slips, including 21 Commercial Houseboats |
| Shasta Lake | Tsasdi Resort | 30 Private Slips |

Source: USFS 2014

The Shasta Unit of the Whiskeytown-Shasta-Trinity National Recreation Area includes many campground sites, including campgrounds for group camping opportunities (USFS 2014), as summarized in Table 15.11. There are other campgrounds within the upper elevations of the Shasta Lake watershed that are not directly or indirectly affected by changes in surface water elevations.

Campers are also affected by declining water elevations because this increases the distance from the campsites to the shoreline. Drawdown of the reservoir has an aesthetic effect on users because the land exposed during drawdown is generally composed of bare earth and rock.

**Table 15.11 Shasta Lake Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Shasta Lake | Antlers | – | 59 |
| Shasta Lake | Arbuckle Flat | Boat-In Campground | 11 |
| Shasta Lake | Beehive | Shoreline Campground | No specified number |
| Shasta Lake | Bailey Cove | – | 7 |
| Shasta Lake | Dekkas Rock | Group Campground | 60 |
| Shasta Lake | Ellery Creek | – | 19 |
| Shasta Lake | Gooseneck Cove | Boat-In Campground | 8 |
| Shasta Lake | Green’s Creek | Boat-In Campground | 9 |
| Shasta Lake | Gregory Creek | Shoreline Campground | 18 |
| Shasta Lake | Hirz Bay | Individual and Group Campground | 48 Individual Sites and 200 Group Sites |
| Shasta Lake | Jones Valley (Upper & Lower) | Includes Shoreline Campground at Inlet | 21 |
| Shasta Lake | Lakeshore East | – | 26 |
| Shasta Lake | Lower Salt Creek | Shoreline Campground | No specified number |
| Shasta Lake | Mariners Point | Shoreline Campground | No specified number |
| Shasta Lake | McCloud Bridge | – | 14 |
| Shasta Lake | Moore Creek | Individual and Group Campground | 12 Individual Sites and 90 Group Sites |
| Shasta Lake | Nelson Point | Individual and Group Campground | 8 Individual Sites and 60 Group Sites |
| Shasta Lake | Oak Grove | – | 45 |
| Shasta Lake | Pine Point | Individual and Group Campground | 14 Individual Sites and 100 Group Sites |
| Shasta Lake | Ski Island | Boat-In Campground | 23 |

Source: USFS 2014

Shasta Lake recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.12. The locations for shoreline day use areas are limited due to the steep and rocky elevations at the shorelines. Uses of these locations are less desirable when the water elevations decline.

**Table 15.12 Shasta Lake Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Shasta Lake | Bailey Cove | Picnic and Trail | 9 picnic sites<br>3.1 miles |
| Shasta Lake | Clikapudi | Trail | 8 miles with 1 mile advanced trail |
| Shasta Lake | Dekkas Rock | Picnic | 5 picnic sites |
| Shasta Lake | Dry Fork Creek | Trail | 4.7 miles |
| Shasta Lake | Fisherman's Point | Picnic and Trail | 7 picnic sites<br>0.5 miles |
| Shasta Lake | Hirz Bay | Trail | 1.6 miles |
| Shasta Lake | McCloud Bridge | Picnic | 5 picnic sites |
| Shasta Lake | Packers Bay | Trail | Four Trails: 0.4 to 2.8 miles |
| Shasta Lake | Potem Falls | Trail | 0.3 miles |
| Shasta Lake | Samwel Cave Nature Trail | Interpretative Trail | 1 mile |
| Shasta Lake | Sugarloaf | Trail | 1 mile |

Source: USFS 2014

Additional recreational opportunities are provided at the Shasta Dam Visitors Center.

Fishing is also popular at Shasta Lake, performed mostly by boat as opposed to from the shoreline. Anglers can catch warmwater and coldwater fish species year-round due to the summer stratification of the lake into a warm layer above a coldwater pool (Reclamation 2013a). Shasta Lake warm water fishing opportunities include Black Bass, Smallmouth Bass, Largemouth Bass, Spotted Bass, Black Crappie, Channel Catfish, and Bluegill (USFS 2014). There are many bass tournaments at Shasta Lake each summer. The cooler water strata supports fishing for Rainbow Trout and Chinook Salmon.

#### 15.3.2.1.2 Keswick Reservoir

Keswick Reservoir is a CVP afterbay that extends 9 miles along the Sacramento River from Shasta Dam to Keswick Dam, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreational facilities and activities at Keswick Reservoir are administered by BLM, Shasta County, and U.S. Forest Service for the Department of the Interior, Bureau of Reclamation (Reclamation). The maximum water storage elevation at the top of the Keswick Dam spillway is

587 feet msl (Reclamation 2009). The water level fluctuates frequently in Keswick Reservoir, depending on the operations of Shasta Dam.

Water-related activities include boating, fishing, and water sports. The Keswick Boat Launch, operated by BLM, is located on the western shoreline at the south end of the reservoir (BLM 2005).

There are several trails along Keswick Reservoir and areas for off highway vehicles (OHVs) with camping allowed at one of the locations (BLM 2005; BLM 2011). The Sacramento Rail Trail extends from Moccasin Creek below Shasta Dam to Redding along the western shoreline of Keswick Reservoir and the Sacramento River downstream of Keswick Dam. The Fisherman Trail extends along the shoreline from the lower Sacramento Rail Trail to Keswick Dam. The F.B. Trail extends from the Ribbon Bridge downstream of the Keswick Dam to Walker Mine Road along the eastern side of the Keswick Reservoir. There are several other trails at higher elevations above Keswick Reservoir, including the Hornbeck Tail, Upper and Lower Sacramento Ditch Trails, Flanagan Trail, and Chamise Peak Trail.

The Chappie-Shasta OHV Area provides over 200 miles of roads in approximately 52,000 acres (Reclamation 2013a). The area is accessed at two staging areas. The Chappie-Shasta OHV Staging Area and Shasta Campground includes a staging area for day use activities, including picnics, and 22 campsites (BLM 2005). This site is located along the western shoreline of Keswick Reservoir at the trailhead of the Sacramento Rail Trail at Moccasin Creek. The Copley Mountain OHV Staging Area is located along the western shoreline of Keswick Reservoir about midway between Shasta and Keswick dams. This site also provides a staging area for day use activities, including picnics.

Fishing opportunities are primarily for German Brown Trout and Rainbow Trout.

#### 15.3.2.1.3 Whiskeytown Lake

Whiskeytown Lake is a CVP facility on Clear Creek that is located approximately 8 miles west of Redding on the eastern slope of the Coast Range, as described in Chapter 5, Surface Water Resources and Water Supplies. Whiskeytown Lake is part of the Whiskeytown-Shasta-Trinity National Recreation Area. Recreational facilities and activities administered by the National Park Service (NPS). When the water storage in the reservoir is at full capacity (water elevation at 1210 feet msl), Whiskeytown Lake has a surface area of 3,250 acres and 36 miles of shoreline (Reclamation 1997).

Boating, water skiing, sailing, kayaking, and canoeing, swimming, and fishing occur in many locations in the lake. Boat launches are available at Oak Bottom, Brandy Creek, and Whiskey Creek and at marinas at Oak Bottom and Brandy Creek (NPS 2012), as summarized in Table 15.13.

**Table 15.13 Whiskeytown Lake Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Whiskeytown Lake | Brandy Creek | – | 1210 to 1190 |
| Whiskeytown Lake | Oak Bottom | – | 1210 to 1195 |
| Whiskeytown Lake | Oak Bottom Marina | – | 1210 to 1198 |
| Whiskeytown Lake | Whiskey Creek | – | 1210 to 1195 |

Sources: NPS 2012; Reclamation 1997

The lake level is relatively stable and do not reduce the ability for boat launching until late summer or early fall.

The Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area includes many campground sites, including campgrounds for group camping opportunities (NPS 2012), as summarized in Table 15.14.

**Table 15.14 Whiskeytown Lake Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Whiskeytown Lake | Brandy Creek RV | – | 37 RV Sites |
| Whiskeytown Lake | Brandy Creek | Primitive Campground | 2 Sites |
| Whiskeytown Lake | Coggins Park | Primitive Campground | 1 Site |
| Whiskeytown Lake | Crystal Creek | Primitive Campground near Crystal Creek | 2 Sites |
| Whiskeytown Lake | Dry Creek | Group Campground | 100 people |
| Whiskeytown Lake | Horse Camp | Primitive Campground | 2 Sites |
| Whiskeytown Lake | Oak Bottom Tent and Recreation Vehicle (RV) | – | 98 Tent Sites and 22 RV Sites |
| Whiskeytown Lake | Peltier Bridge | Primitive Campground near Clear Creek | 9 Sites |
| Whiskeytown Lake | Sheep Camp | Primitive Campground | 4 Sites |

Source: NPS 2012

Whiskeytown Lake recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.15. Shoreline day use areas are limited at some locations due to the steep and rocky elevations at the shorelines.

**Table 15.15 Whiskeytown Lake Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Whiskeytown Lake | Boulder Creek Falls | Trail | 1 mile with 2.75-mile advanced trail |
| Whiskeytown Lake | Brandy Creek Beach and Falls | Picnic, Swimming, and Trails | 1.6 and 1.5 miles |
| Whiskeytown Lake | Buck Hollow | Trail | 1 mile |
| Whiskeytown Lake | Camden Water Ditch | Trail | 1.1 miles |
| Whiskeytown Lake | Clear Creek Canal and Vista | Picnic and Trails | 2.4 and 4.5 miles |
| Whiskeytown Lake | Crystal Creek Water Ditch and Falls | Picnic and Trails | 0.75 and 0.3 miles |
| Whiskeytown Lake | Davis Gulch | Trail | 3.3 miles |
| Whiskeytown Lake | East Beach | Swimming | – |
| Whiskeytown Lake | Guardian Rock | Trail | 0.25 miles |
| Whiskeytown Lake | James K. Carr Trail | Trail | 1.7 miles |
| Whiskeytown Lake | Judge Francis Carr Powerhouse | Picnic | – |
| Whiskeytown Lake | Kanaka Peak | Trail | 3.6 miles |
| Whiskeytown Lake | Logging Camp | Trail | 1 mile |
| Whiskeytown Lake | Mill Creek | Trail | 6.1 miles |
| Whiskeytown Lake | Mt. Shasta Mine | Trail | 3.5 miles |
| Whiskeytown Lake | Mule Mountain Pass | Trail | 4.4 miles |
| Whiskeytown Lake | Oak Bottom Beach | Picnic and Swimming | – |
| Whiskeytown Lake | Oak Bottom Ditch | Trail | 2.75 miles |
| Whiskeytown Lake | Papoose Pass | Trail | 5.5 miles |
| Whiskeytown Lake | Peltier | Trail | 1.75 miles |
| Whiskeytown Lake | Rich Gulch | Trail | 1.8 miles |
| Whiskeytown Lake | Salt Creek | Trail | 1.8 miles |
| Whiskeytown Lake | Salt Gulch | Trail | 1.6 miles |
| Whiskeytown Lake | Shasta Divide Nature Trail | Trail | 0.4 miles |
| Whiskeytown Lake | Whiskey Creek | Group Picnic Area and Swimming | – |

Source: NPS 2012

Additional recreational opportunities are provided at the Whiskeytown Visitors Center.

Fishing opportunities at Whiskeytown Lake include Brown Trout and Rainbow Trout; Kokanee Salmon; Smallmouth Bass, Largemouth Bass, and Spotted Bass; Bluegill; crappie; and Sacramento Pikeminnow (NPS No Date).

#### 15.3.2.1.4 Clear Creek from Whiskeytown Dam to the Sacramento River

Whiskeytown Lake is operated to release most of the water through the Spring Creek Power Conduit into Keswick Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Flows are also released from Whiskeytown Lake to Clear Creek to be consistent with federal and state requirements. During high flow events, additional flows may be released into Clear Creek.

The initial reaches of Clear Creek downstream of the Whiskeytown Dam are located within the Whiskeytown-Shasta-Trinity National Recreation Area. The remaining portions of Clear Creek flow to the Sacramento River through lands owned by BLM and private owners. All of these reaches are located within Shasta County and the most eastern reaches are within the City of Redding.

BLM has established the Clear Creek Greenway along a large portion of the lower Clear Creek from within the Whiskeytown-Shasta-Trinity National Recreation Area to the Sacramento River (BLM n.d.). The area also includes the Horsetown-Clear Creek Preserve which is a private-public partnership recreation area.

Hiking, picnicking, kayaking, swimming, fishing, and gold panning occur along the lower Clear Creek (SRWP 2010). The Clear Creek Greenway includes ten trails and eight picnic areas (BLM n.d.). Hunting is allowed in the Swasey and Muletown Road areas of the Clear Creek Greenway. Fishing opportunities include steelhead, Chinook Salmon, carp, suckers, Bluegill, bass, and Sacramento Pikeminnow (SRWP 2010).

#### 15.3.2.1.5 Sacramento River from Keswick Dam to the Delta

The Sacramento River from Keswick Dam to the Sacramento-San Joaquin Delta (Delta) is divided into three reaches for discussion in this section: Keswick Reservoir to Red Bluff, Red Bluff to the Feather River, and Feather River confluence to the Delta (near the City of West Sacramento).

*Sacramento River from Keswick Dam to Red Bluff*

The upper reach of the Sacramento River flows for approximately 60 miles from Keswick Dam to Red Bluff (Reclamation 1997). Water-related recreational activities include boating, picnicking, camping, and wildlife viewing. Boating opportunities include motor-boating, jet-skiing, kayaking, canoeing, and whitewater rafting in some locations (Reclamation 2013a, Reclamation et al. 2002). River flows can increase for short-term periods when water is being released from the CVP facilities and during and following storm events in the upper Sacramento River watershed. Flows in the late fall months may decrease to levels that are not favorable for boating. Water temperatures in this reach are generally cold throughout the year.

Much of the land along the Sacramento River between Balls Ferry and Red Bluff is owned and managed by BLM (Reclamation 2013a). Public access points are provided by the cities of Redding and Anderson and the BLM. Lake Redding Park, Turtle Bay, and the Anderson River Park are some of the prominent access areas. Boat launching can occur at eight public boat ramps and two smaller launch facilities, including at Turtle Bay, Caldwell Park, and South Bonneyview in the City of Redding; Ball Ferry; Battle Creek confluence with the Sacramento River; Bend Bridge; and Red Bluff River Park in the City of Red Bluff.

There are two whitewater river reaches, including between Keswick Dam and the Anderson-Cottonwood Irrigation District Diversion Dam and between Anderson River Park and William B. Ide Adobe State Historic Park.

Camping facilities include public campgrounds along the Sacramento River at Lake Red Bluff Recreation Area (Reclamation 2013a).

There are trails or trail access and picnicking facilities with access to the river in this reach of the Sacramento River (Reclamation 2013a). The trails include the 13-mile Sacramento River Trail between Keswick Dam to Turtle Bay Park in the City of Redding. Many of the picnicking locations are managed by local municipalities, including the cities of Redding, Anderson, and Red Bluff. Coleman National Fish Hatchery, located along Battle Creek near the Sacramento River, provides recreational and educational opportunities.

Fishing opportunities along the upper Sacramento River include Chinook Salmon, steelhead, Rainbow Trout, sunfish, and bass (Reclamation 2013a). Fishing can occur from boats along the Sacramento River and at four public fishing access points, including Turtle Bay East, Kapusta Property, Deschutes Road, Reading Island, Diestlehorst Pasture River Access, Jellys Ferry, and Sacramento River Island.

The Mouth of Cottonwood Creek Wildlife Area is operated by California Department of Fish and Wildlife (DFW). This area provides viewing opportunities for Swainson’s Hawk, Bald Eagle, ringtail cat, River Otter, and other birds and wildlife (Reclamation 2013a). Hunting opportunities on BLM land occur at Inks Creek, Massacre Flat, Perry Rifle, Paynes Creek, Bald Hill and Iron Canyon. Commonly hunted game includes quail, dove, waterfowl, deer, pig, turkey, and bear (Reclamation 2013a).

*Sacramento River from Red Bluff to Feather River*

The middle reach of the Sacramento River flows approximately 160 miles from Red Bluff to the confluence with the Feather River (Reclamation 1997).

Water-dependent activities along the middle reach include boating, swimming, and fishing (Reclamation 2005a). Water-contact activities are popular in this section of the river due to relatively warm water. Public access points are provided along this reach by California Department of Parks and Recreations (State Parks); and Tehama, Glenn, Colusa, and Sutter counties (Reclamation 2005a; Reclamation 1997). River access in this reach is primarily provided at private fishing access points, marinas, and resorts.

The three major State Parks properties along the middle reach include the Woodson Bridge State Recreation Area, the Bidwell-Sacramento River State Park, and the Colusa-Sacramento River State Recreation area (DFG 2004; Reclamation 2013a). Public access for fishing, hunting, and wildlife viewing also is provided at the DFW Fremont Weir Wildlife Area (DFW 2014a).

Fishing opportunities include Chinook Salmon, steelhead, trout, American Shad, sturgeon, catfish, and Striped Bass (Reclamation 2005a).

Seasonal game includes Ring-necked Pheasants, California Quail, various species of ducks and geese, Mourning Doves, and Mule Deer (Reclamation 2013a).

*Sacramento River from Feather River to the Northern Delta Boundary*

The lower reach of the Sacramento River flows for approximately 20 river miles between the confluence with Feather River and immediately downstream of the confluence with the American River (USACE 1991). The major portion of this reach of the Sacramento River flows along private property.

Water-related activities in this reach include boating, swimming and beach use, picnicking, biking, sightseeing, and fishing. Public access is provided by Yolo County at Elkhorn Regional Park (Yolo County ); Sacramento County and the City of Sacramento at Discovery Park and Miller Park, respectively (Sacramento County 2012; Reclamation 2005a); and by the City of West Sacramento at Broderick Boat Ramp (West Sacramento 2000).

Fishing opportunities in this area include Chinook Salmon, steelhead, American Shad, sturgeon, catfish, and Striped Bass (Reclamation 1997, 2005a).

#### 15.3.2.1.6 Sacramento Valley Wildlife Refuges

Wildlife refuges in the Sacramento Valley that rely upon CVP water supplies include the Sacramento National Wildlife Refuge (NWR) Complex include Sacramento, Delevan, Colusa, and Sutter NWRs and Gray Lodge Wildlife Area, as described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 10, Terrestrial Biological Resources (Reclamation 2012). Water-related activities include wildlife viewing, hiking along the refuge wetlands, and waterfowl hunting. Shoreline fishing opportunities at Gray Lodge Wildlife Area include bass, sunfish, perch, catfish, and carp (DFW 2014b)

#### 15.3.2.1.7 Feather River Watershed

Antelope Lake, Lake Davis, and Frenchman Lake located in the Upper Feather River; Lake Oroville and Thermalito Forebay and Afterbay; and the lower Feather River are located within areas in the Feather River watershed that could be affected by changes in CVP and/or SWP operations.

*Upper Feather River Lakes*

The Upper Feather River Lakes, including Antelope Lake, Lake Davis, and Frenchman Lake, are SWP facilities on the upper Feather River upstream of Lake Oroville. These lakes are part of the Plumas National Forest (DWR 2013a).

Recreational facilities and activities at all three lakes are managed by private concessionaires under contract with the Plumas National Forest.

For Antelope Lake, when the water storage in the lake is at full capacity (water elevation at 5,002 feet), the lake has a surface area of 930 acres and 15 miles of shoreline (DWR 2013a; USFS 2011). Water related activities include boating, water skiing, swimming, fishing, camping, and picnicking. There is a boat launching ramp, three fishing access sites, and a picnic area. There are three campgrounds at Antelope Lake, including Boulder Creek, Lone Rock, and Long Point. There are approximately 194 campsites and 4 group campsites at the three campgrounds for use between May through October. Fishing opportunities in Antelope Lake include Rainbow Trout, Brook Trout, crappie, Channel Catfish, and Smallmouth Bass, Largemouth Bass. Hunting opportunities around Antelope Lake include Mule Deer and Black-tailed Deer.

For Lake Davis, when the water storage in the lake is at full capacity (water elevation at 5,785 feet), the lake has a surface area of 4,030 acres and 32 miles of shoreline (DWR 2013a; USFS 2006a). Water related activities include boating, fishing, camping, and picnicking. There are boat launching ramps at Lightning and Honker Cove, car-top boat ramp at Mallard Cove, a fishing access site, and a picnic area. There are three campgrounds at Lake Davis, including Grizzly, Grasshopper, and Lightning Tree. There are approximately 180 campsites at the three campgrounds for use between May through October. Fishing opportunities in Lake Davis include Rainbow Trout, German Brown Trout, Eagle Lake trout, Brown Bullhead, and Largemouth Bass. Hunting opportunities around Lake Davis include Mule Deer and Black-tailed Deer.

For Frenchman Lake, when the water storage in the lake is at full capacity (water elevation at 5,588 feet), the lake has a surface area of 1,580 acres and 21 miles of shoreline (DWR 2013a; USFS 2006b). Water related activities include boating, water skiing, swimming, fishing, camping, picnicking, and ice fishing. There are two boat launching ramps (Frenchman and Lunker Point), six fishing access sites, and a picnic area. There are five campgrounds at Frenchman Lake, including Chilcoot, Cottonwood Springs, Frenchman, Spring Creek, and Big Cove. There are approximately 209 campsites and 2 group campsites at the five campgrounds for use between May through October. Fishing opportunities in Frenchman Lake include Rainbow Trout, Brown Trout, Eagle Lake trout, and Smallmouth Bass. Hunting opportunities around Frenchman Lake include deer and waterfowl.

*Lake Oroville and Thermalito Forebay and Afterbay*

Lake Oroville and Thermalito Forebay and Afterbay are SWP facilities on the Feather River, as described in Chapter 5, Surface Water Resources and Water Supplies. The upper North Fork arm of Lake Oroville is part of the Lassen National Forest; and the upper Middle Fork and South Fork arms of Lake Oroville are part of Plumas National Forest. The Middle Fork Feather River (from Beckwourth downstream of Lake Davis to Lake Oroville) was designated as part of Public Law 90-542 (Wild and Scenic Rivers Act) to be part of the National Wild and Scenic Rivers System on October 2, 1968. Recreational facilities and activities at the Lake Oroville Complex (including Lake Oroville and Thermalito

Forebay and Afterbay) are managed by State Parks as part of the Lake Oroville State Recreation Area. When the water storage in the lake is at full capacity (water elevation at 900 feet msl), Lake Oroville has a surface area of 15,810 acres and 167 miles of shoreline. Thermalito Forebay has a surface area of 630 acres. Thermalito Afterbay has a surface area of 4,300 acres and 26 miles of shoreline when the water elevation is at 136.5 feet msl (DWR 2007a, 2007c, 2013b).

Water-related activities include boating, whitewater boating, camping, picnicking, and fishing (DWR 2007a). Boating includes kayaking, canoeing, and fishing boats. Whitewater boating occurs on the Big Bend area of the North Fork Feather River when Lake Oroville elevations are sufficiently low to expose several miles of river. This portion of the North Fork Feather River forms the Upper North Fork arm of Lake Oroville. Generally, this area is exposed in the late fall months. Another whitewater area is located in the Bald Rock Canyon on the Middle Fork Feather River. This whitewater area is located upstream of the Middle Fork arm of Lake Oroville.

There are 11 boat ramps on Lake Oroville, as summarized in Table 15.16. Two of the boat ramps are located at marinas (DWR 2007a).

**Table 15.16 Lake Oroville, Thermalito Forebay, and Thermalito Afterbay Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Lake Oroville | Bidwell Canyon | Day Use Area<br>Marina with 280 berths and 400 mooring anchors | 900 to 700 |
| Lake Oroville | Dark Canyon | Car-Top Launching | 900 to 765 |
| Lake Oroville | Enterprise | | 900 to 835 |
| Lake Oroville | Foreman Creek | Car-Top Launching | 900 to approximately 800 |
| Lake Oroville | Lime Saddle | Day Use Area<br>Marina, including houseboat rentals | 900 to 702 |
| Lake Oroville | Loafer Creek | Boat-In Campground | 900 to 775 |
| Lake Oroville | Monument Hill | Day Use Area | 900 to approximately 700 |
| Lake Oroville | Nelson Bar | Car-Top Launching | 900 to 825 |
| Lake Oroville | Spillway | Day Use Area | 900 to 695 |
| Lake Oroville | Stringtown Creek | Car-Top Launching | 900 to 866 |
| Lake Oroville | Vinton Gulch | Car-Top Launching | 900 to 825 |

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Thermalito Forebay | North Thermalito Forebay | Day Use Area<br>Also used by California State University, Chico | Water elevation does not vary substantially |
| Thermalito Forebay | South Thermalito Forebay | Day Use Area | Water elevation does not vary substantially |
| Thermalito Afterbay | Larkin Road | Car-Top Launching | Water elevation does not vary substantially |
| Thermalito Afterbay | Oroville Wildlife Area | | Water elevation does not vary substantially |
| Thermalito Afterbay | Thermalito Afterbay Outlet | | Water elevation does not vary substantially |
| Thermalito Afterbay | Wilbur Road | | Water elevation does not vary substantially |

Sources: DWR 2006, 2007a

There are 16 campgrounds at Oroville Lake and Thermalito complex (DWR 2007a), as summarized in Table 15.17. Campers are affected by declining water elevations because this increases the distance from the campsites to the shoreline, and makes it difficult to access shoreline campgrounds at Bidwell Canyon, Lime Saddle, and Loafer Creek when water elevations are lower than 850 feet msl.

**Table 15.17 Lake Oroville, Thermalito Forebay, and Thermalito Afterbay Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Lake Oroville | Bidwell Canyon | Campground | 75 |
| Lake Oroville | Bloomer Cove | Boat-In Campground | 5 |
| Lake Oroville | Bloomer Group | Boat-In Group Campground | 75 |
| Lake Oroville | Bloomer Knoll | Boat-In Campground | 6 |
| Lake Oroville | Bloomer Point | Boat-In Campground | 25 |
| Lake Oroville | Craig Saddle | Boat-In Campground | 18 |
| Lake Oroville | Floating Campsites | Boat-In Campground | 10 Different Locations with approximately 15 sites per location |
| Lake Oroville | Foreman Creek | Boat-In Campground | 26 |
| Lake Oroville | Goat Ranch | Boat-In Campground | 5 |
| Lake Oroville | Lime Saddle | Campground and Group Campground | 45 |

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Lake Oroville | Loafer Creek | Campground and<br>Group Campground<br>Horse Campground | 137<br>6<br>15 |
| Thermalito Forebay | North Thermalito Forebay “En Route” | Recreational Vehicle Campground | 15 |
| Thermalito Afterbay | Oroville Wildlife Area | Primitive Campground | Several |

Sources: DWR 2006, 2007a

Lake Oroville recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.18. The locations for shoreline day use areas are limited due to the steep and rocky elevations at the shorelines. Uses of these locations are less desirable when the water elevations decline. It is difficult to access shoreline campgrounds at Bidwell Canyon and Loafer Creek when water elevations are lower than 850 feet msl.

**Table 15.18 Lake Oroville, Thermalito Forebay, and Thermalito Afterbay Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Lake Oroville | Bidwell Canyon<br>With Saddle Dam trailhead | Trail and picnic | 4.9 mile trail (hiking and bicycling)<br>21 picnic sites |
| Lake Oroville | Chaparral Trail | Interpretative Trail | 0.2 miles |
| Lake Oroville | Dan Beebe Trail<br>With Saddle Dam, Lakeland Boulevard, Oro Dam Boulevard, and visitor center trailheads | Trail | 14.3 mile trail (equestrian and hiking) |
| Lake Oroville | Lake Oroville Visitors Center | Visitors Center and picnic | 18 picnic sites |
| Lake Oroville | Lime Saddle | Picnic | 13 picnic sites |
| Lake Oroville | Loafer Creek | Trail, swimming, and picnic | 3.2 mile trail (equestrian and hiking)<br>1.7 mile trail (hiking and bicycling)<br>30 picnic sites |
| Lake Oroville | Model Aircraft Flying Facility | Aircraft staging and picnic | 6 picnic sites |

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Lake Oroville | Oroville Dam Overlook and Spillway Day Use Area | Trail, picnic, and shoreline fishing | 1 mile along Oroville Dam crest<br>8 picnic sites |
| Lake Oroville | Potter's Ravine | Trail | 5.5 miles |
| Lake Oroville | Roy Rogers Trail | Trail | 4 miles (equestrian and hiking) |
| Lake Oroville | Sewim Bo Trail | Trail and picnic | 0.5 miles (equestrian and hiking)<br>1 picnic site |
| Lake Oroville | Wyk Island Trail | Trail | 0.2 miles |
| Feather River downstream of Oroville Dam | Feather River Fish Hatchery | Hatchery and picnic | 1 picnic site |
| Oroville Dam Crest, Diversion Pool, Thermalito Forebay, and Thermalito Afterbay | Brad Freeman Trail<br>Diversion Pool access road, East Hamilton Road, Powerhouse Road, Toland Road, and Tres Vias Road trailheads | Trail Loop | 41 miles |
| Thermalito Forebay | North Thermalito Forebay | Picnic, swimming, and shoreline fishing | 117 picnic sites |
| Thermalito Forebay | South Thermalito Forebay | Picnic, swimming, and shoreline fishing | 10 picnic sites |
| Thermalito Afterbay | Monument Hill | Picnic, swimming, and shoreline fishing | 10 picnic sites |
| Oroville Wildlife Area | Rabe Road Shooting Range | Range and target shooting and picnic | 7 picnic sites |
| Oroville Wildlife Area | Clay Pit State Vehicular Recreation Area | Off-highway vehicle riding | – |
| Thermalito Afterbay | Thermalito Afterbay Outlet and Oroville Wildlife Area | Trail, picnic, shoreline fishing, and hunting | Several trails and day use areas |

Sources: DWR 2006, 2007a

Fishing is popular at the Lake Oroville complex and is performed by boat and from the shoreline (DWR 2007a). Fishing opportunities in Lake Oroville include Smallmouth Bass, Largemouth Bass, Spotted Bass, red-eye bass, Black Crappie, Bluegill, Green Sunfish, Channel Catfish, and White Catfish, Coho Salmon, Rainbow Trout, and Brown Trout. In Thermalito Forebay, fish species include Brook Trout, Brown Trout, Rainbow Trout, and Chinook Salmon. In Thermalito Afterbay, fishing opportunities include Smallmouth Bass, Largemouth Bass, trout, Channel Catfish, White Catfish, and carp. Downstream in the Feather River, fishing opportunities include steelhead, Chinook Salmon, American Shad, Smallmouth Bass, Largemouth Bass, and White Sturgeon.

Hunting opportunities occur around Thermalito Afterbay and/or Oroville Wildlife Area for turkey (in the spring), dove, quail, waterfowl, pheasant, deer, squirrel, and rabbit.

*Feather River from Thermalito Afterbay/Oroville Wildlife Area to Sacramento River*

The Feather River flows from the Thermalito Dam to approximately 40 miles downstream to the confluence with the Sacramento River (Reclamation 1997). The Feather River Wildlife Area, managed by DFW, is located along the Feather River near the confluence with the Bear River. The Feather River Wildlife Area includes the Abbott Lake, Star Bend, O'Connor Lakes, Lake of the Woods, and Nelson Slough units; and Bobelaine Audubon Ecological Reserve (DFG 2008a). The southern boundary of the wildlife area is located adjacent to the Sutter Bypass. In Sutter County, water-related recreation opportunities along the Feather River also include public access at Donahue Road Park, Tisdale Boat Ramp, Boyd's Pump boat launch, Feather River parkway, Yuba City Boat Ramp, Riverfront Park in Marysville, and Live Oak Park and Recreation Area (Sutter County 2010). There are several private facilities that offer camping, boating, and river access.

**15.3.2.1.8 Yuba River Watershed**

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007), as described in Chapter 5, Surface Water Resources and Water Supplies. New Bullards Bar Dam and Reservoir are owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation. The Harry L. Englebright Dam and Reservoir were constructed by the California Debris Commission downstream of New Bullards Bar Reservoir to trap and store sediment from historical hydraulic mining sites in the upper watershed, and provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Reservoir (Lake) was assumed by the U.S. Army Corps of Engineers.

Portions of the watershed along the Middle Yuba River between New Bullards Bar Reservoir and Englebright Reservoir are within the Plumas and Tahoe national forests. There are also lands owned and managed by the Bureau of Land Management and U.S. Army Corps of Engineers along this reach of the river.

This reach also includes the confluence with the South Yuba River. Portions of the Lower South Yuba River are designated as a California Wild and Scenic River (USFS et al. No Date). Portions of the South Yuba River State Park located near the confluence along the South Yuba River and Yuba River provide recreational opportunities for swimming, fishing, bird watching, and gold panning (State Parks 2009).

*New Bullards Bar Reservoir*

The New Bullards Bar Reservoir has a storage capacity of 966,103 acre-feet when the water elevation is at 1,956 feet. When full, the lake has a surface area of 4,790 acres and 71.9 miles of shoreline (YCWA 2012). Recreational facilities and activities are the responsibility of Yuba County Water Agency. Water related activities include boating, fishing, camping from May through September, and picnicking (DWR et al. 2007). There are several campgrounds adjacent to the lake, including Schoolhouse and Dark Day campgrounds along the shoreline and Madrone Cove and Garden Point that are only accessed by boat. Boat access is provided at Emerald Cove Resort and Marina, Cottage Creek, and Dark Day. The Cottage Creek and Dark Day boat ramps are not useable when the lake elevation declines below 1,822 and 1,798 feet, respectively. Fishing opportunities include Rainbow Trout, Brown Trout, Kokanee Salmon, Bluegill, crappie, Bullhead, Smallmouth Bass, and Largemouth Bass.

*Englebright Reservoir*

The Englebright Reservoir has a storage capacity of approximately 70,000 acre-feet when the water elevation is at 527 feet (USACE 2012, 2013, 2014). When full, the lake has a surface area of 815 acres and 24 miles of shoreline. Recreational facilities and activities are the responsibility of U.S. Army Corps of Engineers. Water related activities include boating, water-skiing, fishing, boat-access camping, and picnicking. There are 96 boat-access only camping sites. There are two boat ramps to provide access to the lower part of the lake. The upper portion of the lake is characterized by narrow canyons and sharp bends which limit boat access. Fishing opportunities include Rainbow Trout, Brown Trout, Kokanee Salmon, sunfish, catfish, Smallmouth Bass, and Largemouth Bass.

*Lower Yuba River*

Hiking and boating opportunities occur along the 24 miles of the Lower Yuba River between Englebright Reservoir and the Feather River (DWR et al. 2007). Public river access is provided at several locations to support fishing, picnicking, rafting, kayaking, tubing, and swimming. Fishing opportunities include American Shad, Chinook Salmon, steelhead, Smallmouth Bass, and Striped Bass.

#### 15.3.2.1.9 American River Watershed

Folsom Lake and Lake Natoma on the American River and the lower American River are located within areas in the American River watershed that could be affected by changes in CVP and/or SWP operations.

*Folsom Lake and Lake Natoma*

Folsom Lake is a CVP facility on the American River, as described in Chapter 5, Surface Water Resources and Water Supplies. The El Dorado National Forest is located in the upper American River watershed upstream of Folsom Lake. The State of California designated the North Fork American River from the source to Iowa Hill Bridge upstream of Folsom Lake as wild and scenic. Recreational facilities and activities in the Folsom Lake area are within the Folsom Lake State Recreation Area or the Folsom Powerhouse State Historic Park that are managed by State Parks. Recreational activities upstream of Folsom Lake occur on or adjacent to many lands owned by the Bureau of Land Management, State Parks, and El Dorado County. When the water storage in the lake is at full capacity (466 feet msl), Folsom Lake has a surface area of 11,450 acres and 75 miles of shoreline (State Parks and Reclamation 2003, 2007).

The upper extent of Lake Natoma is located about 1 mile downstream of Folsom Dam. Lake Natoma continues from the Rainbow Bridge to Nimbus Dam, about a 4-mile distance (State Parks and Reclamation 2003, 2007). Recreational facilities and activities at the Lake Natoma area are part of the Folsom Lake State Recreation Area and managed by State Parks. When the water storage in the reservoir is at full capacity (132 feet msl), Lake Natoma has a surface area of 540 acres and 14 miles of shoreline.

Water-related activities at Folsom Lake include boating, jet skiing, water skiing, wind surfing, rafting, sailing, canoeing, kayaking, swimming, and fishing (Reclamation 2005b; State Parks and Recreation 2003, 2007). White water rafting occurs along the South Fork American River upstream of Folsom Lake and at Skunk Hollow and Salmon Falls.

Water-related activities at Lake Natoma generally only includes paddling, rowing, and fishing due to a 5 miles/hour speed limit for motorized watercraft. California State University Sacramento operates an aquatic center at Lake Natoma (Reclamation et al. 2006).

Folsom Lake Marina at Brown's Ravine is the only marina at Folsom Lake. There are six boat launch facilities at Folsom Lake and three boat launch facilities at Lake Natoma, as summarized in Table 15.19.

**Table 15.19 Folsom Lake and Lake Natoma Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Folsom Lake | Beal's Point | Day Use Area<br>Informal Boat Ramp | 465 to 420 |
| Folsom Lake | Brown's Ravine | Day Use Area<br>Folsom Lake Marina with 685 wet slips and 175 dry storage slips | 466 to 395 |
| Folsom Lake | Folsom Point | – | 466 to 406 |

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Folsom Lake | Granite Bay | Day Use Area<br>Largest Boat Launch Facility at Folsom Lake | 466 to 360 |
| Folsom Lake | Hobie Cove | – | 426 to 375 |
| Folsom Lake | Peninsula | Day Use Area | 466 to 410 |
| Folsom Lake | Rattlesnake Bar | – | 466 to 425 |
| Lake Natoma | Negro Bar | – | 121 to 115 |
| Lake Natoma | Nimbus Flat | Main Boat Ramp<br>Informal Boat Ramp | 128 to 115<br>128 to 120 |
| Lake Natoma | Willow Creek | Informal Boat Ramp | 125 to 115 |

Sources: Reclamation et al. 2006; State Parks and Reclamation 2003, 2007

Campgrounds are located at Folsom Lake and Lake Natoma, as summarized in Table 15.20. Campers are also affected by declining water elevations because this increases the distance from the campsites to the shoreline. Drawdown of the reservoir has an aesthetic effect on users because the land exposed during drawdown is generally composed of bare earth and rock.

**Table 15.20 Folsom Lake and Lake Natoma Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Folsom Lake | Beal's Point | – | 49 Camp Sites<br>20 Recreation Vehicles |
| Folsom Lake | Peninsula | Campground<br>Boat-In Campground | 104 Camp Sites |
| Lake Natoma | Negro Bar | Group Campground | 3 Major Camp Sites |

Note: State Parks and Reclamation 2003, 2007; Reclamation et al. 2006

Folsom Lake and Lake Natoma recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.21. The locations for shoreline day use areas are limited due to the steep and rocky elevations at the shorelines. Uses of these locations are less desirable when the water elevations decline. The Jedediah Smith Memorial Trail begins at Beal's Point and extends along Lake Natoma to the confluence of the American River and Sacramento River downstream of Nimbus Dam. The Pioneer Express Trail which extends from the Auburn State Recreation Area to Beal's Point is part of the Western States Pioneer Express Trail (a National Recreation Trail).

**Table 15.21 Folsom Lake and Lake Natoma Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Folsom Lake | Beal's Point | Picnic and Swimming<br>Trailhead for Jedediah Smith Memorial Trail | 53 picnic sites in Day Use area<br>69 at campground |
| Folsom Lake | Brown's Ravine Trail | Trail (to Old Salmon Falls) | 12 miles |
| Folsom Lake | Darrington Trail | Trail | 9 miles |
| Folsom Lake | Doton's Point ADA Trail | Trail | 1 mile |
| Folsom Lake | Folsom Point | Picnic and water skiing<br>Trail (to Brown's Ravine Trail) | 50 picnic sites<br>4 miles |
| Folsom Lake | Folsom Powerhouse | Historic Site and Museum<br>Trail | 10 picnic sites<br>1 mile |
| Folsom Lake | Folsom Reservoir River Access Areas | Whitewater rafting (South Fork) | 40 commercial rafting outfitters with 67 permits<br>No permits for private boats |
| Folsom Lake | Granite Bay | Trail<br>Picnic, Swimming, fishing, equestrian, and hiking | Several trails: 1 to 5 miles<br>100 picnic sites |
| Folsom Lake | Los Lagos Trail | Trail | 1.5 miles |
| Folsom Lake | Old Salmon Falls | Swimming, equestrian, and hiking<br>Trailhead for Brown's Ravine and Sweetwater trails | – |
| Folsom Lake | Peninsula | Trail<br>Picnic | 1 mile<br>6 picnic sites in Day Use area<br>104 at campground |
| Folsom Lake | Pioneer Express Trail | Trail | 21 miles |
| Folsom Lake | Rattlesnake Bar | Equestrian | – |
| Folsom Lake | Skunk Hollow and Salmon Falls | Whitewater rafting (South Fork) | – |

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Folsom Lake | Sweetwater Creek | Trailhead for Sweetwater Trail | – |
| Folsom Lake | Sweetwater Trail | Trail | 2 miles |
| Lake Natoma | Lake Natoma Trails | Trail | Several trails: 1 to 10 miles |
| Lake Natoma | Lake Overlook | Trailhead for Lake Natoma Trail | – |
| Lake Natoma | Negro Bar | Picnic, fishing, and equestrian<br>Trailhead for Lake Natoma Trail | 32 picnic sites in Day Use area<br>17 at campground |
| Lake Natoma | Nimbus Fish Hatchery | Hatchery | – |
| Lake Natoma | Nimbus Flat | California State University, Sacramento Aquatic Center<br>Trailhead for Lake Natoma Trail | 37 picnic sites |
| Lake Natoma | Willow Creek | Trailhead for Lake Natoma Trail | 4 picnic sites |

Sources: Reclamation et al. 2006; State Parks and Reclamation 2003, 2007

Fishing is also popular at Folsom Lake and Lake Natoma from boats and the shoreline. Anglers can catch warmwater and coldwater fish species due to the summer stratification of the lake into a warm layer above a coldwater pool especially in Folsom Lake (State Parks and Reclamation 2007). Warm water fishing opportunities include Smallmouth Bass, Largemouth Bass, Spotted Bass, and black and White Crappie. The cooler water strata support fishing for Rainbow Trout, Brown Trout, and Chinook Salmon.

*American River from Nimbus Dam to the Confluence with Sacramento River*

The American River flows 14 miles between Nimbus Dam and the confluence with the Sacramento River was designated by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also designated the Lower American River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

The Jedediah Smith Memorial Trail (also known as the American River Bike Trail) continues along the American River from Beal’s Point at Folsom Lake, along Folsom Lake and Lake Natoma, and along the Lower American River through Discovery Park to the confluence with the Sacramento River (Reclamation 2005b).

The American River Parkway is a 26-mile green space designated and managed by Sacramento County Parks and Recreation along the Lower American River from Nimbus Dam to the confluence with the Sacramento River at Discovery Park. This parkway provides extensive recreational opportunities, including boating rafting, kayaking, canoeing, swimming, and fishing (Reclamation 2005b; Sacramento County 2008). Pedestrian access is provided at 87 locations along the parkway. Bicycle access and equestrian access are provided at 65 and 37 locations, respectively. Boat launch ramps are provided at 7 locations and Car-top Boat Launch opportunities are provided at 17 locations. Picnic locations are located at numerous locations along the American River. Fishing opportunities along the Lower American River include Chinook Salmon, steelhead, trout, Striped Bass, American Shad, Largemouth Bass, Bluegill, crappie, sunfish, and catfish (Sacramento County 2008).

*Sacramento Municipal Utility District – Rancho Seco Park and Lake*

Rancho Seco Park and Lake, operated by Sacramento Municipal Utility District, is used to store CVP water (Reclamation 2005b). The lake has a surface are of 160 acres. Water-related activities include boating, camping, picnicking, bird watching and fishing. Facilities available for these activities are two boat ramps and a fish cleaning facility. Game fish species found at the lake include catfish, Bluegill, crappie, and trout. Birds that use the area include ducks, geese, hawks, Bald Eagles, blue heron, and migratory birds (SMUD 2013).

#### *15.3.2.2 San Joaquin Valley*

Recreational opportunities in the San Joaquin Valley upstream of the Delta that are influenced by CVP and SWP operations occur at Millerton Lake, San Joaquin River between Friant Dam and the Delta, New Melones Reservoir, Stanislaus River between Tulloch Dam and San Joaquin River, San Luis Reservoir complex, recreation areas along Delta Mendota Canal and California Aqueduct, and refuges that use CVP water supplies.

##### 15.3.2.2.1 Millerton Lake

Millerton Lake is a CVP facility on the San Joaquin River, as described in Chapter 5, Surface Water Resources and Water Supplies. Millerton Lake is part of the Millerton State Recreation Area. Recreational facilities and activities at Millerton Lake are administered by State Parks. When the water storage in the lake is at full capacity (water elevation at 580.6 feet msl), Millerton Lake has a surface area of approximately 4,900 acres and 44 miles of shoreline (Reclamation and DWR 2011).

Boating, sailing, water skiing, jetskiing, swimming, tournament and recreational fishing, camping, and picnicking (Reclamation and DWR 2011; Reclamation and State Parks 2010). Whitewater rafting opportunities occur upstream of Millerton Lake. There are six public boat ramps on Millerton Lake, as summarized in Table 15.22.

**Table 15.22 Millerton Lake Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| Millerton Lake | Crow's Nest | On South Shore | 580 to 487 |
| Millerton Lake | Grange Cove | On South Shore | Several Boat Ramps: 580 to 500 |
| Millerton Lake | McKenzie Point | On South Shore | 580 to 472 |
| Millerton Lake | North Shore | On North Shore | 580 to 470 |
| Millerton Lake | South Bay | On South Shore | 580 to 500 |

Sources: Reclamation and DWR 2011; Reclamation and State Parks 2010

The marina at Millerton Lake is located at Winchell Cove on the South Shore (Reclamation and State Parks 2010). The marina includes 500 boat slips. There are also eight boat slips at Crow's Nest.

Campgrounds are located along the Millerton Lake North Shore, as summarized in Table 15.23. Many of these campsites are located along the shoreline. These campsites are affected by declining water elevations because this increases the distance from the campsites to the shoreline.

**Table 15.23 Millerton Lake Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| Millerton Lake | Dumna Strand | – | 10 |
| Millerton Lake | Fort Miller | Shoreline Campground | 36 |
| Millerton Lake | Group Campsites | Group Campground<br>Amphitheater | Two sites with total of 120 sites |
| Millerton Lake | Meadows | Campsites<br>Equestrian Campsites | 59<br>4 corrals and campsites |
| Millerton Lake | Mono | – | 16 |
| Millerton Lake | North Fine Gold Campground | Boat-In Campground | 15 |
| Millerton Lake | Rocky Point | – | 21 |
| Millerton Lake | Temperance Flat Boat | Boat-In Campground | 25 |
| Millerton Lake | Valley Oak | – | 6 |

Source: Reclamation and State Parks 2010

Millerton Lake recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.24 (Reclamation and State Parks 2010). The locations for shoreline day use areas are less desirable when the water elevations decline.

**Table 15.24 Millerton Lake Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| Millerton Lake | Blue Oak | Picnic and Trail along the South Shore | 3 sites<br>4 miles |
| Millerton Lake | Buzzard's Roost Trail | Picnic and Trail | 2 sites<br>0.5 miles |
| Millerton Lake | Crow's Nest | Picnic | 13 sites |
| Millerton Lake | Eagle's Nest | Picnic and Trailhead | 2 sites |
| Millerton Lake | Fort Miller | Trail | 0.25 miles |
| Millerton Lake | Grange Grove | Picnic | 74 sites |
| Millerton Lake | La Playa | Picnic and Swimming | 95 sites |
| Millerton Lake | McKenzie Point | Picnic | – |
| Millerton Lake | Meadows | Picnic | 10 sites |
| Millerton Lake | Millerton Courthouse | Historic Site and Picnic | 3 sites |
| Millerton Lake | San Joaquin River Trail | Portions along the Millerton Lake shoreline | 14 miles |
| Millerton Lake | South Bay | Picnic | 9 sites |
| Millerton Lake | South Fine Gold | Picnic and Trail | 10 sites<br>11 miles |

Sources: Reclamation and State Parks 2010; State Parks 2008

Fishing is also popular at Millerton Lake from boats and shoreline. Fishing opportunities include Striped Bass, Black Bass, Largemouth Bass, Green Sunfish, and American Shad (Reclamation and State Parks 2010).

#### 15.3.2.2.2 San Joaquin River from Friant Dam to the Delta

The San Joaquin River flows 100 miles from Friant Dam to the Delta. Downstream of Friant Dam, the San Joaquin River flows 23 miles through lands within the San Joaquin River Parkway which includes parks, trails, and ecological reserve areas between Friant Dam and State Route 145 managed by the San Joaquin River Parkway and Conservation Trust (Reclamation and DWR 2011).

Water-related recreational activities include boating, canoeing, kayaking, whitewater rafting, camping, picnicking, fishing, and hunting (Reclamation and DWR 2011). Access and facilities for these activities are available at several locations along and adjacent to the San Joaquin River.

Between Friant Dam and the confluence with the Merced River, whitewater rafting occurs between Friant Dam to Skaggs Bridge Park at State Route 145. Public access locations are generally located within the San Joaquin River

Parkway. Seven boat launching locations along the San Joaquin River Parkway that are managed by the San Joaquin River Parkway and Conservation Trust and/or DFW, Fresno County, or private operators. Lost Lake Park, managed by the San Joaquin River Parkway and Conservation Trust and DFW, provides a non-powered car-top boat launch. Sycamore Island Park, managed by San Joaquin River Parkway and Conservation Trust offers a boat ramp for small boats. River access also is available at Skaggs Bridge Park, managed by Fresno County. Picnicking is provided at most of the public access locations and at several other locations within the parkway. Camping is provided at Scout Island and Lost Lake Park managed by Fresno County and the private Fort Washington Beach. Trails include the 5-mile long Lewis S. Eaton Trail.

Downstream of State Route 145, major recreational areas include the 85-acre Mendota Pool in Mendota; Dunkle and Maldonado parks in the City of Firebaugh; and Las Palmas Fishing Access and Laird Park in Stanislaus County. Public access is provided at all of these sites. A boat ramp is located upstream of Mendota Dam.

The majority of these areas permit fishing. Fishing opportunities in the San Joaquin River include sunfish, crappie, Bluegill, Striped Bass, Largemouth Bass, and catfish (Reclamation and DWR 2011).

**15.3.2.2.3 San Joaquin Valley Refuges**

Wildlife refuges in the San Joaquin Valley that rely upon CVP water supplies include the San Luis NWR (including the San Luis Unit, West Bear Creek Unit, East Bear Creek Unit, Freitas Unit, and Kesterson Unit); Merced NWR; Los Banos Wildlife Area; Volta Wildlife Area; Mendota Wildlife Area; North Grasslands Wildlife Area (including China Island Unit and Salt Slough Unit); and Grasslands Resource Conservation District, as described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 10, Terrestrial Biological Resources (Reclamation 2012). Water-related activities include wildlife viewing, and hunting. Hunting opportunities include waterfowl, shorebirds, and pheasants (Reclamation and DWR 2011).

Several wildlife areas along the San Joaquin River could be affected by CVP operations of Millerton Lake, including the West Hilmar Wildlife Area downstream of the confluence with the Merced River and the San Joaquin River NWR located between the Tuolumne and Stanislaus rivers (Reclamation and DWR 2011). West Hilmar Wildlife Area includes 340 acres of wildlife area accessible by boat. The San Joaquin River NWR includes over 7,000 acres of riparian woodlands, wetlands, and grasslands for native wildlife with limited access at Pelican Trail.

In the southern San Joaquin Valley, the Kern and Pixley NWRs provide wildlife viewing opportunities.

#### 15.3.2.2.4 Stanislaus River Watershed

New Melones Reservoir and Tulloch Reservoir on the Stanislaus River and the lower Stanislaus River are located within areas in the Stanislaus River watershed that could be affected by changes in CVP operations.

*New Melones Reservoir*

New Melones Reservoir is a CVP facility on the Stanislaus River, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation activities and facilities at New Melones Reservoir area are managed by Reclamation. When the water storage in the reservoir is at full capacity, New Melones Reservoir has a surface area of approximately 12,500 acres and 105 miles of shoreline at a surface elevation of 1,088 feet msl (Reclamation 1997, 2010a).

Water-related activities include boating, waterskiing, camping, picnicking, wildlife viewing, spelunking, rock climbing, gold panning, and fishing (Reclamation 2010a). Float planes can land within the North, Middle, and South Bays of the reservoir. A model airplane club operates an airstrip near New Melones Dam. Cave exploration occurs in the Stanislaus River Canyon. Rock climbing occurs on Table Mountain. In years when the reservoir elevation is low, whitewater rafters launch at the Old Camp Nine Bridge.

There are five boat ramps at New Melones Reservoir, as summarized in Table 15.25.

**Table 15.25 New Melones Reservoir Boat Ramps**

| Location | Boat Ramp | Comments | Useable Elevations (feet, msl) |
|---|---|---|---|
| New Melones Reservoir | Angels Creek | – | 1,088 to 975 |
| New Melones Reservoir | Glory Hole | Location of New Melones Lake Marina | Several Boat Ramps: 1,088 to 860 |
| New Melones Reservoir | Mark Twain | Unimproved Ramp | 1,088 to 760 |
| New Melones Reservoir | Parrotts Ferry | Unimproved Ramp | Several Boat Ramps: 1,088 to 900 |

Source: Reclamation 2010a

The New Melones Marina is the only location with mooring facilities and houseboat rentals (Reclamation 2010a). Up to 50 private houseboats on mooring balls, 38 private houseboats in slips, and 20 rental houseboats may be maintained on the reservoir.

Campgrounds are located at Glory Hole and Tuttletown, as summarized in Table 15.26 (Reclamation 2010a). Some of the campsites are located along the shoreline. These campsites are affected by declining water elevations because this increases the distance from the campsites to the shoreline.

**Table 15.26 New Melones Reservoir Major Campgrounds**

| Location | Campground | Comments | Number of Campsites |
|---|---|---|---|
| New Melones Reservoir | Glory Hole | Two campgrounds | 144 |
| New Melones Reservoir | Tuttletown | Three campgrounds<br>Two Group campgrounds | 161<br>16 |

Source: Reclamation 2010a

New Melones Reservoir recreational areas also include day use areas for picnicking, swimming, and other recreational opportunities, as summarized in Table 15.27 (Reclamation 2010a). The locations for shoreline day use areas are less desirable when the water elevations decline.

**Table 15.27 New Melones Reservoir Day Use Areas**

| Location | Day Use Area | Comments | Number |
|---|---|---|---|
| New Melones Reservoir | Glory Hole | Picnic and Trails | 61 sites<br>Several trails: 0.25 to 2.5 miles |
| New Melones Reservoir | Mark Twain | Picnic and Norwegian Gulch Trail | 0.5 miles |
| New Melones Reservoir | Natural Bridges | Trail | 0.7 miles |
| New Melones Reservoir | Shoreline | Swimming and Recreational Gold Panning | – |
| New Melones Reservoir | Table Mountain | Trail | Several trails: 1.5 to 4.0 miles |
| New Melones Reservoir | New Melones Lake Visitor | Visitor Center | – |
| New Melones Reservoir | Tuttletown | Picnic and Trail | 52 sites<br>Several trails: 0.4 to 1.7 miles |

Sources: Reclamation 2010a, 2010b, 2014

*Tulloch Reservoir*

Tulloch Reservoir is a reservoir owned and operated by the Oakdale and South San Joaquin Irrigation Districts on the Stanislaus River downstream of New Melones Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. When the water storage in the reservoir is at full capacity (water elevation at 510 feet msl), the reservoir has a surface area of 1,260 acres and 55 miles of shoreline (CBC 2013; Tri-Dam Project 2002).

Water-related activities include boating, sailing, windsurfing, jet and water skiing, camping, picnicking, and fishing. Most of the shoreline is privately owned with shoreline access and more than 400 private docks for residents (Tri-Dam Project 2012). Public access is provided at a DFW marina and campground with a boat ramp at South Shore.

*Stanislaus River from Tulloch Dam to the San Joaquin River*

Downstream of Tulloch Dam, the Stanislaus River flows to Goodwin Dam, and then continues approximately 40 miles to the confluence with the San Joaquin River. Water-related activities along the lower portion of the Stanislaus River include whitewater rafting, camping, picnicking, swimming, and fishing. Whitewater rafting begins at Goodwin Dam and continues almost 4 miles to Knights Ferry (Reclamation 1997). Downstream of Knights Ferry, there are seven parks, including Caswell Memorial State Park, a 258-acre park managed by State Parks (Stanislaus County 1987; State Parks 2006a). Fishing opportunities on the lower Stanislaus River include bass, catfish, and crappie.

#### 15.3.2.2.5 San Luis Reservoir State Recreation Area

The San Luis Reservoir complex includes CVP and SWP offstream storage facilities located south of the Delta, as described in Chapter 5, Surface Water Resources and Water Supplies. The San Luis Reservoir complex includes San Luis Reservoir, O'Neill Forebay, and Los Banos Creek Reservoir. The San Luis Reservoir complex is located within the San Luis Reservoir State Recreation Area, and the recreational facilities are operated by State Parks (State Parks 2003). Los Banos Creek Reservoir is a flood detention basin to protect the community of Los Banos and San Luis Canal/California Aqueduct. This reservoir and a similar flood management reservoir that is not within the San Luis Reservoir State Recreation Area (Little Panoche Creek Reservoir) are not affected by CVP and SWP operations. Therefore, Los Banos Creek Reservoir and Little Panoche Creek Reservoir are not considered in detail in this EIS.

When the water storage in the San Luis Reservoir is at full capacity (water elevation at 540 feet msl), the reservoir has a surface area of 12,700 acres and 65 miles of shoreline (Reclamation and State Parks 2013; State Parks 2010).

The O'Neill Forebay is east of the San Luis Reservoir downstream of the San Luis Dam. When the water storage in the forebay is at full capacity (water elevation of 230 feet msl), the reservoir has a surface area of 2,210 acres and 14 miles of shoreline (Reclamation and State Parks 2013; State Parks 2010).

Water-related activities include boating, camping, picnicking, wildlife and scenic viewing, fishing, and hunting occur throughout the San Luis Reservoir State Recreation Area (Reclamation 2005c; State Parks 2010; Reclamation and State Parks 2013). Boat ramps are located at all three reservoirs, as summarized below.

- San Luis Reservoir: Boat ramps at Basalt Area and Dinosaur Point (operational to 340 feet and 360 feet msl, respectively).

- O'Neill Forebay: Boat ramps at Group Campground and Medeiros Campground.
- Los Banos Creek Reservoir: Boat ramp at Los Banos Creek Campground.

Camping occurs at Basalt Area at San Luis Reservoir (79 sites), O'Neill Forebay (50 sites), San Luis Creek Area (53 sites and two group campsites with 90 sites), and Los Banos Creek Area (14 sites) (Reclamation and State Parks 2013). Picnic sites, swimming, and/or trails occur at Basalt Area, Medeiros Area, and Los Banos Creek Area (Reclamation 2005c; State Parks 2010; Reclamation and State Parks 2013).

Fishing opportunities include Striped Bass, American Shad, and catfish (Reclamation and State Parks 2013). Hunting opportunities occur at San Luis Reservoir for waterfowl, deer, and wild pig (Reclamation 2005c; Reclamation and State Parks 2013).

##### 15.3.2.2.6 Delta Mendota Canal

Delta Mendota Canal is a CVP facility, as described in Chapter 5, Surface Water Resources and Water Supplies. The Delta-Mendota Canal includes two fishing sites: one in Stanislaus County and the other in Fresno County (Reclamation 2005c). Fishing opportunities include Striped Bass and catfish (Reclamation 1997).

##### 15.3.2.2.7 California Aqueduct/San Luis Canal

The California Aqueduct is a SWP facility, as described in Chapter 5, Surface Water Resources and Water Supplies. A portion of the canal is also co-located with the CVP San Luis Canal. Fishing is permitted at 12 sites along the California Aqueduct between Bethany Reservoir and Perris Lake in Southern California. Fishing opportunities include Striped Bass, Largemouth Bass, catfish, crappie, Green Sunfish, Bluegill, and starry flounder (Reclamation 1997).

#### *15.3.2.3 Delta*

The Delta is located at the terminus of the Sacramento River and the San Joaquin River. Water-related activities in the Delta include boating, sailing, water skiing, canoeing, kayaking, picnicking, fishing, and hunting. Recreational opportunities exist in many areas of the Delta; however, the analysis in this EIS is related to areas that could be affected by changes in CVP and/or SWP water supply operations and restoration in the Yolo Bypass. The following discussion describes recreation throughout the Delta followed by more specific discussions of recreation within the Yolo Bypass and Cache Slough.

##### 15.3.2.3.1 Delta Recreational Opportunities

The primary recreational activities in the Delta are related to boating and fishing (DPC 2012). Public recreation facilities are limited within the Delta. Most recreational opportunities are provided by private enterprises, including marinas, restaurants, hunting venues, and wineries and farm visits. Public access is provided at DFW and U.S. Fish and Wildlife Service (USFWS) sites.

The most recent survey of boating opportunities in the Delta was completed in 2002 by the California Department of Boating and Waterways (DBW 2014; DPC 2012). The survey indicated that of the 95 marinas surveyed, three were publically-owned and 92 were privately-owned (including 87 that were open to the public and five that were for members). The survey indicated that within the Delta there were over 11,600 boat slips, 55 boat launches, 2,182 campsites, and 324 picnic sites.

Public access sites for boating and wildlife and scenic viewing in the Delta include:

- USFWS: Stone Lakes NWR, Antioch Dunes NWR.
- DFW: Calhoun Cut Ecological Reserve, Decker Island Wildlife Area, Lower Sherman Island Wildlife Area, Miner Slough Wildlife Area, Rhode Island Wildlife Area, White Slough Wildlife Area, Woodbridge Ecological Reserve, Fremont Weir Wildlife Area, Sacramento Bypass Wildlife Area, and Yolo Bypass Wildlife Area.
- State Parks: Brannan Island-Franks Tract State Recreation Areas, Delta Meadows State Recreation Area.
- Department of Water Resources: Clifton Court Forebay.
- The Nature Conservancy/DFW: Cosumnes River Preserve.
- Solano Land Trust: Jepson Prairie Preserve.
- East Bay Regional Park District: Big Break Regional Shoreline, Antioch/Oakley Regional Shoreline, Browns Island Regional Preserve, Bay Point Regional Shoreline, Martinez Regional Shoreline, Carquinez Strait Regional Shoreline-Crockett Hills Regional Park, and Contra Costa Canal Trail.
- Municipal Marinas, Boat Launching, and Fishing Access Facilities: City of Antioch Marina and Municipal Boat Ramp; City of Pittsburg Riverview Park; Sacramento County Cliffhouse, Georgiana Slough Fishing Access, Hogback Island Access, and Sherman Island Public Access Facility; City of Sacramento Garcia Bend Park; several public and private marinas in Sacramento County; 12 public and private marinas with over 900 boat slips and boat access within the City of Stockton; San Joaquin County Dos Reis Regional Park, Mossdale Crossing Regional Park, and Westgate Landing Regional Park; and Yolo County Clarksburg River Access.

Several of these sites include launch sites for boats, canoes, and kayaks and numerous trails (DPC 2012; DSC 2011; DFG 2008b, 2008d, 2009; EBRPD 2013a; Antioch 2003; Pittsburg 2001; Sacramento County 2014; Sacramento 2005; Stockton 2007; Yolo County 2009).

One of the larger bodies of water in the Delta is the SWP Clifton Court Forebay. Fishing is the only recreational opportunity that occurs within the Clifton Court Forebay; and the opportunities are limited (DWR 2013c). Public access is restricted near the radial gate along West Canal. However, boat access occurs at a boat dock along West Canal to the east of the radial gate and by a trail from Clifton Court Road.

Fishing opportunities in the Delta generally include Striped Bass, Smallmouth Bass, Largemouth Bass, Spotted Bass, American Shad, Black Crappie, Chinook Salmon, steelhead, catfish, sunfish, Tule Perch, Warmouth, and White Sturgeon (DPC 2006).

Hunting opportunities for waterfowl, shorebirds, doves, and pheasants occur in many areas of the Delta on privately-owned land. Hunting also occurs at several publically-owned sites within the Delta, including:

- USFWS: Stone Lakes NWR.
- DFW: Decker Island Wildlife Area, Lower Sherman Island Wildlife Area, Miner Slough Wildlife Area, Rhode Island Wildlife Area, White Slough Wildlife Area, Yolo Bypass Wildlife Area; and on some lands owned by DWR (including Sherman and Twitchell islands and Clifton Court Forebay).

The Delta Protection Commission identified several physical constraints to Delta recreational opportunities that could be affected by CVP and SWP operations, including changes in water quality and operation of the CVP or SWP water facilities (Delta Cross Channel, South Delta Temporary Barriers, and Montezuma Slough Salinity Gates) (DPC 2012).

**15.3.2.3.2 Yolo Bypass and Cache Slough Recreational Opportunities**

The primary recreational activities in the Yolo Bypass and Cache Slough areas are related to wildlife viewing and hunting. Many recreational hunting opportunities occur on private lands, including private hunting clubs. Areas within Yolo Bypass and Cache Slough that provide public access for wildlife viewing or hunting within the Yolo Bypass and Cache Slough area, include:

- Fremont Weir Wildlife Area (DFW 2014a).
  - Wildlife viewing and fishing.
  - Hunting for pheasant, waterfowl, Mourning Dove, deer, quail, rabbit, and turkey.
- Sacramento Bypass Wildlife Area (DFW 2014c).
  - Wildlife viewing and fishing, including for White Sturgeon, White Catfish, and Black Crappie in the Tule Canal; and Largemouth Bass, Bluegill, and White Catfish in the borrow pits.
  - Hunting for pheasant and Mourning Dove.
- Yolo Bypass Wildlife Area (DFG 2008c, 2010).
  - Wildlife viewing and hiking.
  - Fishing for sturgeon, Striped Bass, Black Bass, and catfish.

- Hunting for waterfowl, coots, Moorhens, Snipe, pheasants, and Mourning Doves.
- Educational and interpretative programs.

- Calhoun Cut Ecological Reserve (DFG 2008d).
  - Waterfowl hunting and fishing from a boat.

There are other publically-owned lands within the Yolo Bypass and Cache Slough that provide habitat or will be restored to provide habitat. However, these lands are generally not available for public access to protect fragile ecosystems.

#### *15.3.2.4 Suisun Marsh*

Suisun Marsh is 106,511 acres of wetlands located between the Delta and the San Francisco Bay. Water-related activities at Suisun Marsh include waterfowl hunting, boating, kayaking, hiking, wildlife viewing, fishing, and hunting (Reclamation et al. 2011). Water-related recreation occurs within the two major channels, Montezuma and Suisun sloughs; and several moderately sized channels, Cordelia, Denverton, Nurse, and Hill sloughs.

The DFW manages several areas within the Suisun Marsh for public access, as described in Chapter 10, Terrestrial Biological Resources. These areas include (Reclamation et al. 2011):

- Grizzly Island Wildlife Area
  - Wildlife viewing, hiking, and fishing (February through July, and late September).
  - Hunting (August through mid-September, and October through January).
- Hill Slough Wildlife Area
  - Wildlife viewing and fishing.
- Peytonia Slough Ecological Preserve
  - Kayaking.
  - Wildlife viewing and fishing.
- Belden's Landing Water Access Facility
  - Boat launch ramp and fishing pier.

Suisun City Marina and Solano Yacht Club, Suisun City Boat Launch, and McAvoy Yacht Harbor and Club also provide boat launch ramp facilities (Reclamation et al. 2011). Pier fishing opportunities are provided at Suisun City Boat Launch.

The Solano Land Trust's Rush Ranch also provides opportunities for hiking and picnicking in the wetlands and upland areas near Potrero Hills (Reclamation et al. 2010).

Fishing opportunities within Suisun March include Striped Bass, White Sturgeon, catfish, and carp (Reclamation et al. 2011). Occasionally, Chinook Salmon, steelhead, and Largemouth Bass are caught in Suisun Marsh near Grizzly Island.

Duck hunting generates the most frequent recreational visits in Suisun Marsh (Reclamation et al. 2011). About 37,500 acres of Suisun Marsh are owned and operated by private duck clubs. DFW manages about 15,300 acres of public lands in Grizzly Island Wildlife Area for hunting of waterfowl, Snipe, coots, Moorhens, Mourning Doves, pheasants, rabbits, and Tule Elk.

There are other publically-owned lands within Suisun Marsh that provide habitat or will be restored to provide habitat. However, these lands are generally not available for public access to protect fragile ecosystems.

### 15.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, San Benito, and Napa counties that are within the CVP and SWP service areas. This section describes reservoirs in the San Francisco Bay Area Region that could be affected by CVP and SWP operations, including the CVP Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. CVP and SWP are generally not stored in reservoirs within Santa Clara County (SCVWD 2010).

#### *15.3.3.1 Contra Loma Reservoir*

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal, as described in Chapter 5, Surface Water Resources and Water Supplies. The recreation facilities are managed by East Bay Regional Park District. The 80 acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014a). Water-related activities include boating, wind surfing, kayaking, picnicking, and fishing. No bodily contact is to occur in Contra Loma Reservoir; therefore, a large swimming pool was constructed for the visitors by the East Bay Regional Park District. There is one boat launch at the reservoir. Contra Loma Reservoir accommodates fishing all year-round. Fishing opportunities include catfish, Black Bass, Striped Bass, Largemouth Bass, Bluegill, crappie, trout, and Redear Sunfish (EBRPD 2013c).

#### *15.3.3.2 San Justo Reservoir*

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. San Justo Reservoir recreation facilities have been closed to the public since 2009 due to an infestation by the zebra mussel. Previously, the recreation facilities were managed by San Benito County Water District (SBCWD 2014).

#### 15.3.3.3 Bethany Reservoir

Bethany Reservoir is a SWP facility located between the California Aqueduct and South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies. The recreation facilities are part of the Bethany Reservoir State Recreation Area and are managed by State Parks. When the water storage in the reservoir is at full capacity (water elevation at 243 feet msl), Bethany Reservoir has 161 acres of surface area and 6 miles of shoreline (DWR 2001). Water-related activities include boating, windsurfing, picnicking, and fishing. There is one boat launch at the reservoir (State Parks 2013a). Fishing opportunities include Striped Bass, Smallmouth Bass, Largemouth Bass, Spotted Bass, White Bass, catfish, crappie, and trout.

#### 15.3.3.4 Lake Del Valle

Lake Del Valle is a SWP facility located along the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies. The recreation facilities are managed by East Bay Regional Park District as part of the Del Valle Regional Park. When the water storage in the reservoir is at full capacity (water elevation at 703 feet msl), Lake Del Valle has 708 acres of surface area and 16 miles of shoreline (DWR 2001). Water-related activities include boating, windsurfing, camping, swimming, and fishing (DWR 2001). There is a boat launch at the lake (EBRPD 2014). Boating hazards can occur along the variable shoreline when the surface water elevation declines to 678 feet msl. There are seven group campsites for up to 475 and a family campground (DWR 2001; EBRPD 2014). Fishing opportunities include trout, catfish, Largemouth Bass, and Smallmouth Bass, Striped Bass, and Panfish (EBRPD 2014).

#### 15.3.3.5 Los Vaqueros Reservoir

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by Contra Costa Water District. Water-related activities include boating using rented electrical boats, and fishing (CCWD 2014). The Los Vaqueros recreation facilities include a marina, four fishing piers, 55 miles of trails, several individual and group picnic areas, and an interpretative center. Fishing opportunities include Rainbow Trout, Brown Bullhead, White Catfish, Channel Catfish, sunfish, White Crappie, Largemouth Bass, Striped Bass, Chinook Salmon, Kokanee Salmon, Green Sunfish, and Sacramento Perch (EBRPD 2014).

#### 15.3.3.6 San Pablo Reservoir, Lafayette Reservoir, Lake Chabot, and East Bay Municipal Utility District Trails

The East Bay Municipal Utility District reservoirs in Alameda and Contra Costa County are used to store water within and near the East Bay Municipal Utility District service area. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation is allowed within the waters of San Pablo and Lafayette reservoirs and Lake

Chabot (EBMUD 2011). Recreation is not allowed within the waters of Upper San Leandro and Briones reservoir. East Bay Municipal Utility District maintains trails within the watersheds of the reservoirs.

Recreation facilities at San Pablo Reservoir are managed by East Bay Municipal Utility District. Water-related activities at San Pablo Reservoir include boating, picnicking, and fishing (EBMUD 2014a). There is a boat launch at the reservoir. There are individual sites and nine group picnic areas that can accommodate up to 100 people at each site. Hiking can occur in the San Pablo Reservoir watershed on 8.7 miles of trails which connect to about 13 miles of trails in the Briones Reservoir watershed (EBMUD 2007a). The surface water of the reservoirs can be viewed from many locations along these trails. Fishing opportunities at San Pablo Reservoir include Rainbow Trout, catfish, Black Bass, Bluegill, and crappie (EBMUD 2014a).

Recreation facilities at Lafayette Reservoir are managed by East Bay Municipal Utility District. Water-related activities at Lafayette Reservoir include boating, picnicking, and fishing (EBMUD 2014b). There is a private car-top boat launch at the reservoir. There are 125 picnic sites around the reservoir. Hiking can occur in the Lafayette Reservoir watershed on 7.4 miles of trails. Fishing opportunities at Lafayette Reservoir include Rainbow Trout, catfish, Black Bass, and sunfish.

There are no water-related activities within or adjacent to Upper San Leandro Reservoir. However, East Bay Municipal Utility District maintains over 26 miles of trails within the Upper San Leandro Reservoir watershed. The surface water of the reservoirs can be viewed from many locations along these trails (EBMUD 2007b).

Recreation facilities at Lake Chabot are managed by East Bay Regional Park District as part of the Lake Chabot Regional Park (EBRPD 2011). Water-related activities at Lake Chabot include boating, camping, picnicking, and fishing. There is a boat launch at the reservoir and boat rides are offered on the *Chabot Queen*. Individual campsites and group campsites are located near the southern portion of the park. Picnic sites are located near the Lake Chabot Marina. Hiking can occur along the shoreline on over 9 miles of trails which connect to more than 17 miles of other trails in the watershed (EBRPD 2011, 2013d). Other recreational activities, including equestrian trails and a marksmanship range, are located in the upper Lake Chabot watershed. Fishing opportunities at Lake Chabot include Rainbow Trout, catfish, Black Bass, crappie, Bluegill, and carp.

### 15.3.4 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The SWP water supplies generally are conveyed to Central Coast municipal, industrial, and agricultural water users in pipelines and closed reservoirs. Water is delivered to southern Santa Barbara County communities through Cachuma Lake. Therefore, in the Central Coast Region, the only recreational opportunities that may be affected by changes in SWP operations would be Cachuma Lake in Santa Barbara County (CCWA 2014).

#### *15.3.4.1 Cachuma Lake*

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by Santa Barbara County Parks Department. Water-related activities include boating, and fishing within the lake and along the lake shoreline (Reclamation 2010c). Cachuma Lake recreation facilities include a marina with 87 rental boats and a public boat launch, 94 private boat slips, 520 campsites, equestrian campsites, family center, amphitheater, and trails that range from 0.25 to 9 miles in length. Fishing opportunities include trout, catfish, crappie, bass, Redear Perch, and Bluegill.

### 15.3.5 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. The SWP water supplies generally are conveyed to Southern California municipal, industrial, and agricultural water users in canals and pipelines. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs that store SWP water, include United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, Lower Otay, Hodges, and Murray reservoirs; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

This section does not include reservoirs that do not provide recreational opportunities, such as Vail Lake in Riverside County or Olivenhain Reservoir in San Diego County, or reservoirs that do not store SWP water supplies, such as Lake Mathews in Riverside County which is used to store Colorado River water (RCWD 2011; SDCWA 2015; Riverside County 2000).

#### *15.3.5.1 Quail Lake*

Quail Lake is a SWP facility in Los Angeles County, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by DWR (DWR 2014a). Water-related activities include fishing within the lake and along the shoreline. Fishing opportunities include Channel Catfish, Striped Bass, Blackfish, Tule Perch, Threadfin Shad, and Hitch.

#### *15.3.5.2 Pyramid Lake*

Pyramid Lake is a SWP facility located in Los Angeles County and upstream of Castaic Lake on the West Branch of the California Aqueduct, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by the U.S. Forest Service (DWR 2000, 2014b). Water-related activities include boating, camping, water skiing, swimming, and fishing. Boat launch facilities are available at Vaqueros Beach and Emigrant Landing. A marina and picnic sites are available at Emigrant Landing. Four picnic and viewing sites are accessible only by boat. Family and group camping are available at two sites.

Fishing opportunities include largemouth, smallmouth, and Striped Bass; catfish, blue gill; crappie; and trout. Reservoir elevations can vary substantially on a daily basis because the lake provides short-term storage for the downstream Castaic Powerplant.

#### 15.3.5.3 Castaic Lake

Castaic Lake is a SWP facility located in Los Angeles County at the terminal end of the West Branch of the California Aqueduct, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by the Los Angeles County Department of Parks (DWR 2007b). Water-related activities include boating, water skiing, jet skiing, wakeboarding, camping, picnicking, swimming at the lagoon/afterbay, and fishing. Fishing opportunities include trout, Largemouth Bass, Striped Bass, catfish, and crappie (DWR 2014c).

#### 15.3.5.4 Silverwood Lake

Silverwood Lake is a SWP facility located in San Bernardino County along the East Branch of the California Aqueduct, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by State Parks as part of the Silverwood Lake State Recreational Area (State Parks 2006b). Water-related activities include boating, water skiing, camping, picnicking, swimming, and fishing. Facilities available for boating include a boat ramp, marina, and waterskiing area. Camping facilities include 136 family sites, seven walk-in sites, and several group sites for up to 120 people. The park includes two swimming beaches and 13 miles of trails. Fishing opportunities include Largemouth Bass, Striped Bass, Bluegill, crappie, and catfish.

#### 15.3.5.5 Crafton Hills Reservoir

Crafton Hills Reservoir is a SWP facility located in the City of Yucaipa within San Bernardino County, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by DWR (DWR 2009). Recreation activities in vicinity of the reservoir are associated with hiking trails in the open space within the Crafton Hills watershed. The surface water of the reservoirs can be viewed from many locations along these trails.

#### 15.3.5.6 Lake Perris

Lake Perris is a SWP facility located in Riverside County at the terminal end of the East Branch of the California Aqueduct, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by State Parks as part of the Lake Perris State Recreational Area (State Parks 2013b; DWR 2010). Water-related activities include boating, camping, swimming, picnicking, and fishing. Boating facilities include a marina and three boat launch ramps. Other recreational facilities include two swimming beaches, family campground, seven equestrian camp sites, boat-in picnic sites on Alessandro Island, and the Ya’i Hek’i Regional Indian Museum. Fishing opportunities include Largemouth Bass, catfish, crappie, carp, Bluegill, and Redear Sunfish.

#### *15.3.5.7 Diamond Valley Lake*

Diamond Valley Lake is an offstream storage facility located in Riverside County owned and operated by Metropolitan Water District of Southern California, as described in Chapter 5, Surface Water Resources and Water Supplies (MWD 2013). The lake is used to store SWP water. Water-related activities include boating, and fishing. Boating facilities include a marina with boat rentals. Other recreational facilities include a visitor center, Western Science Center, and the Valley-Wide Recreation and Park District Regional Aquatic Center and Community Park. Fishing opportunities include Black Bass, Bluegill, redear sunfish, Rainbow Trout, blue catfish, and Channel Catfish (DVM 2014).

#### *15.3.5.8 Lake Skinner*

Lake Skinner is an offstream storage facility located in Riverside County owned and operated by Metropolitan Water District of Southern California, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by Riverside County Parks (Riverside County 2014). The lake is used to store SWP water. Water-related activities include boating, camping, and fishing. Other recreational facilities include an amphitheater and Splash Pad. Fishing opportunities include Striped Bass, Largemouth Bass, Bluegill, Rainbow Trout, catfish, and carp.

#### *15.3.5.9 Lake Piru*

Lake Piru is located on Piru Creek, a tributary of the Santa Clara River, in Ventura County (UWCD 2014). The lake is owned and operated by United Water Conservation District, as described in Chapter 5, Surface Water Resources and Water Supplies. Lake Piru is located within Los Padres National Forest (PMC 2014). The lake is used to store SWP water.

Recreation facilities are managed by a private concessionaire for the district (UWCD 2014; PMC 2014). Water-related activities include boating, camping, and picnicking. The marina includes a boat launch and private boat slips. There are over 220 campsites, including several group campsites.

#### *15.3.5.10 Dixon Lake*

Dixon Lake is located in the hills above the City of Escondido in San Diego County (Escondido 2014a). The lake is owned and operated by the City of Escondido, as described in Chapter 5, Surface Water Resources and Water Supplies. The lake is used to store SWP water.

Recreation facilities are managed by the City of Escondido (Escondido 2014b). Water-related activities include camping, picnicking, and fishing. Boats are allowed on the lake for fishing. There are 45 campsites and 22 picnic sites (Escondido 2014 n.d.; Escondido 2014c). Fishing opportunities include trout, bass, Bluegill, carp, catfish, and crappie.

#### *15.3.5.11 San Vicente, El Capitan, Lower Otay, Hodges, and Murray Reservoirs*

San Vicente Reservoir, El Capitan, Lower Otay, Hodges, and Murray reservoirs are located in San Diego County (San Diego 2011). The reservoirs are owned and operated by the City of San Diego, as described in Chapter 5, Surface Water Resources and Water Supplies. The reservoirs are used to store SWP water.

Recreation facilities are managed by the City of San Diego (San Diego 2014a, 2015a, 2015b). Water-related activities at the reservoirs include boating, picnicking, and fishing (San Diego 2014b, 2015a, 2015b). There are 16 picnic sites at Lower Otay Reservoir. Fishing opportunities at Lower Otay Reservoir include Largemouth Bass, Bluegill, black and White Crappie, Channel Catfish, blue catfish, White Catfish, and bullhead. Recreational activities at San Vicente Reservoir are temporarily closed during construction to raise the dam (San Diego 2014c). Fishing opportunities at El Capitan Reservoir include Largemouth Bass, Bluegill, crappie, Channel Catfish, Blue Catfish, Green Sunfish, and carp (San Diego 2014d). Hodges Reservoir provides recreational opportunities including boating, boardsailing, and fishing for bass, catfish, crappie, Bluegill, Bullhead, and carp (San Diego 2015a). Murray Reservoir provides recreational opportunities for boating, floating, swimming, and fishing for Largemouth Bass, Bluegill, Channel Catfish, Black Crappie, and trout (San Diego 2015b).

#### *15.3.5.12 Lake Jennings*

Lake Jennings is located in San Diego County (HWD 2014). The lake is owned and operated by Helix Water District, as described in Chapter 5, Surface Water Resources and Water Supplies. The lake is used to store SWP water.

Recreation facilities are managed by Helix Water District (HWD 2014). Water-related activities include boating, camping, picnicking, and fishing. There are 96 campsites. There are a variety of picnic sites at Lake Jennings including: Cloister Cover, Siesta Point, Hermit Cove, and Eagle Point. Bird watchers at Lake Jennings can see Loons, Grebes, Cormorants, Herons, Swans, Geese, Eagles, Hawks, Thrushes, Warblers, and many others. Hikers at Lake Jennings have access to a variety of different trails near the lake including a 5.5 mile loop around the lake. Fishing opportunities include trout, bass, and catfish.

#### *15.3.5.13 Sweetwater Reservoir*

Sweetwater Reservoir is located in San Diego County (Sweetwater Authority 2014). The lake is owned and operated by Sweetwater Authority, as described in Chapter 5, Surface Water Resources and Water Supplies. The reservoir is used to store SWP water. Recreation facilities are managed by Sweetwater Authority. Water-related activities include fishing.

#### *15.3.5.14 Lake Arrowhead*

Lake Arrowhead is located in San Bernardino County (LACSD 2014). The lake is owned and operated by Arrowhead Lake Association. The Lake Arrowhead Community Services District stores SWP water in the lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Recreation facilities are managed by the Arrowhead Lake Association. Water-related activities include boating, camping, and fishing (Lake Arrowhead 2014).

### 15.3.6 Recreational Fishing in San Pablo and San Francisco Bays

Recreational fishing for sturgeon, Striped Bass, steelhead, trout, and salmon in San Pablo and San Francisco bays could be affected by changes in populations that may occur due to implementation of the alternatives considered in this EIS. Of these species, the majority of recreational fishing in the San Francisco Bay Estuary is related to Striped Bass and sturgeon fishing, especially in San Pablo and Suisun bays.

Recreational fishing for White Sturgeon is limited to three sturgeons per person each year, with a daily bag limit of one fish/day and a size limitation of 40 to 60 inches (from the nose tip to fork in the tail). In addition, White Sturgeon fishing is not allowed in San Francisco Bay from March 16 through December 31. Green sturgeon fishing is not allowed. Striped bass fishing occurs throughout the year with a daily bag limit two fish/day and a minimum size limitation of 18 inches. Salmon sportfishing also occurs within the San Francisco Bay Estuary during periods specified by the National Marine Fisheries Service (NMFS).

### 15.3.7 Recreational Salmon Fishing along Northern California Coast

Chinook Salmon, Coho Salmon, and steelhead are generally the primary species for recreational fishing that could be affected by changes in CVP and SWP operations along the Pacific Coast of Northern California from Pigeon Point to southern Oregon (near Elk River). The Pacific Coast salmon fisheries are managed by the Pacific Fishery Management Council (PFMC) in waters between the United States/Canada border to the United States/Mexico border between 3 and 200 nautical miles offshore (PFMC 2014). The State DFW manages the salmon fisheries within 0 to 3 nautical miles offshore with regulations that are generally similar to the PFMC to the salmon fishing requirements. The PFMC analyzes the a fisheries evaluation each year; and defines the periods of time for the fishing season and minimum size fish to be caught for commercial, recreational, and tribal salmon fishing activities, as described in more detail for recreational and commercial salmon fishing in Chapter 19, Socioeconomics.

## 15.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in recreation resources; results of the impact analysis; potential mitigation measures; and cumulative effects.

### 15.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in recreational resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

As described in Section 15.3, Affected Environment, there are a wide range of recreational opportunities at the reservoirs and along the downstream rivers. This analysis focuses on the potential changes in these recreational opportunities and not specific recreational actions. For example, this analysis focuses on changes in surface water elevations at reservoirs which could affect boating, shoreline camping and picnicking, and use of trails. The changes in reservoir elevations would occur within the historical range of elevation changes; therefore, none of the recreational opportunities would be permanently reduced or expanded. The changes that would occur within the alternatives would change the potential for enjoyable recreational opportunities based upon changes in reservoir surface water elevations and river flows.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change recreational opportunities at water bodies affected by CVP and SWP operations.

##### *15.4.1.1 Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Reservoirs that store CVP and SWP water provide a wide diversity of recreational experiences on the water surface, at shoreline campgrounds, and along shoreline trails. By the end of September, the surface water elevations can decline from higher elevations in the spring by up to 100 feet in Shasta Lake and Lake Oroville; and over 50 feet in Trinity and Folsom lakes and New Melones and San Luis reservoirs. As the water elevations declines, boat ramps become unavailable and the water surface recedes along steep slopes from shoreline campgrounds and trails. Changes in CVP and SWP operations under the alternatives could change the surface water elevations, especially in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison.

The CalSim II model output includes monthly reservoir elevations for CVP and SWP reservoirs in the Central Valley and Trinity Lake. The end of September reservoir elevations generally indicate low reservoir elevations. To assess changes in recreational resources, changes in reservoir elevations for the end of September were compared between alternatives and the No Action Alternative and Second Basis of Comparison. The reservoir elevations at the end of September were compared to minimum allowable boat ramp elevations as a measure of surface water accessibility.

Reservoirs in the San Francisco Bay Area, Central Coast, and Southern California regions store water from multiple water supplies including CVP and SWP water; however, these reservoirs are not included in the CalSim II model simulation. For the purposes of this EIS analysis, changes in surface water elevations in these reservoirs were assumed to be related to changes in CVP and SWP water deliveries to the areas located to the south of the Delta.

#### 15.4.1.2 Changes in Recreational Resources along Rivers downstream of CVP and SWP Reservoirs

Changes in CVP and SWP operations under the alternatives could change the river flows in Trinity, Sacramento, Feather, American, and Stanislaus rivers in a manner that would affect recreational opportunities including boating and swimming during the spring and summer months, especially in dry and critical dry years.

Results of the CalSim II model were used to assess changes in average monthly flows that could affect recreational opportunities under the alternatives, the No Action Alternative, and the Second Basis of Comparison. This analysis is focused on the Trinity, Sacramento, Feather, American, and Stanislaus rivers. Generally, flow in rivers downstream of San Luis Reservoir and the reservoirs in the San Francisco Bay Area, Central Coast, and Southern California that store CVP and SWP water are based upon minimum instream flow requirements except in high flow events because the reservoirs are operated primarily to provide water into downstream water distribution systems.

#### 15.4.1.3 Changes in Recreational Opportunities at Wildlife Refuges

Changes in CVP and SWP operations under the alternatives would not change water supplies to wildlife refuges that use CVP water for Level 2 water demands, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, these changes are not analyzed in this EIS.

#### 15.4.1.4 Effects Related to Water Transfers

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future recreational conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014f). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 15.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to recreational resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *15.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would could increase demand for recreational resources.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 USFWS Biological Opinion (BO) and 2009 NMFS

BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that would affect recreational resources, including restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.

### 15.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

#### *15.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 15.4.3.1.1 Trinity River Region

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations (changes within 5 percent) and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under the No Action Alternative and Second Basis of Comparison. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under the No Action Alternative and Second Basis of Comparison. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 5 percent of the time under the No Action Alternative and Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The following changes would occur on the Trinity River under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Chapter 5, Surface Water Resources and Water Supplies.

- Over long-term conditions, flows would be similar in March through November; and reduced in December through February (up to 9.5 percent).
- In wet years, flows would be similar in April through November; and reduced in December through March (up to 11.2 percent).
- In dry years, flows would be similar in all months.

Flows in Trinity River would be similar during the recreation season (spring and summer months); therefore, recreational opportunities would be similar.

#### 15.4.3.1.2 Central Valley Region

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in recreational resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end of September surface water elevations would be reduced by 6.2 percent in wet and critical dry years.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 35, 20, 10, and 9 percent of the time, respectively, under the No Action Alternative; and approximately 55, 30, 15, 10, and 7 percent of the time, respectively, under the Second Basis of Comparison.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 95, 87, 73, and 35 percent of the time, respectively, under the No Action Alternative; and approximately 85, 75, 62, and 25 percent of the time, respectively, under the Second Basis of Comparison.

At Folsom Lake, boat ramps at Rattlesnake Bar, Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 80, 65, 40, 10, and 7 percent of the time, respectively, under the No Action Alternative; and approximately 65, 40, 10, and 7 percent of the time, respectively, under the Second Basis of Comparison.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 65, 25, 18, and 5 percent of the time, respectively, under the No Action Alternative; and approximately 30, 25, 15, 5 percent of the time, respectively, under the Second Basis of Comparison.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 50 and 10 percent of the time, respectively, under the No Action Alternative; and approximately 20 and 5 percent of the time, respectively, under the Second Basis of Comparison.

At all reservoirs, boating opportunities would be decreased, and shoreline recreational opportunities would be similar or decreased under the No Action Alternative as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Sacramento River downstream of Keswick Dam
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; increased flows in September and November (up to 37.7 percent); and reduced flows in December, January, and June (up to 7.8 percent).
  - In wet years, similar flows would occur in January through July; increased flows in September through November (up to 77.7 percent); and reduced flows in December and August (up to 14.6 percent).
  - In dry years, similar flows would occur in July through October, December through March, and May; increased flows in November (33.4 percent).
- Sacramento River at Freeport
  - Over long-term conditions, similar flows would occur in October, December through May, and August; increased flows in September, November, and July (up to 43.3 percent); and reduced flows in June (11.4 percent).
  - In wet years, similar flows would occur in January through June and October; increased flows in July through September and November (up to 90.3 percent); and reduced flows in December (10.7 percent).
  - In dry years, similar flows would occur in August through October and December through April; increased flows in November and July (up to 15.8 percent); and reduced flows in May and June (up to 11.9 percent).

- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in November and April; increased flows in July through September (up to 76.1 percent); and reduced flows in October, December through March, May, and June (up to 27.2 percent).
  - In wet years, similar flows would occur in October through November and March through May; increased flows in July through September (up to 184 percent) and reduced flows in December through February (up to 26.0 percent).
  - In dry years, similar flows would occur in November through March; increased flows in April and July (up to 52.4 percent); and reduced flows in August through October and May and June (up to 27.6 percent).
- American River downstream of Nimbus Dam
  - Over long-term conditions, similar flows would occur in November through May and July; increased flows in September and October (up to 44.7 percent); and reduced flows in June and August (up to 6.1 percent).
  - In wet years, similar flows would occur in October through November and January through July; increased flows in September (91.1 percent) and reduced flows in December and August (up to 10.7 percent).
  - In dry years, similar flows would occur in all months except October, February and July; increased flows in October (16.5 percent); and reduced flows in February and July (up to 7.3 percent).
- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, similar flows would occur in May and July through September; increased flows in October, March, and April (up to 148.7 percent); and reduced flows in November through February and June (up to 33.8 percent).
  - In wet years, similar flows would occur in February and April; increased flows in October, March, May, July, and August (up to 117.1 percent); and reduced flows in September, November through January, and June (up to 50.8 percent).
  - In dry years, similar flows would occur in July through September; increased flows in October and April (up to 154.3 percent); and reduced flows in November through March, May, and June (up to 35.7 percent).

During the spring and summer months, the changes in flow conditions between the No Action Alternative and the Second Basis of Comparison vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Sacramento River at Freeport would increase in several months under the No Action Alternative as compared to the Second Basis of Comparison by up to 90 percent, and decrease in several months up to 11 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist. However, the value of the recreational opportunities would be both improved and reduced depending upon the timing of the changes.

Overall, under the No Action Alternative and the Second Basis of Comparison, recreational opportunities would be reduced on the Sacramento River downstream of Keswick Dam; and both improved and reduced on the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam depending upon the month.

*Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to recreational resources were identified as changes in reservoir surface water elevations, streams, and the Delta. The analysis indicated that these potential impacts would not be substantial because the conditions with and without the water transfers would be similar.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 15.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Region

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis. Monthly deliveries are not necessarily indicative of reservoir storage because all or a portion of the water deliveries could be directly conveyed to water users in any specific month. Therefore, annual deliveries are considered to be relatively proportional to the amount of water that could be stored over all water year types. In the San Francisco Bay Area Region, values for the CVP municipal and industrial water deliveries and the SWP south of the Delta water deliveries (without Article 21 deliveries) were considered; and SWP south of the Delta water deliveries (without Article 21 deliveries) were considered for the Central Coast and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison CVP water deliveries would be reduced by 10 percent and SWP water deliveries would be reduced by 18 percent. Therefore, for this EIS analysis, it is assumed that recreational resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the

San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

#### *15.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because recreational resource conditions under Alternative 1 are identical to recreational resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 15.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under Alternative 1 and the No Action Alternative. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under Alternative 1 and the No Action Alternative. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 5 percent of the time under Alternative 1 and the No Action Alternative.

The potential for reduced recreational resources at Trinity Lake related to shoreline activities would be less under the No Action Alternative as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The following changes would occur on the Trinity River under Alternative 1 as compared to the No Action Alternative, as summarized in Chapter 5, Surface Water Resources and Water Supplies.

- Over long-term conditions, flows would be similar in March through November; and increased in December through February (up to 10.5 percent).
- In wet years, flows would be similar in April through November; and increased in December through March (up to 12.6 percent).
- In dry years, flows would be similar all months.

Flows in Trinity River would be similar during the recreation season (spring and summer months); therefore, recreational opportunities would be similar.

*Central Valley Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in recreational resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end of September surface water elevations would be increased by 6.6 percent in wet and critical dry years.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 30, 15, 10, and 7 percent of the time, respectively, under Alternative 1; and approximately 55, 35, 20, 10, and 9 percent of the time, respectively, under the No Action Alternative.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 85, 75, 62, and 25 percent of the time, respectively, under Alternative 1; and approximately 95, 87, 73, and 35 percent of the time, respectively, under the No Action Alternative.

At Folsom Lake, boat ramps at Rattlesnake Bar, Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 65, 40, 10, and 7 percent of the time, respectively, under Alternative 1; and approximately 80, 65, 40, 10, and 7 percent of the time, respectively, under the No Action Alternative.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 30, 25, 15, 5 percent of the time, respectively, under Alternative 1 as compared to approximately 65, 25, 18, and 5 percent of the time, respectively, under the No Action Alternative.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 20 and 5 percent of the time, respectively, under Alternative 1; and approximately 50 and 10 percent of the time, respectively, under the No Action Alternative.

At all reservoirs, boating opportunities would be increased, and shoreline recreational opportunities would be similar or increased under Alternative 1 as compared to the No Action Alternative.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Sacramento River downstream of Keswick Dam
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 27.4 percent); and increased flows in December, January, and June (up to 8.4 percent).
  - In wet years, similar flows would occur in January through July; reduced flows in September through November (up to 43.7 percent); and increased flows in December and August (up to 17.0 percent).
  - In dry years, similar flows would occur in July through October, December through March, and May; reduced flows in November (25.0 percent); and increased flows in April and June (up to 7.8 percent).
- Sacramento River at Freeport
  - Over long-term conditions, similar flows would occur in October, December through May, and August; reduced flows in September, November, and July (up to 30.2 percent); and increased flows in June (12.8 percent).
  - In wet years, similar flows would occur in January through June and October; reduced flows in July through September and November (up to 47.4 percent); and increased flows in December (6.6 percent).
  - In dry years, similar flows would occur in August through October and December through April; reduced flows in November and July (up to 13.6 percent); and increased flows in May and June (up to 13.5 percent).
- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in November and April; reduced flows in July through September (up to 43.2 percent); and increased flows in October, December through March, May, and June (up to 37.4 percent).
  - In wet years, similar flows would occur in October, November, and March through May; reduced flows in July through September (up to 64.9 percent); and increased flows in December through February and June (up to 35.1 percent).
  - In dry years, similar flows would occur in December through April; reduced flows in July (34.4 percent); and increased flows in August through October, May, and June (up to 38.1 percent).

- American River downstream of Nimbus Dam
  - Over long-term conditions, similar flows would occur in November through May and July; reduced flows in September and October (up to 30.9 percent); and increased flows in June (5.4 percent).
  - In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (47.7 percent); and increased flows in August (12.0 percent).
  - In dry years, similar flows would occur in November through January, March through June, August, and September; reduced flows in October (14.1 percent); and increased flows in February and July (up to 7.9 percent).
- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, similar flows would occur in July through September; reduced flows in October, March, and April (up to 59.8 percent); and increased flows in November through February and June (up to 51.1 percent).
  - In wet years, similar flows would occur in February and April; reduced flows in October, March, May, July, and August (up to 53.9 percent); and increased flows in September, November through January, and June (up to 103.2 percent).
  - In dry years, similar flows would occur in July through September; reduced flows in October and April (up to 60.7 percent); and increased flows in November through March, May, and June (up to 55.5 percent).

During the spring and summer months, the changes in flow conditions between Alternative 1 as compared to the No Action Alternative vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Sacramento River at Freeport would increase in several months under Alternative 1 as compared to the No Action Alternative by up to 17 percent, and decrease in several months up to 44 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist. However, the value of the recreational opportunities would be both improved and reduced depending upon the timing of the changes.

Overall, under Alternative 1 as compared to the No Action Alternative, recreational opportunities would be improved on the Sacramento River downstream of Keswick Dam; and both improved and reduced on the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam depending upon the month.

*Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on recreational resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 1 as compared to the No Action Alternative, recreational resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 11 to 21 percent in the San Francisco Bay Area Region and 21 percent in the Central Coast and Southern California regions.

#### 15.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *15.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 15.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to recreational resources conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 15.4.3.1, No Action Alternative.

### *15.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations; and additional predation control actions to reduce the populations of striped bass. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 15.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under Alternative 3 and the No Action Alternative. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under Alternative 3 and the No Action Alternative. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 5 percent of the time under Alternative 3 and the No Action Alternative.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The following changes would occur on the Trinity River under Alternative 3 as compared to the No Action Alternative, as summarized in Chapter 5, Surface Water Resources and Water Supplies.

- Over long-term conditions, flows would be similar in March through November; and increased in December through February (up to 11.8 percent).
- In wet years, flows would be similar in April through October; reduced in November (7.0 percent); and increased in December through March (up to 15.1 percent).
- In dry years, flows would be similar in all months.

Flows in Trinity River would be similar during the recreation season (spring and summer months); therefore, recreational opportunities would be similar.

*Central Valley Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in below normal, dry, and critical dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in recreational resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end of September surface water elevations would be increased by 7.9 percent in wet years and 5.7 percent in above normal years.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 30, 15, 10, and 7 percent of the time, respectively, under Alternative 3; and approximately 55, 35, 20, 10, and 9 percent of the time, respectively, under the No Action Alternative.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 85, 75, 62, and 25 percent of the time, respectively, under Alternative 3; and approximately 95, 87, 73, and 35 percent of the time, respectively, under the No Action Alternative.

At Folsom Lake, boat ramps at Rattlesnake Bar, Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 65, 40, 10, and 7 percent of the time, respectively, under Alternative 3; and approximately 80, 65, 40, 10, and 7 percent of the time, respectively, under the No Action Alternative.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 22, 18, 10, and 5 percent of the time, respectively, under Alternative 3 as compared to approximately 65, 25, 18, and 5 percent of the time, respectively, under the No Action Alternative.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 28 and 8 percent of the time, respectively, under Alternative 3; and approximately 50 and 10 percent of the time, respectively, under the No Action Alternative.

At Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir, boating opportunities would be increased, and opportunities would be similar at Shasta Lake under Alternative 3 as compared to the No Action Alternative. At Shasta Lake, Lake Oroville, and New Melones Reservoir shoreline recreational opportunities would be increased, and opportunities would be similar at Folsom Lake and San Luis Reservoir under Alternative 3 as compared to the No Action Alternative.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Sacramento River downstream of Keswick Dam
  - Over long-term conditions, similar flows would occur in October, February through May, July, and August; reduced flows in September and November (up to 20.1 percent); and increased flows in December, January, and June (up to 8.9 percent).
  - In wet years, similar flows would occur in February through August; reduced flows in September through November (up to 42.1 percent); and increased flows in December and January (up to 16.9 percent).
  - In dry years, similar flows would occur in July through September and December through May; reduced flows in November (24.6 percent); and increased flows in January and June (up to 7.3 percent).
- Sacramento River at Freeport
  - Over long-term conditions, similar flows would occur in October, December through May, July, and August; reduced flows in September and November (up to 30.1 percent); and increased flows in June (12.1 percent).
  - In wet years, similar flows would occur in January through May, July, and October; reduced flows in August, September, and November (up to 48.1 percent); and increased flows in December and June (up to 6.6 percent).
  - In dry years, similar flows would occur in July through October and December through April; reduced flows in November (14.2 percent); and increased flows in May and June (up to 15.7 percent).
- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in October, November, March, April, and July; reduced flows in August and September (up to 49.4 percent); and increased flows in December through February, May, and June (up to 33.9 percent).
  - In wet years, similar flows would occur in October, November, February through May, and July; reduced flows in August and September (up to 70.0 percent) and increased flows in December, January, and June (up to 28.1 percent).
  - In dry years, similar flows would occur in September and January through April; reduced flows in October through December and July (up to 14.5 percent); and increased flows in May, June, and August (36.9 percent).
- American River downstream of Nimbus Dam
  - Over long-term conditions, similar flows would occur in November, January through May, July, and August; reduced flows in September and October (up to 28.7 percent); and increased flows in June (5.8 percent).

- In wet years, similar flows would occur in October, November, and January through July; reduced flows in September (45.9 percent); and increased flows in August and December (up to 8.5 percent).
- In dry years, similar flows would occur in November through January and March through September; reduced flows in October (11.2 percent); and increased flows in February (6.1 percent).

- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, reduced flows would occur in October and March through June (up to 58.3 percent); and increased flows in November through February and July through September (up to 36.81 percent).
  - In wet years, similar flows would occur in April; reduced flows in October, March, and May (up to 52.9 percent); and increased flows in June through September and November through February (up to 67.8 percent).
  - In dry years, similar flows would occur in March and July through September; reduced flows in October and April through June (up to 59.6 percent); and increased flows in November through February (up to 37.0 percent).

During the spring and summer months, the changes in flow conditions between Alternative 3 and the No Action Alternative vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Sacramento River at Freeport would increase in several months under Alternative 3 as compared to the No Action Alternative by up to 15 percent, and decrease in several months up to 30 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist. However, the value of the recreational opportunities would be both improved and reduced depending upon the timing of the changes.

Overall, under Alternative 3 as compared to the No Action Alternative, recreational opportunities would be similar or improved on the Sacramento River downstream of Keswick Dam and American River downstream of Nimbus Dam; and both improved and reduced on the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, and the Stanislaus River downstream of Goodwin Dam depending upon the month.

Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 3 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 3 as compared to the No Action Alternative due to actions to reduce predation.

Recreational opportunities related to sport ocean salmon fishing would be reduced under Alternative 3 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on recreational resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the No Action Alternative, recreational resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 9 to 17 percent in the San Francisco Bay Area Region and 17 percent in the Central Coast and Southern California regions.

#### 15.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under Alternative 3 and the Second Basis of Comparison. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under Alternative 3 and the Second Basis of Comparison. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 5 percent of the time under Alternative 3 and the Second Basis of Comparison.

The potential for reduced recreational resources at Trinity Lake related to shoreline activities would be greater in critical dry years and similar in dry years and over the long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

Flows in the Trinity River and recreational opportunities under Alternative 3 would be similar to the Second Basis of Comparison, as summarized in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 30, 15, 10, and 7 percent of the time, respectively, under Alternative 3 and the Second Basis of Comparison.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 85, 75, 62, and 35 percent of the time, respectively, under Alternative 3 and the Second Basis of Comparison.

At Folsom Lake, boat ramps at Rattlesnake Bar; Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 70, 65, 40, 10, and 7 percent of the time, respectively, under Alternative 3 and the Second Basis of Comparison.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 22, 18, 10, and 8 percent of the time, respectively, under Alternative 3 as compared to approximately 30, 25, 15, and 3 percent of the time, respectively, under the Second Basis of Comparison.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 28 and 8 percent of the time, respectively, under

Alternative 3; and approximately 20 and 5 percent of the time, respectively, under the Second Basis of Comparison.

Boating opportunities would be increased at New Melones Reservoir, decreased at San Luis Reservoir, and similar at all other reservoirs under Alternative 3 as compared to the Second Basis of Comparison. Shoreline recreational opportunities would be increased at New Melones Reservoir, decreased at Lake Oroville, and similar at all other reservoirs under Alternative 3 as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Similar or increased flows in the Sacramento River downstream of Keswick Dam and at Freeport.
- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in November and January through June; reduced flows in October, December, and September (up to 12.5 percent); and increased flows in July and August (up to 17.0 percent).
  - In wet years, similar flows would occur in November and January through May; reduced flows in October, December, and September (up to 14.6 percent); and increased flows in June through August (up to 10.9 percent).
  - In dry years, similar flows would occur in November and January through June; reduced flows in August through October (up to 21.2 percent); and increased flows in July (37.1 percent).
- Similar flows in American River downstream of Nimbus Dam.
- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, similar flows would occur in October, December, January, and March; reduced flows would occur in November, May, and June (up to 52.3 percent); and increased flows in February, April, and July through September (up to 26.8 percent).
  - In wet years, similar flows would occur in October, November, January, and April; reduced flows in May and June (up to 44.8 percent); and increased flows in December, February, March, and July through September (up to 68.6 percent).
  - In dry years, similar flows would occur in July through October; reduced flows in November through March and May through June (up to 36.0 percent); and increased flows in April (40.2 percent).

During the spring and summer months, the changes in flow conditions between Alternative 3 and the Second Basis of Comparison vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Stanislaus River downstream of Goodwin Dam would increase in several months under Alternative 3 as compared to the Second Basis of Comparison by up to 90 percent, and decrease in several months up to 11 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist.

Overall, under Alternative 3 as compared to the Second Basis of Comparison, recreational opportunities would be similar or improved on the Sacramento, Feather, and American rivers; and both improved and reduced on the Stanislaus River depending upon the month.

Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 3 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 3 as compared to the Second Basis of Comparison due to actions to reduce predation.

Recreational opportunities related to sport ocean salmon fishing would be reduced under Alternative 3 as compared to the Second Basis of Comparison.

##### *Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on recreational resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

#### *San Francisco Bay Area, Central Coast, and Southern California Regions*

##### *Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the Second Basis of Comparison, recreational resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be similar (changes within 5 percent).

#### *15.4.3.5 Alternative 4*

The recreational resources under Alternative 4 would be similar to the conditions under the Second Basis of Comparison with additional predation control actions to reduce the populations of striped bass.

##### 15.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. However, Alternative 4 includes predation controls as compared to the Second Basis. Therefore, reservoir and flow-related changes in recreational resources under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 15.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 4 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 4 as compared to the No Action Alternative due to actions to reduce predation.

Recreational opportunities related to sport ocean salmon fishing would be reduced under Alternative 4 as compared to the No Action Alternative.

##### 15.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. However, Alternative 4 includes predation controls as compared to the Second Basis of Comparison. Therefore, flow-related changes in recreational resources under Alternative 4 are the same as recreational resources under the Second Basis of Comparison.

Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 4 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 4 as compared to the Second Basis of Comparison due to actions to reduce predation.

Recreational opportunities related to sport ocean salmon fishing would be reduced under Alternative 4 as compared to the Second Basis of Comparison.

#### *15.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 15.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under Alternative 5 and the No Action Alternative. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under Alternative 5 and the No Action Alternative. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 8 percent of the time under Alternative 5 and 5 percent of the time under the No Action Alternative.

The potential for reduced recreational resources at Trinity Lake related to shoreline activities would be slightly less in critical dry years and similar over the long-term average conditions and dry years under Alternative 5 as compared to the No Action Alternative.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

Flows in the Trinity River and recreational opportunities under Alternative 5 would be similar to the No Action Alternative, as summarized in Chapter 5, Surface Water Resources and Water Supplies.

*Central Valley Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 35, 20, 10, and 9 percent of the time, respectively, under Alternative 5 and the No Action Alternative.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 95, 87, 73, and 35 percent of the time, respectively, under Alternative 5 and the Second Basis of Comparison.

At Folsom Lake, boat ramps at Rattlesnake Bar, Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 80, 65, 40, 10, and 7 percent of the time, respectively, under Alternative 5 and the No Action Alternative.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 35, 30, 22, and 8 percent of the time, respectively, under Alternative 5 as compared to approximately 65, 25, 18, and 5 percent of the time, respectively, under the No Action Alternative.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 50 and 10 percent of the time, respectively, under Alternative 5 and the No Action Alternative.

Increased shoreline recreational opportunities at New Melones Reservoir in long-term average conditions and dry years, decreased opportunities at New Melones Reservoir in critical dry years, and similar opportunities at all times analyzed at all other reservoirs under Alternative 5 as compared to the No Action Alternative. Increased boating opportunities at New Melones Reservoir and similar opportunities at all other reservoirs under Alternative 5 as compared to the No Action Alternative.

*Potential Changes in Recreational Resources along Rivers downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Flows in the Sacramento River downstream of Keswick Dam and near Freeport would be similar.
- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in June through April; and reduced flows in May (6.6 percent).
  - In wet years, similar flows would occur in all months.
  - In dry years, similar flows would occur in September through April and June; reduced flows in May (27.1 percent); and increased flows in July and August (up to 8.9 percent).
- Flows in the American River downstream of Nimbus Dam would be similar.
- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, flows would be similar in September through February and June; reduced flows would occur in March, July, and August

(up to 8.0 percent); and increased flows in April and May (up to 22.4 percent).

- In wet years, similar flows would occur in October, November, January, February, and April through June; reduced flows in December, March, and July through September (up to 18.0 percent).
- In dry years, similar flows would occur in June through March; and increased flows in April and May (up to 47.3 percent).

During the spring and summer months, the changes in flow conditions between Alternative 5 and the No Action Alternative vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Feather River downstream of Thermalito Complex would increase in several months under Alternative 5 and the No Action Alternative by up to 9 percent, and decrease in several months up to 27 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist. However, the value of the recreational opportunities would be both improved and reduced depending upon the timing of the changes.

Overall, under Alternative 5 and the No Action Alternative, recreational opportunities would be similar or improved on the Sacramento and American rivers; and both improved and reduced on the Feather and Stanislaus rivers.

*Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on recreational resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under

Alternative 5 as compared to the No Action Alternative, recreational resources would be similar.

#### 15.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations and related recreational resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

There are several boat ramps at Trinity Lake that provide access at different elevations. Boat ramps at Stuart Fork and Bowerman are not useable when the water elevation is less than 2,323 feet which occurs approximately 80 percent of the time under Alternative 5 and the Second Basis of Comparison. Boat ramps at Clark Springs, Fairview, and Trinity Center are not useable when the water elevation is lower than 2,300 feet which occurs approximately 62 percent of the time under Alternative 5 and the Second Basis of Comparison. The Minersville boat ramp is accessible until the elevation declines below 2,170 feet which occurs approximately 8 percent of the time under Alternative 5 and 5 percent of the time under the Second Basis of Comparison.

The potential for reduced recreational resources at Trinity Lake related to shoreline activities would be similar under Alternative 5 as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

Flows in Trinity River would be similar during the recreation season (spring and summer months); therefore, recreational opportunities would be similar under Alternative 5 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations and related recreational resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in wet, above normal, and below normal years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in recreational resources at San Luis Reservoir would be reduced in dry year and critical dry years because the end of September surface water elevations would be decreased by 6.2 percent in dry years and 8.5 percent in critical dry years.

There are several boat ramps at each of the reservoirs that provide access at different elevations. At Shasta Lake, boat ramps at Antlers, Hirz Bay, Packers Bay, Sugar Loaf, and Centimundi and Jones Valley are not accessible approximately 55, 35, 20, 10, and 9 percent of the time, respectively, under Alternative 5; and approximately 55, 30, 15, 10, and 7 percent of the time, respectively, under the Second Basis of Comparison.

At Lake Oroville, boat ramps at Enterprise, Vinton Gulch, and Nelson Bar; Foreman Creek; Dark Canyon and Loafer Creek; and Bidwell Canyon, Lime Saddle, and Spillway are not accessible approximately 95, 87, 73, and 35 percent of the time, respectively, under Alternative 5; and approximately 85, 75, 62, and 25 percent of the time, respectively, under the Second Basis of Comparison.

At Folsom Lake, boat ramps at Rattlesnake Bar are not accessible 80 percent of the time under Alternative 5, and 70 percent of the time, respectively, under the Second Basis of Comparison. Boat ramps at Beal's Point; Peninsula, Brown's Ravine, and Folsom Point; Hobie Cove; and Granite Bay are not accessible approximately 65, 40, 10, and 7 percent of the time, respectively, under Alternative 5 and the Second Basis of Comparison.

At New Melones Reservoir, the boat ramp at Angels Creek, Parrott's Ferry, Glory Hole, and Mark Twain are not accessible approximately 35, 30, 22, and 8 percent of the time, respectively, under Alternative 5 as compared to approximately 30, 25, 15, and 5 percent of the time, respectively, under the Second Basis of Comparison.

At San Luis Reservoir, the boat ramps at Dinosaur Point and Basalt Area are not useable approximately 50 and 10 percent of the time, respectively, under Alternative 5; and approximately 20 and 5 percent of the time, respectively, under the Second Basis of Comparison.

Decreased shoreline recreational opportunities at Shasta Lake, Lake Oroville, and New Melones Reservoir, and similar opportunities at all other reservoirs under Alternative 5 as compared to the Second Basis of Comparison. Decreased boating opportunities at Lake Oroville, New Melones Reservoir, and San Luis Reservoir and similar opportunities at all other reservoirs under Alternative 5 as compared to the Second Basis of Comparison.

*Potential Changes in Recreational Resources along Rivers Downstream of the CVP and SWP Reservoirs*

The recreational opportunities along the Sacramento, Feather, American, and Stanislaus rivers would be affected by the following changes in river flows, as described in Chapter 5.

- Sacramento River downstream of Keswick Dam
  - Over long-term conditions, flows would be similar in July, August, October, and February through April; reduced in December, January, May and June (up to 8.2 percent); and increased in September and November (up to 38.5 percent).

  - In wet years, flows would be similar in January through July; reduced in December and August (up to 15.0 percent); and increased in September through November (up to 77.3 percent).
  - In dry years, similar flows would occur in July through October and December through March; reduced in April through June (up to 10.1 percent); and increased flows in November (32.1 percent).
- Sacramento River at Freeport
  - Over long-term conditions, flows would be similar in October and December through April; reduced in May and June (up to 11.5 percent); and increased in July through September and November (43.4 percent).
  - In wet years, flows would be similar in October and January through June; reduced in December (6.2 percent); and increased in July through September and November (up to 89.0 percent).
  - In dry years, similar flows would occur in August through October and December through April; reduced in May and June (up to 13.6 percent); and increased flows in July and November (up to 19.3 percent).
- Feather River downstream of the Thermalito Complex
  - Over long-term conditions, similar flows would occur in November and April; reduced flows in October, December through March, May, and June (up to 27.7 percent); and increased flows in July through September (up to 76.2 percent).
  - In wet years, similar flows would occur in October, November, March through May; reduced flows in December through February and June (up to 25.6 percent); and increased flows in July through September (up to 181.9 percent).
  - In dry years, similar flows would occur in November through April; reduced flows in October, May, June, August, and September (up to 45.4 percent); and increased flows in July (60.4 percent).
- American River downstream of Nimbus Dam
  - Over long-term conditions, similar flows would occur in November through July; reduced flows in August (5.8 percent); and increased in September and October (42.4 percent).
  - In wet years, similar flows would occur in October, November, and January through July; reduced flows in December and August (up to 13.7 percent); and increased flows in September (88.2 percent).
  - In dry years, similar flows would occur in November through September; and increased flows in October (16.7 percent).
- Stanislaus River downstream of Goodwin Dam
  - Over long-term conditions, similar flows would occur in August; reduced flows would occur in November through February, June, July, August, and

September (up to 35.8 percent); and increased flows in October and March through May (up to 144.8 percent).

- In wet years, similar flows would occur in February and April; reduced flows in November through January and June through September (up to 52.8 percent); and increased flows in October and March (up to 113.1 percent).
- In dry years, similar flows would occur in July through September; reduced flows in November through March and June (up to 35.7 percent); and increased flows in October, April, and May (150.1 percent).

During the spring and summer months, the changes in flow conditions between Alternative 5 and the Second Basis of Comparison vary on a monthly basis in the Sacramento, Feather, American, and Stanislaus rivers within a water year type. For example, flows in the Sacramento River at Freeport would increase in several months under Alternative 5 as compared to the Second Basis of Comparison by up to 89 percent, and decrease in several months up to 13 percent. The overall range of flows is within the historical operational range; therefore, recreational opportunities still exist. However, the value of the recreational opportunities would be both improved and reduced depending upon the timing of the changes.

Overall, under Alternative 5 as compared to the Second Basis of Comparison, recreational opportunities would be similar or improved on the Sacramento River downstream of Keswick Dam and American River downstream of Nimbus Dam; and both improved and reduced on the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, and the Stanislaus River downstream of Goodwin Dam depending upon the month.

*Effects Related to Cross Delta Water Transfers*

Potential effects to recreational resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on recreational resources would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Potential Changes in Recreational Resources at Reservoirs that Store CVP and SWP Water*

Changes in recreational resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 5 as compared to the Second Basis of Comparison, recreational resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

#### ***15.4.3.7 Summary of Impact Assessment***

The results of the impact assessment of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 15.28 and 15.29.

**Table 15.28 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years. Recreational resources would be increased by 6 percent in wet and critical dry years at San Luis Reservoir, by 11 to 21 percent in the San Francisco Bay Area Region, and by 21 percent in the Central Coast and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River, Sacramento River downstream of Keswick Dam, and American River downstream of Nimbus Dam. On the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, and the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in most spring and summer months; and reduced in July in all years and August in wetter years. | No mitigation measures identified at this time to reduce flow reduction impacts on recreation opportunities. |
| Alternative 2 | No effects on recreational resources. | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 3 | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years. Recreational resources would be increased by 8 percent in wet years and 6 percent in above normal years at San Luis Reservoir, by 9 to 17 percent in the San Francisco Bay Area Region, and by 17 percent in the Central Coast and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River, Sacramento River downstream of Keswick Dam, and American River downstream of Nimbus Dam. On the Sacramento River near Freeport and Feather River downstream of Thermalito Complex, recreational opportunities would be similar or improved in most spring and summer months; and reduced in August in all years on both rivers and in July on the Feather River in dry years. On the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in summer months; and reduced in May and June in all water year types.<br>Recreational opportunities related to Striped Bass fishing and sport ocean salmon fishing would be reduced. | No mitigation measures identified at this time to reduce flow reduction impacts on recreation opportunities.<br>No mitigation measures identified at this time to reduce impacts to reduction in Striped Bass and sport ocean salmon fishing opportunities. |
| Alternative 4 | Reservoir and flow-related recreational opportunities would be as described for Alternative 1 compared to the No Action Alternative.<br>Recreational opportunities related to Striped Bass fishing and sport ocean salmon fishing would be reduced. | No mitigation measures identified at this time to reduce flow reduction impacts on recreation opportunities.<br>No mitigation measures identified at this time to reduce impacts to reduction in Striped Bass and sport ocean salmon fishing opportunities. |
| Alternative 5 | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River, Sacramento River downstream of Keswick Dam and near Freeport, and American River downstream of Nimbus Dam. On the Feather River downstream of Thermalito Complex, recreational opportunities would be similar or improved in most spring and summer months; and reduced in May in all years. On the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in spring months; and reduced in July and August in most water year types. | No mitigation measures identified at this time to reduce flow reduction impacts on recreation opportunities. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

**Table 15.29 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years. Recreational resources would be reduced by 6 percent in wet and critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River. On the Sacramento River downstream of Keswick Dam and near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in most spring and summer months; and reduced in June in most years, August in some years on the Feather and American rivers, and in May in some years on Sacramento River near Freeport and on the Feather River. | Not considered for this comparison. |
| Alternative 1 | No effects on recreational resources. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River, Sacramento River downstream of Keswick Dam and near Freeport, and American River downstream of Nimbus Dam. On the Feather River downstream of Thermalito Complex, recreational opportunities would be similar or improved in most spring and summer months; and reduced in August in dry years. On the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in summer months; and reduced in May and June in all water year types.<br>Recreational opportunities related to Striped Bass fishing and sport ocean salmon fishing would be reduced. | Not considered for this comparison. |
| Alternative 4 | Reservoir and flow-related recreational opportunities would be similar.<br>Recreational opportunities related to Striped Bass fishing and sport ocean salmon fishing would be reduced. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 5 | Recreational resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above normal, below normal, and dry years. Recreational resources would be reduced by 6 percent in dry years and 9 percent in critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Recreational opportunities would be similar or improved on Trinity River. On the Sacramento River downstream of Keswick Dam and near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam recreational opportunities would be similar or improved in many spring and summer months. Flows would reduce in May and June in most years on the Sacramento and Feather rivers; in August on the American River; and in June through August on the Stanislaus River. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be "similar."

#### *15.4.3.8 Potential Mitigation Measures*

Mitigation measures are not included in this EIS to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in adverse changes in recreational resources at reservoirs. However, implementation of Alternatives 1, 3, 4, and 5 would result in adverse changes in recreational opportunities along rivers downstream of CVP and SWP reservoirs. Implementation of Alternatives 3 and 4 would result in adverse changes in recreational Striped Bass and sport ocean salmon fishing opportunities. Mitigation measures have not been identified at this time.

#### *15.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Recreational Opportunities are summarized in Table 15.30.

**Table 15.30 Summary of Cumulative Effects on Recreational Opportunities with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions Included and in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- San Joaquin River Restoration Program<br>- Contra Loma Recreation Resource Management Plan<br>- San Luis Reservoir State Recreation Area Resource Management Plan/General Plan | <u>These effects would be the same under all alternatives.</u><br>Climate change and sea level rise and development under the general plans are anticipated to reduce carryover storage in reservoirs and changes in stream flow patterns in a manner that would change recreational opportunities, and could reduce the opportunities for sport ocean salmon fishing.<br>Other actions, including restoration projects, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to improve recreational opportunities. |
| Future Actions Considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program | <u>These effects would be the same under all alternatives.</u><br>Some of the future reasonably foreseeable actions to improve water quality and FERC Relicensing projects would improve recreational opportunities.<br>Other future reasonably foreseeable actions, such as expanded or new reservoirs would improve recreational opportunities. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative with future reasonably foreseeable actions would result in changes stream flows would result in changes to related recreational opportunities as compared to historical conditions prior to the BOs. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with future reasonably foreseeable actions would result in reduced stream flows and related recreational opportunities along the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam in July in all years and August in wetter years compared to the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with future reasonably foreseeable actions for recreational opportunities would be the same as for the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased sport ocean salmon fishing harvest limitations | Implementation of Alternative 3 with future reasonably foreseeable actions would result in reduced stream flows and related recreational opportunities along the Sacramento River near Freeport, Feather River downstream of Thermalito Complex would be reduced in August in all years on both rivers and in July on the Feather River in dry years. On the Stanislaus River downstream of Goodwin Dam recreational opportunities would be reduced in May and June in all water year types compared to the No Action Alternative with the added actions.<br>Recreational opportunities related to Striped Bass fishing would initially be increased; however by 2030 recreational fishing related to Striped Bass would be reduced.<br>Recreational opportunities related to sport ocean salmon fishing would be reduced. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased sport ocean salmon fishing harvest limitations | Implementation of Alternative 4 with future reasonably foreseeable actions would result in reduced stream flows and related recreational opportunities along the Sacramento River near Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam, and the Stanislaus River downstream of Goodwin Dam in July in all years and August in wetter years compared to the No Action Alternative with the added actions.<br>Recreational opportunities related to Striped Bass fishing would initially be increased; however by 2030 recreational fishing related to Striped Bass would be reduced.<br>Recreational opportunities related to sport ocean salmon fishing would be reduced. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with future reasonably foreseeable actions would result in reduced stream flows and related recreational opportunities along the Feather River downstream of Thermalito Complex would be reduced in May in all years compared to the No Action Alternative with the added actions. On the Stanislaus River downstream of Goodwin Dam recreational opportunities would be reduced in July and August in most water year types compared to the No Action Alternative with the added actions. |

## 15.5 References


Antioch (City of Antioch). 2003. *Draft General Plan Update Environmental Impact Report.* July.

BLM (Bureau of Land Management). 1997. *Interlakes Special Recreation Management Area Final Plan and Environmental Impact Statement. Shasta*.

____. 2005. *Chappie-Shasta Off-Highway Vehicle Guide, BLM Redding Field Office*.

____. 2011. *Keswick Area – Non Motorized Trails*.

____. n.d. (No date). *Clear Creek Greenway, Swasey Recreation Area, and Mule Ridge Trails*.

BLM et al. (Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Forest Service). 2012. *River Mileage Classifications for Components of the National Wild and Scenic Rivers System*. September.

California Coastal Trail. 2014. *Welcome to California Coastal Trail.info*. Site accessed February 24, 2014. http://www.californiacoastaltrail.info/cms/pages/main/index.html.

CBC (Clark Broadcasting Corporation). 2013. mymotherlode.com Lake Tulloch. Site accessed February 25, 2013. http://www.mymotherlode.com/community/destination/lake-tulloch.

CCWA (Central Coast Water Authority). 2014. *The State Water Project in Santa Barbara County*. Site accessed March 9, 2014. http://www.ccwa.com/docs/History1.pdf.

CCWD (Contra Costa Water District). 2014. *Welcome to Los Vaqueros Reservoir*. Site accessed March 9, 2014. http://www.ccwater.com/files/MarketingBrochure.pdf.

DBW (California Department of Boating and Waterways). 2014. *Sacramento-San Joaquin Delta Boating Needs Assessment 2000-2020, 2002*. Site accessed March 3, 2014. http://www.dbw.ca.gov/Reports/deltaindex.aspx.

Del Norte County. 2003. *Del Norte County General Plan*. January 28.

DFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2004. *Comprehensive Management Plan for the Sacramento River Wildlife Area*. February.

____. 2008a. *Feather River Wildlife Area, Sutter, Yuba Counties*. June.

____. 2008b. *Fremont Weir Wildlife Area, Sutter, Yolo Counties*. June.

____. 2008c. *Yolo Bypass Wildlife Area, Land Management Plan*. June.

____. 2008d. *Calhoun Cut Ecological Reserve*. December.

____. 2009. *Sacramento Bypass Wildlife Area, Yolo County*. July.

____. 2010. *Yolo Bypass Wildlife Area, Waterfowl Hunting Map 2010*. November.

DFW (California Department of Fish and Wildlife). 2014a. *Fremont Weir Wildlife Area – Sutter and Yolo Counties*. Site accessed February 25, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Fremont-Weir-WA.

____. 2014b. *Things to do at the Gray Lodge Wildlife Area*. Site accessed February 28, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Gray-Lodge-WA.

____. 2014c. *Sacramento Bypass Wildlife Area – Sutter and Yolo Counties*. Site accessed March 4, 2014. https://www.wildlife.ca.gov/Lands/Places-to-Visit/Sacramento-Bypass-WA.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

DPC (Delta Protection Commission). 2006. *Preliminary Findings for The Aquatic Recreation Component of the Delta Recreation Strategy Plan*. March 28.

____. 2012. *Economic Sustainability Plan for the Sacramento-San Joaquin Delta*. January.

DSC (Delta Stewardship Council). 2011. *Delta Plan Draft Program Environmental Impact Report*. November.

DVM (Diamond Valley Marina). 2014. *Welcome to Diamond Valley*. Site accessed March 9, 2014. http://www.dvmarina.com.

DWR (California Department of Water Resources). 2000. *Pyramid Lake*. May.

____. 2001. *South Bay Aqueduct (Bethany Reservoir and Lake Del Valle)*. April.

____. 2006. *Settlement Agreement Recreation Management Plan, Oroville Facilities FERC Project No.2100*. March.

____. 2007a. *Draft Environmental Impact Report Oroville Facilities Relicensing*—FERC Project No. 2100. May.

____. 2007b. *State Water Project Castaic Lake*. September.

____. 2007c. *Monterey Plus Draft Environmental Impact Report*. October.

____. 2009. *East Branch Extension Phase II, Final Environmental Impact Report*. January.

____. 2010. *State Water Project Lake Perris*. June.

____. 2013a. *Upper Feather River Lakes*. April.

____. 2013b. *Thermalito Facilities*. Site accessed March 4, 2013. http://www.water.ca.gov/swp/facilities/Oroville/thermalito.cfm.

____. 2013c. *Initial Study/Proposed Mitigated Negative Declaration, Clifton Court Forebay Fishing Facility*. June.

____. 2013d. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

____. 2014a. *Quail Lake*. Site accessed March 9, 2014. http://www.water.ca.gov/recreation/locations/quail/quailcontent.cfm.

____. 2014b. *Pyramid Lake*. Site accessed March 9, 2014. http://www.water.ca.gov/recreation/locations/pyramid/pyramidcontent.cfm.

____. 2014c. *Castaic Lake*. Site accessed March 9, 2014. http://www.water.ca.gov/recreation/locations/castaic/castaiccontent.cfm.

DWR, Reclamation, USFWS and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

DWR et al. (California Department of Water Resources, Yuba County Water Agency, Bureau of Reclamation). 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord*. June.

EBMUD (East Bay Municipal Utility District). 2007a. *Trails Around Lake Chabot and Upper San Leandro Reservoirs*. October.

____. 2007b. *Trails Around San Pablo and Briones Reservoirs*. November.

____. 2011. *Urban Water Management Plan 2010*. June.

____. 2014a. *San Pablo Reservoir*. Site accessed March 9, 2014. http://www.ebmud.com/recreation/san-pablo-reservoir.

____. 2014b. *Lafayette Reservoir Recreation Area*. January.

EBRPD (East Bay Regional Parks District). 2011. *Anthony Chabot Regional Park, Lake Chabot Regional Park, Leona Canyon Regional Open Space Preserve*. June.

____. 2013a. *Master Plan 2013*. July.

____. 2013b. *Contra Loma Regional Park*. October.

____. 2013c. *Contra Loma Regional Park*. Site accessed February 26, 2013. http://www.ebparks.org/parks/contra_loma.

____. 2013d. *Lake Chabot Regional Park*. October.

____. 2014. *Del Valle Regional Park*. January.

Escondido (City of Escondido). 2014a. *Water Treatment Plant*. Site accessed March 28, 2014. http://www.escondido.org/water-treatment-plant.aspx.

____. 2014b. *Dixon Lake*. Site accessed March 28, 2014. http://www.escondido.org/dixon-lake.aspx.

____. 2014c. *Dixon Lake Picnic Area Map*. Site accessed March 28, 2014. http://www.escondido.org/dixon-lake-picnic-area-map.aspx.

____. n.d. (No Date). *Dixon Lake Campground Guide*. Site accessed March 28, 2014. http://www.escondido.org/dixon-lake.aspx.

FERC (Federal Energy Regulatory Commission). 2013. *Draft Environmental Impact Statement for Hydropower License.* May.

____. 2015. *FERC: Hydropower- General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp.

HWD (Helix Water District). 2014. *About Helix – Water Storage – Lake Jennings*. Site accessed March 28, 2014. http://www.hwd.com/about/.

LACSD (Lake Arrowhead Community Services District). 2014. *Glossary of Terms*. Site accessed May 21, 2014. http://www.lakearrowheadcsd.com/index.aspx?=page=85.

____. 2014. *Lake Arrowhead Activities and Things To Do!*. Site accessed May 19, 2014. http://www.lakearrowhead.com/activities.html.

MWD (Metropolitan Water District of Southern California). 2013. *Diamond Valley Lake – at a glance*. June.

National Wild and Scenic Rivers System. 2013. *State Listings. California*. Site accessed February 13 and March 25, 2013. http://www.rivers.gov/california.php.

NCRWQCB et al. (California North Coast Regional Water Quality Control Board and Bureau of Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

NID (Nevada Irrigation District). 2005. *Raw Water Master Plan Update, Phase I: Technical Analysis, Volume I, Final Report*. September.

____. 2014. *Recreation & Campground Information*. Site accessed May 20, 2014. http://nidwater.com/recreation.

____. n.d. (No date). *Combie Reservoir, Carrying Capacity and Safety Study*.

NPS (National Park Service). 2012. *The Whiskeytown Nugget, Park Guide*.

____. n.d. (No date). *Fishing at Whiskeytown*.

Pittsburg (City of Pittsburg). 2001. *Pittsburg 2020: A Vision for the the 21st Century, City of Pittsburg General Plan, Draft Environmental Impact Report*. January.

PFMC (Pacific Fishery Management Council). 2014. *Review of 2013 Ocean Salmon Fisheries*. February.

PMC (Parks Management Company). 2014. *Lake Piru Campground*. Site accessed March 26, 2014. http://campone.com/campsites/lake-piru/.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

Reclamation (Bureau of Reclamation). 1997. *Draft Central Valley Project Improvement Act – Programmatic Environmental Impact Statement/Report.* September.

____. 2005a. *Sacramento River Division Contractors, Long-Term Renewal Contract Final Environmental Assessment*. February.

____. 2005b. *Central Valley Project Long-Term Water Service Contract Renewal American River Division Environmental Impact Statement*. June.

____. 2005c. *Central Valley Project Long-Term Water Service Contract Renewal San Luis Unit, Public Draft Environmental Impact Statement and Appendices*. September.

____. 2009. *Keswick Dam*. Retrieved February 28, 2013, from http://www.usbr.gov/projects/Facility.jsp?fac_Name=Keswick+Dam&groupName=Hydraulics+%26+Hydrology. June.

____. 2010a. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

____. 2010b. *New Melones Lake Trail Map*.

____. 2010c. *Cachuma Lake Final Resource Management Plan/Environmental Impact Statement*. May.

____. 2012. *Refuge Water Supply Program 2012 Annual Work Plan, CVPIA 3406(b)(3) & (d)(1)(2)(5)*.

____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

____. 2014a. *Contra Loma Reservoir and Recreation Area, Final Resource Management Plan and Final Environmental Impact Statement*. September.

____. 2014b. New Melones. Site accessed March 2, 2014. http://www.usbr.gov/mp/ccao/newmelones/planning_visit.html

____. 2014c. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

____. 2014d. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

____. 2014e. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

____. 2014f. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2011. *San Joaquin River Restoration Program Environmental Impact Statement/Report*.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2010. *Millerton Lake Final Resource Management Plan/General Plan Environmental Impact Statement/Environmental Impact Report*. April.

____. 2013. *San Luis Reservoir State Recreation Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/ Environmental Impact Report*. June.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation and Tehama Colusa Canal Authority). 2002. *Fish Passage Improvement Project at the Red Bluff Diversion Dam Draft Environmental Impact Statement/Environmental Impact Report*. August.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft*

*Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

Recreation.gov. 2014. *San Justo Reservoir, CA*. Site accessed March 4, 2014. http://www.recreation.gov/recAreaDetails.do?contractCode=NRSO&recAreaId=41&agency.

Riverside County (County of Riverside). 2000. *Riverside County Integrated Project, Existing Setting Report*. March.

____. 2014. *Lake Skinner*. Site accessed March 9, 2014. http://www.rivcoparks.org/parks/lake-skinner/lake-skinner-home.

RNSP (Redwood National and State Parks). 2013. *Visitor Guide*.

Sacramento (City of Sacramento). 2005. *City of Sacramento, Department of Parks and Recreation, Garcia Bend Park*. May.

Sacramento County (County of Sacramento). 2008. *Sacramento County American River Parkway Plan 2008*.

____. 2012. American River Parkway – Discovery Park. Site accessed March 3, 2013. http://www.regionalparks.saccounty.net/Parks/Pages/DiscoveryPark.aspx.

____. 2014. *Sacramento County Regional Parks – Sacramento River/Delta*. Site accessed March 3, 2014. http://www.regionalparks.saccounty.net/Parks/SacramentoRiverandDelta/Pages/default.aspx.

San Diego (City of San Diego). 2011. *2010 Urban Water Management Plan*. July.

____. 2014a. *Water*. Site accessed March 28, 2014. http://www.sandiego.gov/water/recreation/reservoirs/index.shtml.

____. 2014b. *Water – Lower Otay Reservoir*. Site accessed March 28, 2014. http://www.sandiego.gov/water/recreation/reservoirs/lowerotay.shtml.

____. 2014c. *Water – San Vicente Reservoir*. Site accessed March 28, 2014. http://www.sandiego.gov/water/recreation/reservoirs/sanvicente.shtml.

____. 2014d. *Reservoirs –El Capitan Reservoir*. Site accessed May 19, 2014. http://www.sandiego.gov/water/recreation/reservoirs/elcapitan.shtml.

____. 2015a. *Reservoirs –Hodges Reservoir*. Site accessed May 25, 2015. http://www.sandiego.gov/water/recreation/reservoirs/hodges.shtml.

____. 2015b. *Reservoirs –Murray Reservoir*. Site accessed May 25, 2015. http://www.sandiego.gov/water/recreation/reservoirs/murray.shtml.

SBCWD (San Benito County Water District). 2014. *Zebra Mussel Resolution – Eradication at San Justo Reservoir*. Site accessed March 4, 2014. http://www.sbcwd.com/zebra/.

SCVWD (Santa Clara Valley Water District). 2010. *Urban Water Management Plan*.

SDCWA (San Diego County Water District). 2015. *Draft Mitigated Negative Declaration and Initial Study/Environmental Checklist, Application of Copper-Based Algaecides at Five Reservoirs, San Diego County, California*. March.

SMUD (Sacramento Municipal Utility District). 2013. Rancho Seco Recreation Area. Site accessed February 27, 2013. https://www.smud.org/en/about-smud/community/recreational-areas/rancho-seco-lake.htm

SRWP (Sacramento River Watershed Project). 2010. *The Sacramento River Basin, A Roadmap to Watershed Management*. October.

Stanislaus County (County of Stanislaus County). 1987. *Stanislaus County General Plan Support Documentation*. June.

State Parks (California Department of Parks and Recreation). 2003. *San Luis Reservoir State Recreation Area*.

____. 2006a. *Caswell Memorial State Park*.

____. 2006b. *Silverwood Lake State Recreation Area*.

____. 2008. *Millerton Lake State Recreation Area*.

____. 2009. *South Yuba River State Park*.

____. 2010. *San Luis Reservoir State Recreation Area*.

____. 2013a. *Bethany Reservoir State Recreation Area*.

____. 2013b. *Lake Perris State Recreation Area*.

State Parks and Reclamation (California Department of Parks and Recreation and Bureau of Reclamation). 2003. *Draft Resource Inventory, Folsom Lake State Recreation Area*. April.

____. 2007. *Folsom General Plan/Resource Management Plan Preliminary General Plan & Resource Management Plan, and Draft Environmental Impact Report/Environmental Impact Statement*. November.

Stockton (City of Stockton). 2007. *Background Report, Stockton General Plan 2035*. December.

Sutter County (County of Sutter). 2010. *Draft Sutter County General Plan Draft Environmental Impact Report*. September

Sweetwater Authority. 2014. *Sweetwater Reservoir*. Site accessed March 28, 2014. http://www.sweetwater.org/index.aspx?page=112.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

____. 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Tri-Dam Project. 2002. *Tulloch Project, FERC No. 2067, Tulloch Reservoir Shoreline Management Plan*. December.

____. 2012. *Tulloch Project, FERC No. 2067, Recreation Plan for Black Creek Arm Day Use Area*. December.

USACE (U.S. Army Corps of Engineers). 1991. *Sacramento River, Sloughs, and Tributaries, California 1991 Aerial Atlas Collinsville to Shasta Dam*.

____. 2012. *Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir, and Daguerre Point Dam on the Yuba River*. January.

____. 2013. *Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River*. October.

____. 2014. *Recreation at Englebright Lake*. Site accessed May 19, 2014. http://www.spk.usace.army.mil/Locations/SacramentoDistrictParks/EnglebrightLake.aspx.

USFS (U.S. Department of Agriculture, Forest Service). 2006a. *Lake Davis Recreation Area*. May.

____. 2006b. *Frenchman Lake Recreation Area*. May.

____. 2011. *Antelope Lake Recreation Area*. July.

____. 2014. *Management Guide Shasta and Trinity Units, Whiskeytown-Shasta-Trinity National Recreation Area*.

USFS et al. (U.S. Department of Agriculture, Forest Service; Bureau of Land Management; California State Parks; County of Nevada). n.d. (No Date). *South Yuba River Comprehensive Management Plant*.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. *Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report*. October.

UWCD (United Water Conservation District). 2014. *Facilities and Strategies*. Site accessed March 26, 2014. http://www.unitedwater.org/about-us-6/facilities-a-strategies.

West Sacramento (City of West Sacramento). 2000. *City of West Sacramento General Plan, Background Document*. June.

YCWA (Yuba County Water Agency). 2012. *Yuba County Water Agency's Yuba River Development Project Relicensing*.

Yolo County (County of Yolo). 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report*. April.

____. 2014. *18989 Old River Road, West Sacramento, CA 95691*. Site accessed March 28, 2014. http://www.yolocounty.org/general-government/general-government-departments/parks/parks-information/elkhorn-regional-park.

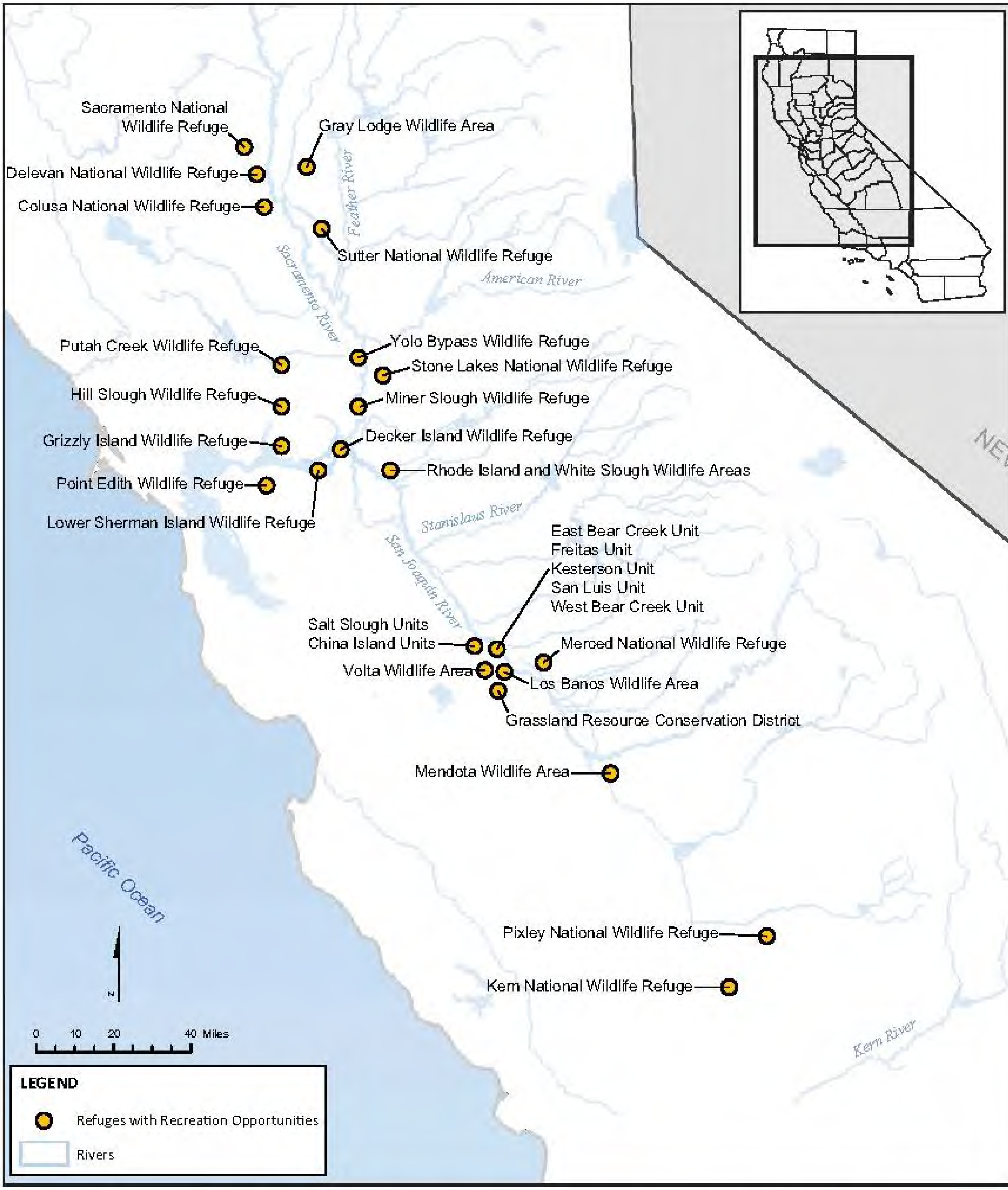



**Figure 15.1 Wildlife Refuges Identified to Receive Central Valley Project Water Supplies**

This page left blank intentionally.

Chapter 16

# Air Quality and Greenhouse Gas Emissions

## 16.1 Introduction

This chapter describes existing and future air quality conditions and the potential for greenhouse gas emissions that could occur as a result of implementing the alternatives that could change the long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) as evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect CVP and SWP water deliveries which could indirectly affect air quality.

## 16.2 Terminology

Important air quality and greenhouse gas emission terminology used in this chapter are defined by the U.S. Environmental Protection Agency (USEPA) and the California Air Resources Board (ARB), as summarized below.

- **Attainment Area:** A geographic area considered to have air quality as good as or better than the national and/or state ambient air quality standards. An area may be an attainment area for one pollutant and a non-attainment area for others (USEPA 2006).
- **California Ambient Air Quality Standard (CAAQS):** A legal limit that specifies the maximum level and time of exposure in the outdoor air for a given air pollutant and which is protective of human health and public welfare (California Health and Safety Code section 39606b). CAAQS are recommended by the California Office of Environmental Health Hazard Assessment and adopted into regulation by the ARB. CAAQS are the standards which must be met per the requirements of the California Clean Air Act (ARB 2010).
- **Criteria Pollutant:** An air pollutant for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set (ARB 2010). The criteria pollutants are ozone ($O_3$), carbon monoxide (CO), nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), particulate matter less than 10 microns in aerodynamic diameter ($PM_{10}$), particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$), and lead (Pb).
- **Greenhouse Gases (GHGs):** Atmospheric gases (such as carbon dioxide ($CO_2$), methane ($CH_4$), hydrofluorocarbons (HFC), nitrous oxide ($N_2O$), $O_3$, perfluorocarbons (PFC), sulfur hexafluoride ($SF_6$), and water vapor) that slow the passage of re-radiated heat through the Earth's atmosphere (ARB 2010).

Six of the GHGs are the subject of reductions under the Kyoto Protocol and California Assembly Bill 32 are $CO_2$, $CH_4$, $N_2O$, HFC, PFC, and $SF_6$.

- **National Ambient Air Quality Standard (NAAQS):** Standards established by USEPA that apply for outdoor air throughout the United States (USEPA 2006).
- **Nonattainment Area:** A geographic area identified by the USEPA and/or ARB as not meeting either NAAQS or CAAQS for a given pollutant (ARB 2010).
- **Precursor:** In photochemistry, a compound antecedent to a pollutant. For example, volatile organic compounds (VOC) and $NO_x$ react in sunlight to form the criteria pollutant ozone. As such, VOCs and $NO_x$ are precursors to $O_3$ (USEPA 2006).
- **Reactive Organic Gas (ROG):** A photochemically reactive chemical gas composed of non-methane hydrocarbons (HCs) that may contribute to the formation of smog (ARB 2010). ROG may also be referred to as non-methane organic gases, VOCs, or HCs.
- **State Implementation Plan (SIP):** A plan prepared by states and submitted to USEPA describing how each area will attain and maintain NAAQS. SIPs include the technical foundation for understanding the air quality (e.g., emission inventories and air quality monitoring), control measures and strategies, and enforcement mechanisms (ARB 2010).
- **Toxic Air Contaminant (TAC):** An air pollutant, identified in regulation by the ARB, which may cause or contribute to an increase in deaths or in serious illness, or which may pose a present or potential hazard to human health. Health effects of TACs may occur at extremely low levels and it is typically difficult to identify levels of exposure that do not produce adverse health effects (ARB 2010).

In California, local air districts have been established to oversee the attainment of air quality standards within air basins as defined by the State. Local air districts administer air quality laws and regulations within the air basins. The local air districts have permitting authority over all stationary sources of air pollutants within their district boundaries and provide the primary review of environmental documents prepared for projects with air quality issues.

## 16.3 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect future air quality conditions and the potential for GHG emissions. Implementation of the alternatives could affect CVP and SWP water deliveries which could affect air quality related to agricultural operations and fugitive dust generation. Changes in air quality and GHG emissions are analyzed in this EIS relative to appropriate Federal and state agency policies and regulations, as described in Chapter 4, Approach to Environmental Analyses.

Several of the Federal and state laws and regulations that provide quantitative criteria to determine compliance also are summarized in this subsection of this chapter to provide context for information provided in the remaining sections of this chapter, including:

- Federal Clean Air Act
  - National Ambient Air Quality Standards and Federal Air Quality Designations
  - Federal General Conformity Requirements
- California Clean Air Act
- California Assembly Bill 32, California Global Warming Solutions Act of 2006

### 16.3.1 Federal Clean Air Act

National air quality policies are regulated through the Federal Clean Air Act (FCAA) of 1970 and its 1977 and 1990 amendments. Basic elements of the FCCA include NAAQS for criteria air pollutants, hazardous air pollutants standards, state attainment plans, motor vehicle emissions standards, stationary source emissions standards and permits, acid rain control measures, stratospheric ozone protection, and enforcement provisions.

#### *16.3.1.1 National Ambient Air Quality Standards and Federal Air Quality Designations*

Pursuant to the FCAA, the USEPA established NAAQS for $O_3$, CO, $NO_2$, sulfur dioxide (SOx as $SO_2$), $PM_{10}$, $PM_{2.5}$, and lead. These pollutants are referred to as criteria pollutants because numerical health-based criteria have been established that define acceptable levels of exposure for each pollutant. The NAAQS and the CAAQS are summarized in Table 16.1 (ARB 2013).

**Table 16.1 Federal and State Ambient Air Quality Standards**

| Pollutant | Averaging Time | National Standards[a] Primary[b, i] | National Standards[a] Secondary[c, i] | California Standards[d] |
|---|---|---|---|---|
| Ozone | 8 Hour<br>1 Hour | 0.075 ppm<br>– | 0.075 ppm<br>– | 0.07 ppm<br>0.09 ppm |
| Carbon monoxide | 8 Hour<br>1 Hour | 9 ppm<br>35 ppm | –<br>– | 9.0 ppm<br>20 ppm |
| Nitrogen dioxide[j] | Annual Arithmetic Mean<br>1 Hour | 0.053 ppm<br>100 ppb | 0.053 ppm<br>– | 0.30 ppm<br>0.18 ppm |
| Sulfur dioxide[e] | Annual Arithmetic Mean<br>24 Hour<br>3 Hour<br>1 Hour | 0.030 ppm<br>0.14 ppm<br>–<br>75 ppb | –<br>–<br>0.5 ppm<br>– | –<br>0.04 ppm<br>–<br>0.25 ppm |
| $PM_{10}$ [f] | Annual Arithmetic Mean<br>24 Hour | –<br>150 $\mu g/m^3$ | –<br>150 $\mu g/m^3$ | 20 $\mu g/m^3$<br>50 $\mu g/m^3$ |
| $PM_{2.5}$[f] | Annual Arithmetic Mean<br>24 Hour | 12 $\mu g/m^3$<br>35 $\mu g/m^3$ | 15 $\mu g/m^3$<br>35 $\mu g/m^3$ | 12 $\mu g/m^3$<br>– |
| Sulfates | 24 Hour | – | – | 25 $\mu g/m^3$ |
| Lead[g, k] | 30 Day Average<br>Calendar Quarter<br>Rolling 3-Month Average | –<br>1.5 $\mu g/m^3$<br>0.15 $\mu g/m^3$ | –<br>1.5 $\mu g/m^3$<br>0.15 $\mu g/m^3$ | 1.5 $\mu g/m^3$<br>–<br>– |
| Hydrogen sulfide | 1 Hour | – | – | 0.03 ppm |
| Vinyl chloride | 24 Hour | – | – | 0.01 ppm |
| Visibility-reducing particles | 8 Hour | – | – | See Note[h] |

Source: ARB 2012, ARB 2013b.

Notes:

a. National standards, other than ozone, particulate matter, and those based on annual averages or annual arithmetic means, are not to be exceeded more than once a year. The ozone standard is attained when the fourth highest eight hour concentration in a year, averaged over three years, is equal to or less than the standard. For $PM_{10}$, the 24-hour standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$ is equal to or less than one. For $PM_{2.5}$, the 24-hour standard is attained when 98 percent of the daily concentrations, averaged over 3 years, are equal to or less than the standard.

b. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

c. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

d. California standards for ozone, carbon monoxide, sulfur dioxide (1-hour and 24-hour), nitrogen dioxide, suspended particulate matter ($PM_{10}$, $PM_{2.5}$, and visibility reducing particles), are values that are not to be exceeded. All others are not to be equaled or exceeded. All others are not to be equaled or exceeded. California ambient air quality standards are listed in the Table of Standards in Section 70200 of Title 17 of the California Code of Regulations.

e. On June 2, 2010, a new 1-hour $SO_2$ standard was established and the existing 24-hour and annual primary standards were revoked. To attain the 1-hour national standard, the 3-year average of the annual 99th percentile of the 1-hour daily maximum concentrations at each site must not exceed 75 ppb. The 1971 $SO_2$ national standards (24-hour and annual) remain in effect until one year after an area is designated for the 2010 standard, except for areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

f. On December 14, 2012, the national annual $PM_{2.5}$ primary standard was lowered from 15 $\mu g/m^3$ to 12.0 $\mu g/m^3$. The existing national 24-hour $PM_{2.5}$ standards (primary and secondary) were retained at 35 $\mu g/m^3$, as was the annual secondary standard of 15 $\mu g/m^3$. The existing 24-hour $PM_{10}$ standards (primary and secondary) of 150 $\mu g/m^3$ also were retained. The form of the annual primary and secondary standards is the annual mean, averaged over 3 years.

g. The national standard for lead was revised on October 15, 2008, to a rolling 3-month average. The 1978 lead standard (1.5 µg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except for areas designated nonattainment for the 1978 standard, where the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

h. In 1989, the ARB converted both the general statewide 10-mile visibility standard and the Lake Tahoe 30-mile visibility standard to instrumental equivalents, which are “extinction of 0.23 per kilometer” and “extinction of 0.07 per kilometer” for the statewide and Lake Tahoe Air Basin standards, respectively.

i. Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25°C and a reference pressure of 760 torr. Most measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 torr; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

j. To attain the 1-hour national standard, the 3-year average of the annual $98^{th}$ percentile of the 1-hour daily maximum concentrations at each site must not exceed 100 ppb. Note that the national 1-hour standard is in units of parts per billion (ppb). California standards are in units of parts per million (ppm). To directly compare the national 1-hour standard to the California standards the units can be converted from ppb to ppm. In this case, the national standard of 100 ppb is identical to 0.100 ppm.

k. The ARB has identified lead and vinyl chloride as 'toxic air contaminants' with no threshold level of exposure for adverse health effects determined. These actions allow for the implementation of control measures at levels below the ambient concentrations specified for these pollutants.

$\mu g/m^3$ = micrograms per cubic meter.
ppb = parts per billion (by volume).
ppm = parts per million (by volume).

The USEPA designates areas as attainment, nonattainment, or unclassified for individual criteria pollutants depending on whether the areas achieve (i.e., attain) the applicable NAAQS for each pollutant. For some pollutants, there are numerous classifications of the nonattainment designation, depending on the severity of an area's nonattainment status. Areas that lack monitoring data are designated as unclassified areas, and considered as attainment areas for regulatory purposes.

Under the 1977 FCAA amendments, states (or areas within states) with ambient air quality concentrations that do not meet the NAAQS are required to develop and maintain SIPs. These implementation plans constitute a federally enforceable definition of the state's approach and schedule for the attainment of the NAAQS. If a nonattainment area achieves compliance, the area is classified as an attainment maintenance area for 20 years.

#### *16.3.1.2 Federal General Conformity Requirements*

The 1977 FCAA amendments state that the Federal government is prohibited from engaging in, supporting, providing financial assistance for, licensing, permitting, or approving any activity that does not conform to an applicable SIP. In the 1990 FCAA amendments, the USEPA included provisions requiring Federal agencies to ensure that actions undertaken in nonattainment or attainment maintenance areas are consistent with applicable SIPs. The process of determining whether a Federal action is consistent with applicable SIPs is called "conformity" determination. A conformity determination is required only for the project alternative that is ultimately selected and approved. The USEPA general conformity regulation applies only to Federal actions that result in emissions of "nonattainment or maintenance pollutants" or their precursors in federally designated nonattainment or maintenance areas. The emission thresholds that trigger requirements of the general conformity regulation for Federal actions emitting nonattainment or maintenance pollutants, or their precursors, are called *de Minimis* levels, as summarized in Table 16.2.

**Table 16.2 General Conformity *de Minimis* Levels**

| Pollutant | Area Type | Tons/Year |
|---|---|---|
| Ozone (VOC or NOx) | Serious nonattainment | 50 |
| | Severe nonattainment | 25 |
| | Extreme nonattainment | 10 |
| | Other areas outside an ozone transport region | 100 |
| Ozone (NOx) | Marginal and moderate nonattainment inside an ozone transport region | 100 |
| | Maintenance | 100 |
| Ozone (VOC) | Marginal and moderate nonattainment inside an ozone transport region | 50 |
| | Maintenance within an ozone transport region | 50 |
| | Maintenance outside an ozone transport region | 100 |
| Carbon monoxide, $SO_2$ and $NO_2$ | All nonattainment and maintenance | 100 |
| $PM_{10}$ | Serious nonattainment | 70 |
| | Moderate nonattainment and maintenance | 100 |
| $PM_{2.5}$<br>Direct emissions, $SO_2$, NOx (unless determined not to be a significant precursor), VOC or ammonia (if determined to be significant precursors) | All nonattainment and maintenance | 100 |
| Lead (Pb) | All nonattainment and maintenance | 25 |

Source: USEPA 2015b

#### *16.3.1.3 California Clean Air Act*

The California Clean Air Act (CCAA) provides the State with a comprehensive framework for air quality planning regulation. Prior to passage of the CCAA, Federal law contained the only comprehensive planning framework. The CCAA requires attainment of state ambient air quality standards by the earliest practicable date.

The FCAA requires adoption of SIPs for nonattainment areas to describe actions that will be undertaken to achieve the NAAQS. In addition, the CCAA requires local air districts in nonattainment areas to prepare and maintain Air Quality Management Plans (AQMPs) to achieve compliance with CAAQS. These AQMPs also serve as a basis for preparing the SIP for the State of California, which must ultimately be approved by the USEPA and codified in the Code of Federal Register (CFR).

## 16.4 Affected Environment

This section describes the area of analysis, ambient air quality and conditions, and GHG emissions in the study area.

The air basins and air districts in California, including those in the study area, do not specifically align with the study area regions, as noted below and in the description of each air basin (ARB 2011a; ARB 2011b).

The discussion in this chapter area is organized by the study area regions and air basins. The study area regions include the following air basins and counties.

- Trinity River Region is located within portions of the North Coast Air Basin.
  - The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and the area in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.
- Central Valley Region is located within portions of the Sacramento Valley, Mountain Counties, San Joaquin Valley, San Francisco Bay Area, Mojave Desert air basins.
  - The Central Valley Region includes all or portions the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, Solano, Napa, San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern that are within the CVP and SWP service areas.
- San Francisco Bay Area Region is located within portions of the San Francisco Bay Area and North Central Coast air basins.
  - The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas.
- Central Coast Region is located within portions of the South Central Coast Air Basin.
  - The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP.
- Southern California Region is located within portions of the South Central Coast, South Coast, San Diego, Mojave Desert, and Salton Sea air basins.
  - The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

### 16.4.1 Ambient Air Quality

Air quality conditions and potential impacts in the project area are evaluated and discussed qualitatively, rather than quantitatively. The following subsections briefly describe the existing air quality environmental setting by air basin for the project area. The counties within each air basin in the project area are presented in Table 16.3, along with non-attainment designations to characterize existing ambient air quality. Non-attainment designations indicate that concentrations of pollutants measured in ambient air exceed the applicable ambient air quality standards. As shown in Table 16.3, many of the counties included in the project area are designated as nonattainment for the Federal and/or State ozone and particulate matter standards. These air quality issues may be exacerbated under dry conditions because when irrigation water supplies are decreased, there is increased potential for the formation and transport of fugitive dust.

**Table 16.3 Pollutants Designated as Nonattainment Pursuant to Federal and State Ambient Air Quality Standards**

| County | Air Basin | Air District | Federal Nonattainment Designations[a] | State Nonattainment Designations[b] |
|---|---|---|---|---|
| **Trinity River Region** | | | | |
| Trinity | North Coast | North Coast Unified | – | – |
| Humboldt | North Coast | North Coast Unified | – | – |
| Del Norte | North Coast | North Coast Unified | – | – |
| **Central Valley Region** | | | | |
| Shasta | Sacramento Valley | Shasta | – | Ozone, $PM_{10}$ |
| Tehama | Sacramento Valley | Tehama | Ozone (Tuscan Buttes area) | Ozone, $PM_{10}$ |
| Butte | Sacramento Valley | Butte | Ozone and $PM_{2.5}$ in Chico | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Glenn | Sacramento Valley | Glenn | – | $PM_{10}$ |
| Colusa | Sacramento Valley | Colusa | – | $PM_{10}$ |
| Yuba | Sacramento Valley | Feather River | – | Ozone, $PM_{10}$ |
| Sutter | Sacramento Valley | Feather River | Ozone | Ozone, $PM_{10}$ |
| Yolo | Sacramento Valley | Yolo-Solano | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$ |
| Sacramento | Sacramento Valley | Sacramento Metro | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$ |

| County | Air Basin | Air District | Federal Nonattainment Designations[a] | State Nonattainment Designations[b] |
|---|---|---|---|---|
| Plumas | Mountain Counties | Northern Sierra | – | $PM_{10}$<br>$PM_{2.5}$ (Portola Valley) |
| Placer | Sacramento Valley, Mountain Counties, Lake Tahoe | Placer | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$ |
| El Dorado | Sacramento Valley, Mountain Counties, Lake Tahoe | El Dorado | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$ |
| San Joaquin | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Stanislaus | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Merced | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Fresno | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Madera | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Kings | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Tulare | San Joaquin Valley | San Joaquin Valley | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Kern | San Joaquin Valley, Mojave Desert | San Joaquin Valley, Kern | Ozone, $PM_{2.5}$, $PM_{10}$ (East Kern) | Ozone, $PM_{10}$, $PM_{2.5}$ (San Joaquin Valley Air Basin) |
| **San Francisco Bay Area Region** | | | | |
| Napa | San Francisco Bay Area | Bay Area | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Solano | Sacramento Valley, San Francisco Bay Area | Yolo-Solano and Bay Area | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Contra Costa | San Francisco Bay Area | Bay Area | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Alameda | San Francisco Bay Area | Bay Area | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Santa Clara | San Francisco Bay Area | Bay Area | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |

| County | Air Basin | Air District | Federal Nonattainment Designations[a] | State Nonattainment Designations[b] |
|---|---|---|---|---|
| San Benito | North Central Coast | Monterey Bay Unified | – | Ozone, $PM_{10}$ |
| **Central Coast Region** | | | | |
| San Luis Obispo | South Central Coast | San Luis Obispo | Ozone (Eastern San Luis Obispo) | Ozone, $PM_{10}$ |
| Santa Barbara | South Central Coast | Santa Barbara | – | Ozone, $PM_{10}$ |
| **Southern California Region** | | | | |
| Ventura | South Central Coast | Ventura | Ozone | Ozone, $PM_{10}$ |
| Los Angeles | South Coast, Mojave Desert | South Coast, Antelope Valley | Ozone, $PM_{2.5}$, Lead | Ozone; $PM_{10}$; $PM_{2.5}$ |
| San Bernardino | South Coast, Mojave Desert | South Coast, Mojave Desert | Ozone, $PM_{10}$, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| Riverside | South Coast, Mojave Desert, Salton Sea | South Coast, Mojave Desert | Ozone, $PM_{10}$, $PM_{2.5}$ | Ozone; $PM_{10}$; $PM_{2.5}$ |
| Orange | South Coast | South Coast | Ozone, $PM_{2.5}$ | Ozone, $PM_{10}$, $PM_{2.5}$ |
| San Diego | San Diego County | San Diego | Ozone | Ozone, $PM_{10}$, $PM_{2.5}$ |

Sources: USEPA 2014; ARB 2015

Notes:
a. Areas designated as nonattainment by U.S. Environmental Protection Agency related to National Ambient Air Quality Standards as of January 30, 2015.

b. Areas designated as nonattainment by California Air Resources Board related to California Ambient Air Quality Standards as of April 10, 2014. No changes to the state area designations were proposed for 2014.

#### *16.4.1.1 North Coast Air Basin*

The North Coast Air Basin includes Humboldt, Del Norte, Trinity, Mendocino, and north Sonoma counties (ARB 2013a). This air basin is located within the Trinity River Region of the study area. The basin is sparsely populated, and stretches along the northern coastline through forested mountains. Prevailing winds blow clean air inland from the Pacific Ocean, and air quality is typically good. Humboldt, Del Norte, and Trinity counties are designated attainment for the federal and state air quality standards (USEPA 2015b, ARB 2014).

#### *16.4.1.2 Sacramento Valley Air Basin*

The Sacramento Valley Air Basin encompasses 9 air districts and 11 counties, including: all of Shasta, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Sacramento, and Yolo counties; the westernmost portion of Placer County; and the northeastern half of Solano County. The air basin is bounded by tall mountains, including the Coast Range to the west, the Cascade Range to the north, and the Sierra Nevada Range to the east. This air basin is located within the northern portion of the Central Valley Region of the study area.

Winters are wet and cool, and summers are hot and dry. When air stagnates, or is trapped by an inversion layer in the valley, ambient pollutant concentrations can reach or exceed threshold levels. On-road vehicles are the largest source of smog-forming pollutants, and particulate matter emissions are primarily from area sources, such as fugitive dust from paved and unpaved roads and vehicle travel (ARB 2013a).

To characterize the existing ambient air quality in the Sacramento Valley Air Basin, data from area monitoring stations were reviewed (ARB 2011d). For the three years from 2007 to 2009, monitoring data indicated the following:

- Concentrations of $O_3$ and 24-hour $PM_{2.5}$ have exceeded the NAAQS and CAAQS.
- Concentrations of $PM_{10}$ have exceeded the CAAQS but are below the NAAQS.
- Measured concentrations of CO and $NO_2$ have complied with the NAAQS and CAAQS.
- Monitored $SO_2$ concentrations are extremely low, and lead concentrations are monitored as part of the air toxics program.

In the time since ARB compiled the 2007 to 2009 air quality monitoring data reported above, Glenn and Colusa counties have been redesignated as attainment for the California ozone standards (ARB 2014). In addition, Sacramento County has been redesignated as attainment for the California $PM_{2.5}$ standards (ARB 2014). No other changes in air quality nonattainment designations have been recorded (USEPA 2014; ARB 2014).

#### *16.4.1.3 Mountain Counties Air Basin*

The Mountain Counties Air Basin includes the mountainous areas of the central and northern Sierra Nevada Mountains, from Plumas County south to Mariposa County, including Plumas, Sierra, Nevada, Central Placer, West El Dorado, Amador, Calaveras, Tuolumne, and Mariposa counties (ARB 2013a). This air basin includes portions of the central-eastern Central Valley Region of the study area; as well as areas located to the east of the study area.

Sparsely populated, motor vehicles are the primary source of emissions in the air basin. Air quality issues often result when eastward surface winds transport pollution from more populated air basins to the west and south. Wood smoke from stoves and fireplaces contribute to elevated ambient $PM_{10}$ concentrations during winter. Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, and Mariposa counties are designated as nonattainment for the Federal and State ozone standards (ARB 2014). Plumas, Sierra, Nevada, Placer, El Dorado, and Calaveras counties are designated as nonattainment for the State $PM_{10}$ standards (ARB 2014).

#### *16.4.1.4 San Joaquin Valley Air Basin*

The San Joaquin Valley Air Basin encompasses eight counties, including: all of San Joaquin, Stanislaus, Madera, Merced, Fresno, Kings, Tulare counties; and western Kern County. It is bounded on the west by the Coast Range, on the east by the Sierra Nevada, and in the south by the Tehachapi Mountains. This air basin is located within the central and southern portions of the Central Valley Region of the study area.

Winters are cool and wet and summers are dry and very hot. The area is heavily agricultural, and hosts other localized industries such as forest products, oil and gas production, and oil refining. On-road vehicles are the largest source of smog-forming pollutants, and $PM_{10}$ emissions are primarily from sources such as agricultural operations and fugitive dust from paved and unpaved roads and vehicle travel (ARB 2013a). Air quality issues may be exacerbated under dry conditions. When water supplies and irrigation levels are decreased in urban, rural, and agricultural areas, there is increased potential for the formation and transport of fugitive dust.

To characterize the existing ambient air quality for the San Joaquin Valley Air Basin, data from area monitoring stations were reviewed (ARB 2011d). For the three years from 2007 to 2009, monitoring data indicated the following:

- Concentrations of $O_3$ and 24-hour $PM_{2.5}$ have exceeded the NAAQS and CAAQS.
- Concentrations of $PM_{10}$ have exceeded the CAAQS but are below the NAAQS.
- Measured concentrations of CO and $NO_2$ have complied with the NAAQS and CAAQS.
- Monitored $SO_2$ concentrations are extremely low, and lead concentrations are monitored as part of the air toxics program.

In the time since ARB compiled the 2007 to 2009 air quality monitoring data reported above, no changes in air quality nonattainment designations have been recorded in the San Joaquin Valley Region counties in this study (USEPA 2015; ARB 2014).

##### 16.4.1.4.1 Dust and Particulate Matter in San Joaquin Valley

The San Joaquin Valley Air Pollution Control District (SJVAPCD) is the local regulatory agency with jurisdiction over air quality issues in the San Joaquin Valley area. In response to the area's historical air quality problems with dust and particulate matter, the SJVAPCD was the first agency in the state to regulate emissions from on-field agricultural operations. In 2004, the agency adopted Rule 4550, the Conservation Management Practices rule, and Rule 3190, the Conservation Management Practices Fee rule. To comply with these rules, farmers with 100 acres or more of contiguous land must prepare and implement biennial Conservation Management Plans to reduce dust and particulate matter emissions from on-farm sources, such as unpaved roads and equipment yards, land preparation, harvest activities, and other farming activities. A handbook titled "Agricultural Air Quality Conservation Management Practices for San Joaquin Valley Farms" was published by the agriculture industry in 2004 to provide guidance to farmers on Conservation Management Practices (SJVAPCD 2004a, 2004b). Examples of Conservation Management Practices include activities that reduce or eliminate the need for soil disturbance, activities that protect soil from wind, dust suppressants, alternatives to burning agricultural wastes, and reduced travel speeds on unpaved roads and equipment yards. Lands not currently under cultivation or used for pasture are exempt from Rule 4550, other than recordkeeping to document the exemption. Fees vary depending on the size of the farm, and include an initial application fee, and a biennial renewal fee.

In addition to requirements for on-field agricultural practices, the SJVAPCD rules and regulations address avoidance of nuisance conditions (Rule 4102), prohibitions on opening burning (Rule 4103), and fugitive-dust control (Regulation VIII). Specifically, the SJVAPCD dust-control rules include Rule 8021 for control of $PM_{10}$ from construction, demolition, excavation, extraction, and other earth moving activities; Rule 8031 for control of $PM_{10}$ from handling and storage of bulk materials; Rule 8051 for control of $PM_{10}$ from disturbed open areas; Rule 8061 for control of $PM_{10}$ from travel on paved and unpaved roads; Rule 8071 for control of $PM_{10}$ from unpaved vehicle and equipment traffic areas; and Rule 8081 for off-field agricultural sources, such as bulk materials handling and transport and travel on unpaved roads. Each of these rules requires fugitive dust control, often through application of water, gravel, or chemical dust stabilizers.

#### *16.4.1.5 San Francisco Bay Area Air Basin*

The San Francisco Bay Area Air Basin consists of a single air district and nine counties, including: all of Napa, Marin, San Francisco, Contra Costa, Alameda, San Mateo, and Santa Clara counties; the southern portion of Sonoma County; and the southwestern portion of Solano County (ARB 2013a). The hills of the Coast Range bound the San Francisco and San Pablo bays and the inland valleys of the air basin. This air basin includes the San Francisco Bay Area Region of the study area.

The San Francisco Bay Area Air Basin includes the second largest urban area in California, hosting industry, airports, international ports, freeways, and surface streets. On-road vehicles are the largest source of smog-forming pollutants, and $PM_{10}$ emissions are primarily from area sources, such as fugitive dust from paved and unpaved roads and vehicle travel (ARB 2013a). Air quality in the San Francisco Bay Area is often good as sea breezes blow clean air from the Pacific Ocean into the air basin, but transport of pollutants from the San Francisco Bay

Area can exacerbate air quality problems in the downwind portions of the San Francisco Bay Area Air Basin; as well as in the Sacramento Valley and San Joaquin Valley air basins.

To characterize the existing ambient air quality for the San Francisco Bay Area Air Basin, data from area monitoring stations were reviewed (ARB 2011d). For the three years from 2007 to 2009, monitoring data indicated the following:

- Concentrations of $O_3$ and 24-hour $PM_{2.5}$ have exceeded the NAAQS and CAAQS.
- Concentrations of $PM_{10}$ exceeded the CAAQS in 2008 but were below the CAAQS in 2007 and 2009. Concentrations of $PM_{10}$ were below the NAAQS.
- Measured concentrations of CO and $NO_2$ have complied with the NAAQS and CAAQS.
- Monitored $SO_2$ concentrations are extremely low, and lead concentrations are monitored as part of the air toxics program.

In the time since ARB compiled the 2007 to 2009 air quality monitoring data reported above, no changes in air quality nonattainment designations have been recorded in the San Francisco Bay Region counties in this study (USEPA 2015; ARB 2014).

#### *16.4.1.6 North Central Coast Air Basin*

The North Central Coast Air Basin includes Santa Cruz, San Benito and Monterey counties (ARB 2013a). This air basin includes San Benito County which is located within the San Francisco Bay Area Region of the study area.

The North Central Coast Air Basin is in attainment for all NAAQS, and is designated as nonattainment for the State ozone and $PM_{10}$ standards (ARB 2014). Though separated by the Santa Cruz Mountains and Coast Ranges to the north, wind can transport air pollution from the San Francisco Bay Area Air Basin and contribute to elevated ozone concentrations in the area (ARB 2013a).

#### *16.4.1.7 South Central Coast Air Basin*

The South Central Coast Air Basin includes San Luis Obispo, Santa Barbara and Ventura counties. It is bordered by the Pacific Ocean on the south and west and lies just north of the highly populated South Coast Air Basin. This air basin includes the Central Coast Region and the northern Southern California Region of the study area.

Sources of pollutants in the air basin include power plants, oil production and refining, vehicle travel, and agricultural operations. San Luis Obispo, Santa Barbara, and Ventura counties are designated as nonattainment for the State ozone and $PM_{10}$ standards. Eastern San Luis Obispo and Ventura counties are designated as nonattainment for the Federal ozone standard (USEPA 2015). Wind patterns link Ventura and Santa Barbara counties, resulting in pollutant transport between the South Central Coast and South Coast air basins. San Luis Obispo County is separated from these counties by mountains, and the air quality in San Luis Obispo County is linked more with conditions in the San Francisco Bay Area Air Basin and San Joaquin Valley Air Basin. Additionally, air emissions from the South Coast Air Basin can be blown offshore, and then carried to the coastal cities of the South Central Coast Air Basin. Under some conditions, the reverse air flow can carry pollutants from the South Central Coast Air Basin to the South Coast Air Basin and contribute to ozone violations there (ARB 2013a).

#### *16.4.1.8 South Coast Air Basin*

The South Coast Air Basin is California's largest metropolitan region. The area includes the southern two-thirds of Los Angeles County, all of Orange County, and the western urbanized portions of Riverside and San Bernardino counties. The South Coast Air Basin is bounded by the Pacific Ocean on the west and by mountains on the other three sides. This air basin includes the western-central portion of the Southern California Region of the study area.

The area includes industry, airports, international ports, freeways, and surface streets. On-road vehicles are the largest source of smog-forming pollutants, and $PM_{10}$ emissions are primarily from area sources, such as fugitive dust from paved and unpaved roads and vehicle travel (ARB 2013a). One-third of the state's total criteria pollutant emissions are generated within the basin (ARB 2013a). The pollutant emissions and fugitive dust generated in the South Coast Air Basin affects other air basins. For example, fugitive dust generated in the South Coast Air Basin contributes to poor air quality in the Salton Sea Air Basin and the Coachella Valley portion of Riverside County (USGS 2014).

The persistent high pressure system and frequent low inversion heights caused by the surrounding mountains on three sides of the air basin trap pollutants in the air basin (ARB 2013a). Sunny weather contributes to smog formation. Portions of the South Coast Air Basin are designated as nonattainment for the Federal and State ozone, $PM_{10}$, and $PM_{2.5}$ standards (ARB 2014; USEPA 2015). Wind often transports air pollutants from the South Coast Air Basin to nearby air basins.

#### *16.4.1.9 Mojave Desert Air Basin*

The sparsely populated Mojave Desert Air Basin covers most of California's high desert and is made up of eastern Kern and Riverside counties and northern Los Angeles and San Bernardino counties. The San Gabriel and San Bernardino mountains lie to the south, separating the Mojave Desert Air Basin from the South Coast Air Basin. To the northwest, the Tehachapi Mountains separate the Mojave Desert Air Basin from the San Joaquin Valley Air Basin. This air basin includes the southeastern portion of the Central Valley Region and the northeastern portion of the Southern California Region of the study area.

The primary sources of air pollution in the air basin are military bases, highways, railroads, cement manufacturing, and mineral processing (ARB 2013a). The Mojave Desert Air Basin also is affected by air quality conditions in the San Joaquin Valley and South Coast air basins. Air from the South Coast Air Basin is transported over the San Gabriel Mountains, heavily impacting the areas of the Mojave Desert Air Basin located to the north of the South Coast Air Basin.

The Mojave Desert Air Basin also is located downwind of the San Joaquin Valley Air Basin; and the winds pass through the Tehachapi Mountains carrying air emissions from the San Joaquin Valley Air Basin. Due to the impacts from the South Coast Air Basin, the worst air quality in the Mojave Desert Air Basin is along the southern edge that borders the South Coast Air Basin. This is also where most of the population within the Mojave Desert Air Basin is located (ARB 2013a).

Portions of the Mojave Desert Air Basin are designated as nonattainment for the Federal and State ozone and $PM_{10}$ standards (ARB 2014; USEPA 2015).

#### *16.4.1.10 San Diego Air Basin*

The San Diego Air Basin is in the southwest corner of California and comprises all of San Diego County. This air basin includes the southwestern portion of the Southern California Region of the study area.

The population and emissions are concentrated in the western portion of the air basin, which is bordered on the west by the Pacific Ocean. The climate is relatively mild near the ocean, with higher temperatures and seasonal variations further inland (ARB 2013a).

The air basin includes industrial facilities, airports, an international port, freeways, and surface streets. The San Diego Air Basin is designated as nonattainment for the Federal ozone standard and the State ozone, $PM_{10}$, and $PM_{2.5}$ standards (ARB 2014). Air quality in the San Diego Air Basin is impacted not only by local emission sources, but also from transport of air emissions from the South Coast Air Basin and Mexico.

#### *16.4.1.11 Salton Sea Air Basin*

The Salton Sea Air Basin is in the southeast corner of California and includes all of Imperial County and central Riverside County. The air basin is characterized by flat terrain and the Salton Sea surrounded by high mountains to the west, north, and east. The southern portion of the air basin extends towards the Gulf of California. The flat terrain and strong temperature differentials created by intense heating and cooling patterns produce moderate winds and deep thermal circulation systems which disperse local air emissions (DWR 2006). This air basin includes the northeastern portion of the Southern California Region of the study area.

The primary sources of air pollution are from vehicles and equipment exhaust and particulate matter from disturbed soils and wind erosion. The Salton Sea Air Basin is designated as nonattainment for the Federal and State ozone and $PM_{10}$ standards (ARB 2014; USEPA 2015). Portions of the Salton Sea Air Basin located outside of the study area near Calexico also are in nonattainment for $PM_{2.5}$ standards.

## 16.4.2 Existing Greenhouse Gases and Emissions Sources

This subsection presents an overview of the greenhouse effect and climate change, and potential sources of GHG emissions and information related to climate change and GHG emissions in California. GHG emissions and their climate-related impacts are not limited to specific geographic locations, but occur on global or regional scales. GHG emissions contribute cumulatively to the overall heat-trapping capability of the atmosphere, and the effects of the warming, such as climate change, are manifested in different ways across the planet.

### *16.4.2.1 Greenhouse Gas Emissions Regulations and Analyses*

Global warming is the name given to the increase in the average temperature of the Earth's near-surface air and oceans since the mid-20th century and its projected continuation. Warming of the climate system is now considered to be unequivocal (DWR 2010) with global surface temperature increasing approximately 1.33°F over the last one hundred years. Continued warming is projected to increase global average temperature between 2 and 11 degrees Fahrenheit (°F) over the next one hundred years.

The causes of this warming have been identified as both natural processes and as the result of human actions. The Intergovernmental Panel on Climate Change (IPCC) concludes that variations in natural phenomena such as solar radiation and volcanoes produced most of the warming from pre-industrial times to 1950 and had a small cooling effect afterward. However, after 1950, increasing GHGs concentrations resulting from human activity such as fossil fuel burning and deforestation have been responsible for most of the observed temperature increase. These basic conclusions have been endorsed by more than 45 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries.

Increases in GHG concentrations in the Earth's atmosphere are thought to be the main cause of human-induced climate change. GHGs naturally trap heat by impeding the exit of solar radiation that has hit the Earth and is reflected back into space. Some GHGs occur naturally and are necessary for keeping the Earth's surface inhabitable. However, increases in the concentrations of these gases in the atmosphere during the last hundred years have decreased the amount of solar radiation that is reflected back into space, intensifying the natural greenhouse effect and resulting in the increase of global average temperature (DWR 2010).

The principal GHGs considered in this EIS are $CO_2$, $CH_4$, $N_2O$, $SF_6$, PFC, and HFC, in accordance with the California Health and Safety Code section 38505(g) (DWR 2010). Each of the principal GHGs has a long atmospheric lifetime (one year to several thousand years). In addition, the potential heat-trapping ability of each of these gases varies significantly from one another, and also vary over time. For example, $CH_4$ is 25 times as potent as $CO_2$; while $SF_6$ is 32,800 times more potent than $CO_2$ with a 100-year time horizon (IPCC 2007).

The primary man-made processes that release these gases include: burning of fossil fuels for transportation, heating and electricity generation; agricultural practices that release $CH_4$, such as livestock grazing and crop residue decomposition; and industrial processes that release smaller amounts of high global warming potential gases such as $SF_6$, PFCs, and HFCs (DWR 2010). Deforestation and land cover conversion have also been identified as contributing to global warming by reducing the Earth's capacity to remove $CO_2$ from the air and altering the Earth's albedo or surface reflectance, allowing more solar radiation to be absorbed.

#### *16.4.2.2 An Overview of the Greenhouse Effect*

The greenhouse effect is a natural phenomenon that is essential to keeping the Earth's surface warm (DWR 2010). Like a greenhouse window, GHGs allow sunlight to enter and then prevent heat from leaving the atmosphere. Solar radiation enters the Earth's atmosphere from space. A portion of this radiation is reflected by particles in the atmosphere back into space, and a portion is absorbed by the Earth's surface and emitted back into space. The portion absorbed by the Earth's surface and emitted back into space is emitted as lower-frequency infrared radiation. This infrared radiation is absorbed by various GHGs present in the atmosphere. While these GHGs are transparent to the incoming solar radiation, they are effective at absorbing infrared radiation emitted by the Earth's surface. Therefore, some of the lower-frequency infrared radiation emitted by the Earth's surface is retained in the atmosphere, creating a warming of the atmosphere.

##### 16.4.2.2.1 Global Climate Trends and Associated Impacts

The rate of increase in global average surface temperature over the last hundred years has not been consistent (DWR 2010). The last three decades have warmed at a much faster rate than the previous seven decades – on average 0.32°F per decade. Eleven of the twelve years from 1995 to 2006, rank among the twelve warmest years in the instrumental record of global average surface temperature since 1850.

Increased global warming has occurred concurrent with many other changes have occurred in other natural systems (DWR 2010). Global sea levels have risen on average 1.8 millimeters per year; precipitation patterns throughout the world have shifted, with some areas becoming wetter and other drier; tropical storm activity in the North Atlantic has increased; peak runoff timing of many glacial and snow fed rivers has shifted earlier; as well as numerous other observed conditions. Though it is difficult to prove a definitive cause and effect relationship between global warming and other observed changes to natural systems, there is high confidence in the scientific community that these changes are a direct result of increased global temperatures.

##### 16.4.2.2.2 Overview of Greenhouse Gas Emission Sources

Naturally occurring GHGs include water vapor, $CO_2$, methane, and nitrous oxide. Water vapor is introduced to the atmosphere from oceans and the natural biosphere. Water vapor introduced directly to the atmosphere from agricultural or other activities is not long lived, and thus does not contribute substantially to a warming effect (NAS 2005). Carbon and nitrogen contained in $CO_2$, methane, and nitrous oxide naturally cycle from gaseous forms to organic biomass through processes such as plant and animal respiration and seasonal cycles of plant growth and decay (USEPA 2012). Although naturally occurring, the emissions and sequestration of these gases are also influenced by human activities, and in some cases, are caused by human activities (anthropogenic). In addition to these GHGs, several classes of halogenated substances that contain fluorine, chlorine, or bromine also contribute to the greenhouse effect. However, these compounds are the product of industrial activities for the most part.

Each of the GHGs has a different capacity to trap heat in the atmosphere, with some of these gases being more effective at trapping heat than others. For calculating emissions, ARB (ARB 2007) uses a metric developed by the IPCC to account for these differences and to provide a standard basis for calculations. The metric, called the global warming potential (GWP), is used to compare the future climate impacts of emissions of various long-lived GHGs. The GWP of each GHG is indexed to the heat-trapping capability of $CO_2$, and allows comparison of the global warming influence of each GHG relative to $CO_2$. The GWP is used to translate emissions of each GHG to emissions of carbon dioxide equivalents, or $CO_2e$. In this way, emissions of various GHGs can be summed, and total GHG emissions can be inventoried in common units of metric tons per year of $CO_2e$. Most international inventories, including the United States inventory, use GWP values from the IPCC Fourth Assessment Report, per international consensus (IPCC 2007; USEPA 2012).

$CO_2$ is a byproduct of burning fossil fuels and biomass, as well as land-use changes and other industrial processes (USEPA 2012). It is the principal anthropogenic GHG that contributes to the Earth's radiative balance, and it represents the dominant portion of GHG emissions from activities that result from the combustion of fossil fuels (e.g., construction activities, electrical generation, and transportation).

#### *16.4.2.3 California Climate Trends and Greenhouse Gas Emissions*

Maximum (daytime) and minimum (nighttime) temperatures are increasing almost everywhere in California but at different rates. The annual minimum temperature averaged over all of California has increased 0.33°F per decade during the period 1920 to 2003, while the average annual maximum temperature has increased 0.1°F per decade (DWR 2010).

With respect to California's water resources, the most significant impacts of global warming have been changes to the water cycle and sea level rise. Over the past century, the precipitation mix between snow and rain has shifted in favor of more rainfall and less snow, and snow pack in the Sierra Nevada is melting earlier in the spring (DWR 2010). The average early spring snowpack in the Sierra Nevada has decreased by about 10 percent during the last century, a loss of 1.5 million acre-feet of snowpack storage. These changes have significant implications for water supply, flooding, aquatic ecosystems, energy generation, and recreation throughout the state.

During the same period, sea levels along California's coast have risen. The Fort Point tide gauge in San Francisco was established in 1854 and is the longest continually monitored gauge in the United States. Sea levels measured at this gauge and two other west coast gauges indicate that the sea levels have risen at an average rate of about 7.9 inches/century (0.08 inch/year) over the past 150 years (BCDC 2011). Continued sea level rise associated with global warming may threaten coastal lands and infrastructure, increase flooding at the mouths of rivers, place additional stress on levees in the Sacramento-San Joaquin Delta, and intensify the difficulty of managing the Sacramento-San Joaquin Delta as the heart of the state's water supply system (DWR 2010).

#### 16.4.2.3.1 Potential Effects of Global Climate Change in California

Warming of the atmosphere has broad implications for the environment. In California, one of the effects of climate change could be increases in temperature that could affect the timing and quantity of precipitation. California receives most of its precipitation in the winter months, and a warming environment would raise the elevation of snow pack and result in reduced spring snowmelt and more winter runoff. These effects on precipitation and water storage in the snow pack could have broad implications on the environment in California.

The following are some of the potential effects of a warming climate in California (California Climate Change Portal 2007):

- Loss of snowpack storage will cause increased winter runoff that generally would not be captured and stored because of the need to reserve flood capacity in reservoirs during the winter.
- Less spring runoff would mean lower early summer storage at major reservoirs, which would result in less hydroelectric power production.
- Higher temperatures and reduced snowmelt would compound the problem of providing suitable cold water habitat for salmonid species. Lower reservoir levels would also contribute to this problem, reducing the flexibility of cold water releases.
- Sea level rise would affect the Delta, worsening existing levee problems, causing more saltwater intrusion, and adversely affecting many coastal marshes and wildlife reserves. Release of water to streams to meet water quality requirements could further reduce storage levels.
- Increased temperatures would increase the agricultural demand for water and increase the level of stress on native vegetation, potentially allowing for an increase in pest and insect epidemics and a higher frequency of large, damaging wildfires.

Future climate scenarios have also been evaluated in the U.S. Global Change Research Program National Climate Assessments. The most recent assessment, *Climate Change Impacts in the United States*, was released in May 2014 (USGCRP 2014). For the Southwest Region of the United States, the report projects that water supply availability would be reduced as compared to recent conditions due to reduced snowpack and declining stream flows. Rising temperatures in the future would increase disruptions to electricity generation which could further reduce water availability. The National Climate Assessment also indicates that mitigation policies and other factors have lowered the United States' nationwide GHG emissions in recent years; however, substantial global emissions reductions are needed to avoid many of the predicted consequences. A considerable amount of planning for resilience and adaptation is underway, but implementation of adaptive measures have been limited in scope.

#### 16.4.2.3.2 Current California Emission Sources

The recent California's GHG emission inventory was released on April 6, 2012, with data updated through October 2011. The GHG emissions in California have been estimated for each year from 2000 to 2009, and are reported for several large sectors of emission sources. The estimates for 2009 are summarized in Table 16.4, reported by sector as millions of tons per year of $CO_2$ (ARB 2011e).

**Table 16.4 California Greenhouse Gas Emissions by Sector in 2009**

| Sector | Total Emissions (million tons/year of $CO_2e$) | Percent of Statewide Total Gross Emissions[a] |
|---|---|---|
| Agriculture | 32.1 | 7 |
| Commercial and Residential | 43 | 9.4 |
| Electric Power | 103.6 | 22.7 |
| Forestry (excluding $CO_2$ sinks) | 0.2 | < 1.0 |
| Industrial | 81.4 | 17.8 |
| Recycling and Waste | 7.3 | 1.6 |
| Transportation | 172.9 | 37.9 |
| High Global Warming Potential substance and ozone-depleting substance use[b] | 16.3 | 3.6 |
| **Total** | **456.8** | **100** |
| Forestry Net Emissions | -3.8 | – |

Source: ARB 2011e.

Notes:

a. Based on the 456.8 million tons/year of $CO_2e$ Total Gross Emissions estimate.

b. High Global Warming Potential substance and ozone-depleting substance use are not attributed to an individual sector.

Total gross statewide GHG emissions in 2009 were estimated to be 456.8 million tons per year of $CO_2e$. The two largest sectors contributing to emissions in California are transportation and electric power (the latter sector includes both in-state generation and imported electricity). The agricultural sector represents only 7 percent of the total gross statewide emissions.

The agricultural sector includes manure management, enteric fermentation, agricultural residue burning, and soils management. The forestry sector contributes to overall emissions, but is a net sink of emissions.

The California Global Warming Solutions Act of 2006 (California Assembly Bill 32) requires California to reduce statewide emissions to 1990 levels by 2020.

In December 2007, ARB adopted an emission limit for 2020 of 427 million tons per year of $CO_2$e. Increases in the stateside renewable energy portfolio and reductions in importation of coal-based electrical power will contribute to meeting California's near-term GHG emission reduction goals. The ARB estimates that a reduction of 169 million metric tons net $CO_2$e emissions below business-as-usual would be required by 2020 to meet the 1990 levels (ARB 2007). This amounts to approximately a 30 percent reduction from projected "business-as-usual" levels in 2020.

# 16.5 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in air quality and GHG emissions; results of the impact analysis; potential mitigation measures; and cumulative effects.

## 16.5.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in air quality and GHG emissions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could directly or indirectly change air quality and GHG emissions due to use of engines or electricity that operate groundwater wells, changes in cropping patterns, or odor emissions.

### *16.5.1.1 Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants*

Changes in CVP and SWP operations under the alternatives could change the use of individual engines to operate groundwater wells. The CVHM model is used to evaluate changes in groundwater conditions in the Central Valley, as described in Chapter 7, Groundwater Resources and Groundwater Quality. To evaluate the potential for changes in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants, results from the CVHM model that indicate changes in groundwater withdrawals due to changes in CVP and SWP operations. However, it is not known how many of the groundwater pumps use electricity and how many use diesel engines. The diesel engines have the potential to emit criteria air pollutants and precursors, and toxic air contaminants.

Most of the groundwater wells in the Central Valley use electrical pumps. As reported in a recent environmental assessment, approximately 14 to 15 percent of the pumps used diesel fuel in 2003 (Reclamation 2013a). It is assumed for this EIS, that the portion of groundwater pumps that use electricity would remain approximately at 85 percent. Therefore, it is assumed that increases or decreases in groundwater pumping would be indicative of an increase or decrease in the use of diesel engines in the Central Valley as well as in the San Francisco Bay Area, Central Coast, and Southern California regions. Changes in CVP and SWP operations would not result in changes in groundwater pumping in the Trinity River Region; therefore, this analysis does not address Trinity River Region.

#### *16.5.1.2 Changes in Exposure of Sensitive Receptors to Particulate Matter*

Changes in CVP and SWP operations under the alternatives could change the potential for dust generation on irrigated lands that would be idled due to reduced CVP and SWP water supplies. However, as described in Chapter 12, Agricultural Resources, irrigated acreage under Alternatives 1 through 5 would be similar to irrigated acreage under both the No Action Alternative and the Second Basis of Comparison. Therefore, there would be no change in potential for dust generation. Therefore, these changes are not analyzed in this EIS.

#### *16.5.1.3 Changes in Exposure of Sensitive Receptors to Odor Emissions from Wetlands*

Restoration of seasonal floodplains and tidally-influenced wetlands could result in additional odors at surrounding sensitive receptors near the restoration locations. However, these actions would occur in a similar manner under the No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison, as described in Chapter 3, Description of Alternatives. Therefore, odor emissions would be the same under all of the alternatives and the Second Basis of Comparison. Therefore, this change is not analyzed in this EIS.

#### *16.5.1.4 Changes in GHG Emissions due to Changes in Energy Generation or Use*

Changes in CVP and SWP operations under the alternatives could change CVP and SWP energy generation and use, and the associated GHG emissions. In addition, operational changes could also affect the use of energy by CVP and SWP water users through the implementation of regional and local alternative water supplies, such as recycling or desalination. When CVP and SWP water deliveries decline, CVP and SWP net energy generation changes; and water users are anticipated to increase use of groundwater, recycled water, and/or desalinated water from existing facilities or facilities that are reasonably foreseeable to be constructed by 2030. When CVP and SWP water deliveries increase, CVP and SWP net energy generation would change; and water users are anticipated to reduce use of alternate water supplies either due to economic considerations or to allow the amount of stored water to increase under a conjunctive use pattern. It is not known whether the changes in CVP and SWP net energy generation would be similar to the changes in energy use for alternate regional and local water supplies.

Changes in the timing and magnitude of net CVP and SWP hydropower generation would result in changes in GHG emissions. Increased net CVP and SWP hydropower generation would reduce the need for electricity generated through fossil fuel combustion, and would avoid the GHG emissions that would result from fossil fuel use. In comparison, reduced hydroelectric generation would increase the need for other types of electricity production, including electricity generated from fossil fuels, with the result that GHG emissions would increase.

Potential changes in GHG emissions due to changes in CVP and SWP energy generation or use, and the evaluation of potential for changes in use of energy by CVP and SWP water users to implement alternative water supplies, are analyzed broadly and qualitatively across the overall study area. Some of the changes in energy use and generation will occur across the CVP and SWP system, others may require additional energy resources. Specific locations of the energy sources and users have not been defined.

##### *16.5.1.5 Effects due to Cross Delta Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future air quality conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation

2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 16.5.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to air quality that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *16.5.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in warmer temperatures, more short-duration high-rainfall events, and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling which could result in increased dust generation.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would be required to be implemented in accordance with adopted air quality management plans.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects. These projects would increase energy demand and could be associated with increases in indirect greenhouse gas emissions.

By 2030, more efficient energy use, increases in renewable energy production, and energy conservation are also anticipated to reduce future GHG emissions rates.

Under the No Action Alternative and the Second Basis of Comparison, there are several major variables with varying degrees of uncertainty. These variables include future population growth in the air basins, the extent and emissivity of various emissions sources from existing and future activities, and the success of the local jurisdictions and others in implementing effective air emissions control measures. It is assumed that air quality in 2030 will be similar to the conditions described in the Affected Environment even with population growth because the current air quality management plans were developed with consideration of future growth by at least 2030. It is anticipated that the non-attainment areas will reduce the contaminants to a level of attainment in accordance with adopted air quality management plans. In addition, it is assumed that the California Renewables Portfolio Standard (RPS) will be implemented by 2020. The RPS was established in accordance with California Senate Bill 1078 in 2002, Senate Bill 107 in 2006, and Senate Bill 2 in 2011 to require investor-owned utilities, electric service providers, and community-choice aggregators (e.g., local agencies that purchase or generate electricity for their community) to provide at least 33 percent of their total energy procurement from renewable energy sources by 2020.

Increased groundwater use and related groundwater elevation reductions could occur due to reduction in CVP and SWP water supplies. The increased pumping would increase demand for electricity, and could result indirectly in increases in greenhouse gas emissions. As described above, approximately 15 percent of groundwater pumps rely upon diesel fuels. Increased groundwater pumping could result in increased emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants from increased use of diesel engines.

The No Action Alternative and the Second Basis of Comparison would include restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass. Operation of wetlands restoration projects could result in periodic odors due to anaerobic decomposition of organic matter in portions of the wetlands. As a result, odorous compounds, such as ammonia and hydrogen sulfide, are generated and may be released into the environment. Marshes and wetlands can also be a source of odors during some time periods when ponds or shallow water areas undergo algal or vegetative growth. Marshes, wetlands, shallow water areas, or canals may require periodic maintenance to inhibit algal or vegetative growth, and avoid conditions conducive to anaerobic digestion. The occurrence and severity of odor impacts depend on numerous factors, including the nature, frequency, and intensity of the source; wind speed and direction; and the presence of sensitive receptors. Although odors rarely cause any physical harm, they can still be unpleasant to some individuals.

## 16.5.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

### *16.5.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 16.5.3.1.1 Central Valley Region

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

As described in Chapter 7, Groundwater Resources and Groundwater Quality, groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would increase by 8 percent under the No Action Alternative as compared to the Second Basis of Comparison. It is not known if the additional groundwater pumping would rely upon electricity or diesel to drive the pump engines. Under the worst case analysis, it is assumed that the increased use of diesel engines would be proportional to the increased use of groundwater. Therefore, under the No Action Alternative, there would be a potential increase in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to air quality were identified as increased emissions of air pollutants due to the use of diesel engines for groundwater pumps that were used to provide transfer water through groundwater substitution programs. The analysis indicated that the effects could be reduced to avoid substantial impacts through the use of electric engines or reducing the amount of groundwater substitution. Other identified effects were considered to be not substantial or beneficial as related to crop idling to provide transfer water in the seller's service area; and reduction of groundwater pumping that could use diesel engines or dust generation from crop idled lands in the purchaser's service area.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 16.5.3.1.2 San Francisco Bay Area, Central Coast, and Southern California Regions

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be decreased by 10 percent and 18 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under No Action Alternative as compared to the Second Basis of Comparison. The decrease in surface water supplies could result in additional use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also increased.

#### 16.5.3.1.3 Overall Study Area

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes in CVP and SWP operations under the No Action Alternative as compared to the Second Basis of Comparison would result in a reduction of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use for conveyance would decline. CVP annual net generation would be similar; and SWP net energy generation would increase which could result indirectly in less GHG emissions if the hydropower generation replaces fossil fuel generation.

In addition to changes in CVP and SWP energy generation and use and the associated GHG emissions, CVP and SWP operations under the No Action Alternative as compared to the Second Basis of Comparison could potentially increase use of energy by CVP and SWP water users to implement regional and local alternate water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. These facilities would require energy which could result in increased GHG emissions.

### *16.5.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because CVP and SWP operations conditions under Alternative 1 are identical to conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 16.5.3.2.1 Alternative 1 Compared to the No Action Alternative

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would decrease by 8 percent under Alternative 1 as compared to the No Action Alternative. It is not known if the reduction in groundwater pumping would result in a reduction of the use of electricity or diesel to drive the pump engines. For this analysis, it is assumed that the decreased use of diesel engines would be proportional to the decreased use of groundwater. Therefore, under Alternative 1, there would be a potential decrease in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on air quality would not be substantial due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be increased by 11 percent and 21 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 1 as compared to the No Action Alternative. The increase in surface water supplies could result in the reduction in use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also decreased.

*Overall Study Area*

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes CVP and SWP operations under Alternative 1 as compared to the No Action Alternative would result in an increase of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use for conveyance would increase. CVP annual net generation would be similar, and SWP annual net generation would be decrease over the long-term average conditions. This could result in increased GHG emissions if fossil fuel generation replaces hydropower generation.

In addition to changes in CVP and SWP energy generation and use, and the associated GHG emissions, CVP and SWP operations under Alternative 1 as compared to the No Action Alternative could potentially decrease the use of energy by CVP and SWP water users due to less need to implement regional and local alternative water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. As the need for alternative water supplies is decreased, the associated energy demand and indirect GHG emissions would also be decreased under Alternative 1 as compared to the No Action Alternative.

#### 16.5.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *16.5.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, as described in Chapter 3, Description of Alternatives; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 16.5.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to air quality and GHG emission conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 16.5.3.1, No Action Alternative.

#### *16.5.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 16.5.3.4.1 Alternative 3 Compared to the No Action Alternative

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would decrease by 6 percent under Alternative 3 as compared to the No Action Alternative. It is not known if the reduction in groundwater pumping would result in a reduction of the use of electricity or diesel to drive the pump engines. For this analysis, it is assumed that the decreased use of diesel engines would be proportional to the decreased use of groundwater. Therefore, under Alternative 3, there would be a potential decrease in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on air quality would not be substantial due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be increased by 9 percent and 17 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 3 as compared to the No Action Alternative. The increase in surface water supplies could result in the reduction in use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also decreased.

*Overall Study Area*

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes in CVP and SWP operations under Alternative 3 as compared to the No Action Alternative would result in an increase of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use for conveyance would increase. CVP annual net energy generation would be similar; and SWP annual net energy generation would be less which could result in increased GHG emissions if fossil fuel generation replaces hydropower generation.

In addition to changes in CVP and SWP energy generation and use, and the associated GHG emissions, CVP and SWP operations under Alternative 3 as compared to the No Action Alternative could potentially decrease the use of energy by CVP and SWP water users due to less need to implement regional and local alternative water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. As the need for alternative water supplies is decreased, the associated energy demand and GHG emissions would also be decreased under Alternative 3 as compared to the No Action Alternative.

#### 16.5.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would be similar (within a 5 percent change) under Alternative 3 as compared to the Second Basis of Comparison. Therefore, the emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on air quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies and emissions from diesel engines used for groundwater pumping would be similar in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 3 as compared to the Second Basis of Comparison.

*Overall Study Area*

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes in CVP and SWP operations under Alternative 3 as compared to the Second Basis of Comparison would result in a decrease of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use for conveyance would decrease. CVP annual net energy generation would be similar; and SWP annual net energy generation would be greater which could result in decreased GHG emissions if hydropower generation replaces fossil fuel generation.

In addition to changes in CVP and SWP energy generation and use, and the associated GHG emissions, CVP and SWP operations under Alternative 3 as compared to the Second Basis of Comparison could potentially increase the use of energy by CVP and SWP water users to implement regional and local alternative water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. These facilities would require energy which could indirectly result in increased GHG emissions.

#### *16.5.3.5 Alternative 4*

The air quality and GHG emissions under Alternative 4 would be identical to the air quality and GHG emissions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 16.5.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 is identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in air quality and GHG emissions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 16.5.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### ***16.5.3.6 Alternative 5***

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### **16.5.3.6.1 Alternative 5 Compared to the No Action Alternative**

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would be similar under Alternative 5 as compared to the No Action Alternative. Therefore, the emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants would be similar under Alternative 5 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on air quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies and emissions from diesel engines used for groundwater pumping would be similar in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 5 as compared to the No Action Alternative.

*Overall Study Area*

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes in CVP and SWP operations under Alternative 5 as compared to the No Action Alternative would result in similar CVP and SWP water deliveries to areas located south of the Delta except in April and May when exports would decline. Overall, annual CVP and SWP net energy generation would be similar under Alternative 5 and the No Action Alternative.

In addition to changes in CVP and SWP energy generation and use, and the associated GHG emissions, CVP and SWP operations under Alternative 5 as compared to the No Action Alternative could potentially increase the use of energy by CVP and SWP water users to implement regional and local alternative water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. These facilities would require energy which could indirectly result in increased GHG emissions.

**16.5.3.6.2 Alternative 5 Compared to the Second Basis of Comparison**

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would increase by 8 percent under Alternative 5 as compared to the Second Basis of Comparison. It is not known if the additional groundwater pumping would rely upon electricity or diesel to drive the pump engines. Under the worst case analysis, it is assumed that the increased use of diesel engines would be proportional to the increased use of groundwater. Therefore, under Alternative 5, there would be a potential increase in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to air quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on air quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be decreased by 10 percent and 18 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 5 as compared to the Second Basis of Comparison. The decrease in surface water supplies could result in increased use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also increased.

*Overall Study Area*

*Changes in GHG Emissions due to Changes in Energy Generation or Use*

As described in Chapter 8, Energy, changes in CVP and SWP operations under Alternative 5 as compared to the Second Basis of Comparison would result in a decrease of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use for conveyance would decrease. CVP annual net generation would be similar; and SWP net energy generation would increase which could result indirectly in less GHG emissions if the hydropower generation replaces fossil fuel generation.

In addition to changes in CVP and SWP energy generation and use, and the associated GHG emissions, CVP and SWP operations under Alternative 5 as compared to the Second Basis of Comparison could potentially increase the use of energy by CVP and SWP water users to implement regional and local alternative water supplies, such as increased groundwater pumping and use of recycled water treatment plants and desalination water treatment plants. These facilities would require energy which could indirectly result in increased GHG emissions.

#### 16.5.3.7 Summary of Environmental Consequences

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 16.5 and 16.6.

**Table 16.5 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Decrease potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 11 to 21 percent in the San Francisco Bay Area Region, and by 21 percent in the Central Coast and Southern California regions.<br>Potentially, could indirectly result in an increase of GHG emissions due to a decrease in SWP net energy generation; however, GHG emissions could decrease due to a reduced need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | None needed |
| Alternative 2 | No effects on air quality. | None needed |
| Alternative 3 | Decrease potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 6 percent in the Central Valley, 9 to 17 percent in the San Francisco Bay Area Region, and by 17 percent in the Central Coast and Southern California regions.<br>Potentially, could indirectly result in an increase of GHG emissions due to a decrease in SWP net energy generation; however, GHG emissions could decrease due to a reduced need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | None needed |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 5 | Similar potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.<br>Potentially, could indirectly result in an increase of GHG emissions due to the need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | None needed |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be "similar."

**Table 16.6 Comparison of Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Increase potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Potentially, could indirectly result in a decrease of GHG emissions due to an increase in SWP net energy generation; however, GHG emissions could increase due to the need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | Not considered for this comparison. |
| Alternative 1 | No effects on air quality. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 3 | Similar potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.<br>Potentially, could indirectly result in a decrease of GHG emissions due to an increase in SWP net energy generation; however, GHG emissions could increase due to the need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | Not considered for this comparison. |
| Alternative 4 | No effects on air quality. | Not considered for this comparison. |
| Alternative 5 | Increase potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Potentially, could indirectly result in a decrease of GHG emissions due to an increase in SWP net energy generation; however, GHG emissions could increase due to the need for additional energy for alternative water supplies. The overall changes in GHG emissions are not known at this time because the need for energy use by alternative water supplies is not known at this time. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

#### *16.5.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in changes in air quality. Therefore, there would be no adverse impacts to air quality; and no mitigation measures are required.

#### *16.5.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis considers potential incremental impacts of the alternatives when added to other past and present actions (as described in the Affected Environment section) and reasonably foreseeable future actions (as described in the No Action Alternative section plus cumulative effects) regardless of what agency (federal or non-federal) or person undertakes such actions (40 CFR 1508.7, 1508.25, and 43 CFR 46.115). The quantitative effects of these items are based upon the quantitative comparisons of Alternatives 1 through 5 to the No Action Alternative presented in previous sections of this chapter; and the qualitative cumulative effects of the alternatives are based upon the qualitative comparisons of Alternatives 1 through 5 to the No Action Alternative presented in previous sections of this chapter and the effects of the cumulative actions that are less certain than future actions under the No Action Alternative.

The cumulative effects analysis for Alternatives 1 through 5 for Air Quality issues are summarized in Table 16.7.

**Table 16.7 Summary of Cumulative Effects on Air Quality with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>• Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>• General plans for 2030.<br>• Trinity River Restoration Program.<br>• Central Valley Project Improvement Act programs<br>• Folsom Dam Water Control Manual Update<br>• FERC Relicensing for the Middle Fork of the American River Project<br>• San Joaquin River Restoration Program<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | These effects would be the same under all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce carryover storage in reservoirs and changes in stream flow patterns in a manner that could reduce hydroelectric generation in the summer and fall months which could result in increased use of fossil fuels and indirectly increase GHG emissions for fossil fuel generation and increased use of diesel engines for additional groundwater use.<br>Reduced CVP and SWP water deliveries south of the Delta would reduce CVP and SWP electricity use for conveyance; and could reduce the need for electricity generation using fossil fuels and indirectly reduce GHG emissions.<br>Future water supply projects are anticipated to both improve water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects. However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased energy use could increase use of electricity generation by fossil fuels; which could increase air quality issues and indirectly increase GHG emissions.<br>Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>• Bay-Delta Water Quality Control Plan Update<br>• FERC Relicensing Projects<br>• Bay Delta Conservation Plan (including the California WaterFix alternative)<br>• Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>• El Dorado Water and Power Authority Supplemental Water Rights Project<br>• Sacramento River Water Reliability Project<br>• Semitropic Water Storage District Delta Wetlands<br>• North Bay Aqueduct Alternative Intake<br>• Irrigated Lands Regulatory Program<br>• San Luis Reservoir Low Point Improvement Project<br>• *Westlands Water District v. United States Settlement*<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same under all alternatives.</u><br>Most of the future reasonably foreseeable actions are anticipated to improve water supplies in California to reduce impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth. If CVP and SWP water supply reliability increases, energy use for conveyance of CVP and SWP water supplies also would increase.<br>Some of the future reasonably foreseeable actions are anticipated to potentially reduce CVP and SWP water supply reliability (e.g., Water Quality Control Plan Update and FERC Relicensing Projects).<br>Future water supply projects are anticipated to both improve water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects. However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased use of groundwater pumps would increase energy use. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP | Implementation of No Action Alternative would result in changes stream flows and related changes in hydroelectric generation patterns, and reduced CVP and SWP water supplies as compared to conditions prior to the BOs.<br>If CVP and SWP water supply reliability decreases, energy use for conveyance of CVP and SWP water supplies also would decrease and energy use for alternative water supplies could increase.<br>Increased energy use could increase use of electricity generation by fossil fuels; which could increase air quality issues and indirectly increase GHG emissions. |
| Alternatives 1 and 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions.<br>Increased energy use for CVP and SWP conveyance could increase use of electricity generation by fossil fuels; which could increase air quality issues and indirectly increase GHG emissions. However, decreased energy use for alternative water supplies could decrease use of electricity generation by fossil fuels; which could decrease air quality issues and indirectly decrease GHG emissions as compared to for the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions for energy resources would be the same as for the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions.<br>Increased energy use for CVP and SWP conveyance could increase use of electricity generation by fossil fuels; which could increase air quality issues and indirectly increase GHG emissions. However, decreased energy use for alternative water supplies could decrease use of electricity generation by fossil fuels; which could decrease air quality issues and indirectly decrease GHG emissions as compared to for the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar net CVP and SWP hydroelectric generation, and reduced CVP and SWP water supplies as compared to the No Action Alternative with the added actions.<br>It is anticipated that energy use for alternative water supplies would increase as compared to the No Action Alternative with cumulative effects which could increase air quality issues and indirectly increase GHG emissions as compared to for the No Action Alternative with the added actions. |

# 16.6 References

ARB (California Air Resources Board). 2007. *Draft California Greenhouse Gas Inventory (millions of metric tonnes of $CO_2$ equivalent) – By IPCC Category*. November 19.

ARB (California Air Resources Board). 2010. *Glossary of Air Pollution Terms*. October 19. Site accessed February 4, 2011. http://www.arb.ca.gov/html/gloss.htm.

ARB (California Air Resources Board). 2011a. *Air Basin and County Map Boundaries*. Site accessed February 7, 2011. http://www.arb.ca.gov/desig/adm/basincnty.htm.

ARB (California Air Resources Board). 2011b. *California Map for Local Air District Websites*. Site accessed February 7, 2011. http://www.arb.ca.gov/capcoa/dismap.htm.

ARB (California Air Resources Board). 2011c. *Attachment D, Final Supplement to the AB 32 Scoping Plan Functional Equivalent Document*. August 19.

ARB (California Air Resources Board). 2011d. *iADAM Air Quality Data Statistics*. Site accessed January 26 and 27, 2011. http://www.arb.ca.gov/adam/.

ARB (California Air Resources Board). 2011e. *California's 2000-2009 Greenhouse Gas Emissions Inventory Technical Support Document*. December.

ARB (California Air Resources Board). 2012. *Ambient Air Quality Standards*. June 7.

ARB (California Air Resources Board). 2013a. California Air Basins. Sacramento, California. Site accessed March 6, 2013. http://www.arb.ca.gov/knowzone/basin/basin.swf.

ARB (California Air Resources Board). 2013b. *Ambient Air Quality Standards*. June 4.

ARB (California Air Resources Board). 2014. Final Regulation Order, Area Designations for State Ambient Air Quality Standards. Chapter 1. Air Resources Board. Subchapter 1.5. Air Basins and Air Quality Standards. Article 1.5. Area Pollutant Designations. April 10.

BCDC (Bay Conservation and Development Commission). 2011. *Draft Staff Report. Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*. September 23.

California Climate Change Portal. 2007. *Potential Effects of Global Warming on California Water and Forest Resources*.

DWR (Department of Water Resources). 2006. *Salton Sea Ecosystem Restoration Draft Program Environmental Impact Report*. October.

DWR (Department of Water Resources). 2010. *Model CEQA Climate Change Discussion and Impact Analysis Section, California Department of Water Resources Internal Guidance Document*. *CEQA Climate Change Committee*. January.

IPCC (Intergovernmental Panel on Climate Change). 2007. *Climate Change 2007, The Physical Science Basis*.

NAS (National Academy of Sciences). 2005. *Understanding and Responding to Climate Change, Highlights of National Academies Reports*. October.

Reclamation (Bureau of Reclamation). 2013a. *Environmental Assessment 2013 Water Transfers*. May.

Reclamation (Bureau of Reclamation). 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2013n. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

SJVAPCD (San Joaquin Valley Air Pollution Control District). 2004a. *Agricultural Air Quality Conservation Management Practices for San Joaquin Valley Farms.*

SJVAPCD (San Joaquin Valley Air Pollution Control District). 2004b. *List of Conservation Management Practices*. May 20.

USEPA (U.S. Environmental Protection Agency). 2006. *Terms of the Environment, Glossary, Abbreviations, and Acronyms*. Site accessed February 4, 2011. http://www.epa.gov/OCEPAterms/aterms.html.

USEPA (U.S. Environmental Protection Agency). 2012. *Glossary of Climate Change Terms*. Site accessed December 18, 2012. http://epa.gov/climatechange/glossary.html.

USEPA (U.S. Environmental Protection Agency). 2013. *Currently Designated Nonattainment Areas for All Criteria Pollutant, California, As of December 14, 2012*. Site accessed January 14, 2013. http://www.epa.gov/air/oaqps/greenbk/ancl.html#CALIFORNIA.

USEPA (U.S. Environmental Protection Agency) 2014. *Green Book – Currently Designated Nonattainment Areas for All Criteria Pollutants, As of*

*December 5, 2013*. Site accessed June 02, 2014. http://www.epa.gov/oaqps001/greenbk/ancl.html.

USEPA (U.S. Environmental Protection Agency) 2015a. *General Conformity De Minimis Level*. Site accessed June 7, 2015. http://www.epa.gov/oaqps001/genconform/deminimis.html.

USEPA (U.S. Environmental Protection Agency) 2015b. *Green Book – Currently Designated Nonattainment Areas for All Criteria Pollutants, As of January 30, 2015.*

USGCRP (U.S. Global Change Research Program). 2014. *Climate Change Impacts in the United States*. May.

USGS (U.S. Geological Survey). 2014. *Effects of Climatic Variability and Land Use on American Drylands*. Site accessed June 22, 2014. http://esp.cr.usgs.gov/projects/sw/swdust/salton_sea.html.

Chapter 17

# Cultural Resources

## 17.1 Introduction

Cultural resources are defined as prehistoric and historic archaeological sites, architectural features (e.g., buildings, bridges, flumes, trestles, railroads), and traditional cultural properties. However, the focus of this chapter is more on cultural resources than historic properties.

This chapter describes the known existing cultural resources conditions in the study area and the potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect cultural and historic resources through potential changes in the operation of the Central Valley Project (CVP) and State Water Project (SWP). Changes in CVP and SWP operations could increase the frequency and duration of low-elevation reservoir conditions that would increase the time of exposure of inundated cultural resources within reservoirs that store CVP and SWP water. Changes in CVP and SWP operations also could reduce water supply availability to agricultural lands, and those lands could be subject to land use changes that could increase disturbances of cultural resources if present.

## 17.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect reservoirs, streams, and lands served by CVP and SWP water supplies located on lands with cultural resources. Actions implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 17.3 Affected Environment

This section describes the types of cultural resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in areas with cultural resources due to changes in CVP and SWP operations may occur at reservoirs that store CVP and SWP water and on lands that use CVP and SWP water supplies in the Trinity River, Central Valley, San Francisco Bay Area, and Central Coast and Southern California regions.

## 17.3.1 Prehistoric Context

### *17.3.1.1 Introduction to the Prehistoric Context*

The study area has a long and complex cultural history with distinct regional patterns that extend back more than 11,000 years (Reclamation 1997). The first generally agreed upon evidence for the presence of prehistoric peoples in the study area is represented by the distinctive fluted spear points called Clovis points. These artifacts have been found on the margins of extinct lakes in the San Joaquin Valley. The Clovis points are found on the same surface with the bones of animals that are now extinct, such as mammoths, sloths, and camels. The subsequent period from about 10000 to 8000 BP (before present) was characterized by a small number of sites with stemmed spear points instead of fluted spear points. Approximately 8,000 years ago, many California cultures shifted the main focus of their subsistence strategies from hunting to seed gathering as evidenced by the increase in food-grinding implements found in archaeological sites dating to this period. In the last 3,000 years, the archaeological record becomes more complex as specialized adaptations to locally available resources were developed and populations expanded. Many sites dated to this time period contain mortars and pestles or are associated with bedrock mortars, implying that the occupants exploited acorns intensively. The range of subsistence resources that were used increased, exchange systems expanded, and social stratification and craft specialization occurred as indicated by well-made artifacts such as charm stones and beads, which were often found with burials.

### *17.3.1.2 Prehistory of the Trinity River Region*

The Trinity River Region includes portions of Trinity County including Trinity Lake, Lewiston Reservoir, and Trinity River from Lewiston Reservoir to the Humboldt County boundary (near the eastern boundary of Hoopa Valley Indian Reservation); portions of Humboldt County including the Hoopa Valley Indian Reservation, Trinity River from the Humboldt County border to the Del Norte County border (near the confluence of the Trinity and Klamath rivers); and Del Norte County including the Lower Klamath River from the confluence with the Trinity River to the Pacific Ocean.

The area surrounding the present Trinity Lake and the Trinity River to its confluence with the Klamath River and along the Klamath River to the Pacific Ocean was inhabited by the Wintu, Chimariko, Yurok, and Hupa Indians at the time of Euroamerican contact.

### *17.3.1.3 Prehistory of the Central Valley Region*

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains and includes the Sacramento Valley, San Joaquin Valley, and the Delta and Suisun Marsh areas. The Sacramento Valley and San Joaquin Valley are divided into Eastern and Western subregions.

#### 17.3.1.3.1 Prehistory of the Sacramento Valley

The western Sierra Nevada foothills appear to have been first used by Great Basin people around 8000 BP (Reclamation 1997). By approximately 4000 BP, people possibly from the Great Basin were seasonally hunting and gathering in the Sierra Nevada and the Sacramento Valley.

In the northern western portion of Sacramento Valley, between approximately 12,000 and 150 years ago (12000 to 100 BP), the prehistoric societies of northern California underwent a series of slow but significant changes in subsistence and economic orientation, population densities and distribution, and social organization. These changes are thought to reflect migrations of various peoples into the area and displacement of earlier populations (Jensen and Reed 1980; Farber 1985; Reclamation 1997). Early archaeological investigations within Nomlaki and Wintu ethnographic territory, particularly the present Redding area and adjacent tracts of the southern Klamath Mountains, appear to indicate that human occupation of this area began approximately 1050 to 950 BP.

Little is known of human occupation on the floor of the Sacramento Valley prior to 4500 BP (Reclamation 1997). Because of alluvial and colluvial deposition over the past 10,000 years, ancient cultural deposits have been deeply buried in many areas. Initially, humans appeared to adapt to lakes, marshes, and grasslands environments until approximately 8000 to 7000 BP (Placer County 2007). The earliest evidence of widespread villages and permanent occupation of the lower Sacramento Valley, Delta, and Suisun Marsh areas comes from several sites assigned to the Windmiller Pattern (previously, “Early Horizon”), dated circa 4500 to 2500 BP (Ragir 1972; Reclamation 1997; Reclamation et al. 2010).

From circa 2500 to 1500 BP in the Central Valley area, villages were characterized by deep midden deposits, suggesting intensified occupation and a broadened subsistence base (Reclamation 1997, 2005a; Reclamation et al. 2010; Beardsley 1948; Heizer and Fenenga 1939; Moratto 1984).

During the late prehistoric period from 1500 to 100 BP, development may have been initiated due to the southward expansion of Wintuan populations into the Sacramento Valley (Moratto 1984; Reclamation 1997; Reclamation et al. 2010). The period is characterized by intensified hunting, fishing, and gathering subsistence with larger communities, highly developed trade networks, elaborate ceremonial and mortuary practices, and social stratification.

#### 17.3.1.3.2 Prehistory of the San Joaquin Valley

Evidence of prehistoric occupation of the central and southern Sierra Nevada foothills goes back to 9,500 years ago. The vast majority of investigated sites, however, are less than 500 years old, probably representing a relatively recent proliferation of settlements by Yokut Indians (Moratto 1984; Reclamation 1997). The chronological sequence developed in the south-central Sierra Nevada as a result of the Buchanan Reservoir project in present Madera County is still used as a general framework (Reclamation 1997). Similar findings were identified in major settlement sites along the San Joaquin River and in the present New Melones Reservoir area (Reclamation 2010; Reclamation and DWR 2011).

During the early Holocene period (10,000 to 12,000 years ago), peoples probably inhabited or passed through the San Joaquin Valley; however, few indications of this period have been discovered, probably due to burial beneath accumulated river sediment (Reclamation 1997, 2012). Examples of early Holocene cultural remains are known primarily from the Tulare Basin in the southern San Joaquin Valley. Evidence along the southern shoreline of the ancient Tulare Lake indicates that human presence may have occurred from 11000 BP (Reclamation and State Parks 2013).

From approximately 1650 to 950 BP, there is evidence that the people of the eastern San Joaquin Valley may have interacted with people in the Delta area (Reclamation 1997, 2012).

From approximately 450 to 100 BP, the people of the eastern San Joaquin Valley may have interacted with people in the Central Coast and Southern California areas. Material found in Pacheco to Panoche strata indicates a trade relationship with people of the Delta, Central Coast, and Southern California regions (Moratto 1984; Reclamation 1997, 2012).

#### *17.3.1.4 Prehistory of the San Francisco Bay Area Region*

The San Francisco Bay Area Region only includes portions of the Bay Area that could be affected through implementation of the alternatives considered in this EIS, which includes Contra Costa, Alameda, Santa Clara, and San Benito counties. The prehistory context is different throughout the San Francisco Bay Area Region. Human occupation in the northern valley regions of present San Benito County occurred as described above for the western San Joaquin Valley (San Benito County 2010).

Human occupation in the coastal regions of present Contra Costa and Alameda counties occurred as described above for the southern portion of the Sacramento Valley (Reclamation 1997; DWR 2008; Zone 7 2006). From 5000 to 2500 BP, dense settlements extended from the coastal marshes to interior grasslands and woodlands (Zone 7 2006). From about 2500 to 950 BP, coastal communities relied upon shellfish, and major shellmounds were created near these communities, including near the present Alameda County shorelines and some interior valleys.

Settlement of the interior valleys of the present Contra Costa, Alameda, and Santa Clara counties occurred during the past 12,000 years. From 6000 to 1700 BP, settlements occurred, as there was less emphasis on nomadic hunting for large animals and increased emphasis on the use of plant materials and hunting, fishing, and shellfish collection (Santa Clara County 2012; CCWD et al. 2009). The communities established economies and traded between the communities.

#### 17.3.1.5 Prehistory of the Central Coast Region

The prehistory of the Central Coast Region for this EIS (present day San Luis Obispo and Santa Barbara counties) is poorly known but may have begun around 11000 BP and probably represents mobile hunter-gatherers (Reclamation 1997; San Luis Obispo County 2010; Santa Barbara 2010). Fishing, intensive shellfish collecting, and hunting began around 9000 BP. Use of milling stones and establishment of communities occurred after about 8500 BP. After about 5000 BP, there was greater reliance on hunting of land and sea mammals, gathering of shellfish, and use of mortars and pestles. Subsequently, larger settlements occurred for ethnographically known peoples, including the Chumash.

#### 17.3.1.6 Prehistory of the Southern California Region

The Southern California Region includes the present Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties, which have substantially different prehistory characteristics.

In the coastal areas of the Southern California Region (present Ventura, Los Angeles, Orange, and San Diego counties), early habitation extends over 12,000 years ago (Ventura County 2005; Los Angeles 2005; San Diego County 2011b). Between 12000 and 7500 BP, the inhabitants were hunter-gatherer populations that used land and marine resources. The population along the northern coast of Southern California began expanding between 9000 and 8500 BP. Permanent coastal settlements expanded as plants, shellfish, and marine mammals became a large part of the subsistence (Glassow et al. 2007; Los Angeles 2005). From 5000 to 450 BP, the use of plant materials and exploitation of fish and sea mammals increased sedentism and socioeconomic interaction (Glassow 1999; Los Angeles 2005; San Diego County 2011b).

The interior area within the Southern California Region considered in this EIS includes portions of Riverside and San Bernardino counties that use SWP water supplies, including the Mojave Desert and the Peninsular Ranges.

Clovis (circa 12000 to 10000 BP) is the only cultural complex dating from the Pleistocene that can be consistently identified in the Mojave Desert (Sutton et al. 2007). The Clovis culture characteristics appear to be associated with Paleo-Indian groups as big game hunters. More recently, there have been indications that the people had greater cultural and economic diversity than previously recognized (CDFG 2009). Paleo-Indian groups were likely small, highly mobile populations living in small, temporary camps near permanent water sources (Sutton et al. 2007).

From 10000 and 8000 BP, communities were organized around relatively small social units (Sutton et al. 2007; Riverside County 2000). From 7000 to 4000 BP, hunting continued while foraging subsistence transformed during this period to more collection of plant and animal materials within adjacent ecological zones (CDFG 2009; Riverside County 2000; Sutton et al. 2007). Between 4000 and 1750 BP, permanent seasonally occupied settlements occurred in the lower valley with the use of oak woodlands and mesquite groves (Riverside County 2000; Sutton et al. 2007).

From 1750 to 850 BP, communities increased and trade between communities expanded (CDFG 2009; Gardner 2002, 2006; Riverside County 2000; Sutton et al. 2007; Sutton 1988, 1996; Warren and Crabtree 1986). During this period, the lower Coloradan culture became more prevalent along the shoreline of the Lake Cahuilla area (site of the present Salton Sea and Coachella Valley Water District) (Riverside County 2000). The lower Coloradans relied upon shellfish, fish, aquatic birds, marsh and riparian vegetation, and mammals. The culture may have been influenced by the Anasazi settlements of present Southern Nevada, including cultivation of corns, beans, and squash. The Anasazi people also occupied portions of present San Bernardino County where turquoise was mined. Extensive trading occurred between the people in the inland areas and the people along the coast.

After about 850 BP, populations appeared to decline, and several cultural complexes emerged (Sutton et al. 2007). Late Prehistoric occupation sites were based on hunting and gathering, especially of plant foods and small game (Riverside County 2000). Villages in Antelope Valley began to disappear in the later prehistoric times, probably due to the disappearance of lakes that were the headwaters of the Mojave River or changes in trade route locations (DWR 2009). Lake Cahuilla declined around 450 BP and the large populations dispersed to the Colorado River, western Peninsular Ranges in present western Riverside County, and the Pacific Ocean coast (Riverside County 2000).

## 17.3.2 Ethnographic Context

### *17.3.2.1 Introduction to Ethnographic Context*

This section provides brief ethnographic sketches for each native cultural group whose traditional territories are within the study area. Each ethnographic sketch presents the territorial limits of each respective cultural group and then focuses mainly on those aspects of culture that are potentially represented in the archaeological record.

The study area encompasses lands occupied by more than 40 distinct Native American cultural groups. Although most California tribes shared similar elements of social organization and material culture, linguistic affiliation and territorial boundaries primarily distinguish them from each other. Before European settlement of California, an estimated 310,000 native Californians spoke dialects of as many as 80 mutually unintelligible languages representing six major North American language stocks (Cook 1978; Moratto 1984; Reclamation 1997; Shipley 1978).

### *17.3.2.2 Ethnography of the Trinity River Region*

The Trinity River Region includes portions of Shasta, Trinity, Siskiyou, Humboldt, and Del Norte counties. This area is bounded by the Sacramento River on the east, the Pacific Ocean on the west, and the middle and upper Klamath Basin on the north. The ethnography of the Yurok, Hupa, Wintu, and Chimariko is described below.

#### 17.3.2.2.1 Yurok

The Yurok inhabited California's northwestern coastline from Little River to Damnation Creek; along the Klamath River from the confluence with the Pacific Ocean up past the Klamath-Trinity confluence to Slate Creek; and approximately 6 miles along the Trinity River upstream of the confluence with the Klamath River (Pilling 1978; USFWS et al. 1999). The Yurok life, communities, society, and ceremonies are deeply connected with the Klamath River (DOI and CDFG 2012). Yurok culture and traditional stories describe that the Klamath River was created to facilitate the interaction with two neighboring people, the Hupa and the Karuk, and with the salmon that lived in the Klamath River. Both the Hupa and Karuk culture and traditional stories also describe this close interaction of the peoples, salmon, and Klamath River.

Yurok are recognized for their highly stylized art forms and their skills in making redwood canoes, weaving fine baskets, hunting, and especially riverine salmon fishing. The ancient traditions are continued through contemporary times (USFWS et al. 1999). The redwood canoes for ocean conditions can be 30 to 40 feet in length, designed to haul large amounts of fish and seal carcasses, and paddled by 5 to 20 paddlers (DOI and CDFG 2012). The canoes are used to gather food and materials, transport people and materials, and for ceremonial aspects of the Yurok culture. The Jump and Deerskin ceremonies are held in late fall to give thanks for abundant food supplies. The Deerskin Ceremony includes a Boat Ceremony in which the participants travel down the Klamath River to thank the river for continuing to flow and provide resources.

#### 17.3.2.2.2 Hupa

The Hupa inhabited the area surrounding the lower reaches of the Trinity River from approximately Salyer to approximately 6 miles upstream from the confluence with the Klamath River (Wallace 1978a; USFWS et al. 1999). Hupa life is defined by extended families affiliated with villages.

The Hupa believe that the Klamath and Trinity rivers were created to provide interaction with other peoples (Yurok and Karuk) and with the salmon (DOI and CDFG 2012). Many of the Hupa ceremonies highlight their relationship with the rivers, including world renewal ceremonies and ceremonies for bountiful harvests. The world renewal ceremonies include the White Deerskin and Jump ceremonies to honor the earth and the creator for providing food and other resources. The ceremonies for bountiful harvest of fish and acorns include the First Salmon ceremony and the Acorn Feast.

#### 17.3.2.2.3 Wintu

When the Europeans and Americans first explored California, most of the western side of the Sacramento Valley north of about Suisun Bay was inhabited by Wintun-speaking people (USFWS et al. 1999). Early in the anthropological study of the region, a linguistic and cultural distinction was recognized between the Wintun-speaking people in the southwestern Central Valley (the Patwin) and the people occupying the northwestern Central Valley and Trinity River Valley (LaPena 1978; USFWS et al. 1999).

#### 17.3.2.2.4 Chimariko

The Chimariko lived in a 20-mile-long reach of the Trinity River from approximately Big Bar to the confluence with the South Fork (Silver 1978a; USFWS et al. 1999). Although the Chimariko language is now extinct, early ethnographers recorded some words, and the language is thought to be of Hokan stock.

### *17.3.2.3 Ethnography of the Central Valley Region*

#### 17.3.2.3.1 Ethnography of the Sacramento Valley

*Maidu, Konkow, and Nisenan*

Maidu (also known as northeastern Maidu), Konkow (also known as northwestern Maidu), and Nisenan (also known as southern Maidu) inhabited an area of California from Lassen Peak to the Cosumnes River, and from the Sacramento River to Honey Lake (Reclamation 1997; Shipley 1978). Northeastern Maidu territory extended from Lassen Peak on the west to Honey Lake on the east, Sierra Buttes on the south, and Eagle Lake on the north. The Konkow inhabited the region from the Lower Feather River in the north, to the Sutter Buttes in the south, and to the west beyond the Sacramento River. The Nisenan lived in the area east of the Sacramento River and along the Middle Fork Feather River, Bear River, American River, and Cosumnes River from the Sacramento River almost to Lake Tahoe (Riddell 1978; Wilson and Towne 1978; Reclamation 1997, 2005b).

*Yana*

The Yana of north-central California inhabited an area from Lassen Peak and the southern Cascade foothills on the east, Rock Creek on the south, Pit River on the north, and the eastern bank of the Sacramento River on the west. The western boundary is the most uncertain (J. Johnson 1978a; Reclamation 1997).

*Achumawi, Atsugewi, and Shasta*

The Achumawi and Atsugewi of northeastern California are two linguistically and culturally distinct but related groups (Reclamation 1997). The Achumawi and Atsugewi languages belong to the Palaihnihan family, or Hokan stock. The territory of the Achumawi extended generally to Mount Lassen, west to Mount Shasta, northeast to Goose Lake, and east to the Warner Range (Kroeber 1925; Olmsted and Stewart 1978; Garth 1978; Reclamation 1997). Overlapping this area to some extent, the Atsugewi territory ranged from Mount Lassen in the southwest, the Pit River in the north, and Horse Lake to the east.

The Shasta peoples were originally thought to be associated with the Achumawi and Atsugewi but then were considered as a separate group (Kroeber 1925; Reclamation 1997; Shipley 1978). The Shasta peoples inhabited the area from southern Oregon at the Rogue River, south to the present Cecilville, and the area between the Marble and Salmon mountains to Mount Shasta in the west and the

Cascade Range in the east. In California, the core areas of settlement were in Shasta Valley, Scotts Valley, and along the Klamath River from about Scotts River to the town of Hornbrook (Silver 1978b).

*Plains Miwok*

The Plains Miwok established villages along river courses in the foothills located east of Sacramento and the Delta (Reclamation 2005b).

*Nomlaki*

Two major divisions existed among the Nomlaki: the River and Hill Nomlaki (Goldschmidt 1978; DuBois 1935; Reclamation 1997). The River Nomlaki occupied the Sacramento River Valley in present eastern Tehama County. The Hill Nomlaki occupied the eastern side of the Coast Ranges in present Tehama and Glenn counties. The Nomlaki and Wintu conducted trading between the peoples (Goldschmidt 1978; DuBois 1935; Reclamation 1997).

*Patwin*

The Patwin lived along the western side of the Sacramento Valley from the present Princeton to Benicia, including Suisun Marsh (Kroeber 1925; Reclamation 1997; Reclamation et al. 2010). Within this large area, the Patwin have traditionally been divided into River, Hill, and Southern Patwin groups. Settlements generally were located on high ground along the Sacramento River or tributary streams, or in the eastern Coast Range valleys. The ethnographically recorded villages of Aguasto and Suisun were located near San Pablo and Suisun bays (P. Johnson 1978b; Reclamation 1997; Reclamation et al. 2010).

#### 17.3.2.3.2 Ethnography of the San Joaquin Valley

*Eastern Miwok*

The Miwok cultures in present California include the Coast Miwok, Lake Miwok, and Eastern Miwok divisions. The Eastern Miwok included five separate groups (Bay, Plains, Northern Sierra, Central Sierra, and Southern Sierra) that inhabited the area from present Walnut Creek in Contra Costa County and the Delta, along the lower Mokelumne and Cosumnes rivers and along the Sacramento River from present Rio Vista to Freeport, the foothill and mountain areas of the upper Mokelumne River and Calaveras River watersheds, the upper Stanislaus River and Tuolumne River watersheds, and the upper Merced River and Chowchilla River watersheds, respectively (Levy 1978a; Reclamation 1997; Shipley 1978). No one Miwok tribal organization encompassed all the peoples speaking Miwokan languages, nor was there a single tribal organization that encompassed an entire division.

*Yokuts*

Yokuts are a large and diverse number of people in the San Joaquin Valley and Sierra Nevada foothills of central California, including the Southern San Joaquin Valley Yokuts, Northern San Joaquin Valley Yokuts, and Foothill Yokuts (Reclamation 1997; Reclamation et al. 2011a; SJRRP 2011). The three subdivisions of the Yokuts languages belong to the Yokutsan family, or Penutian stock (Shipley 1978).

The Southern Valley Yokuts inhabited the southern San Joaquin Valley from present Fresno to the Tehachapi Mountains (Wallace 1978b). The Northern Valley Yokuts inhabited the northern San Joaquin Valley from Bear Creek to the San Joaquin River near present Mendota, western San Joaquin Valley near present San Luis Reservoir, and eastern present Contra Costa and Alameda counties (ECCCHCPA et al. 2006; Wallace 1978c; Reclamation and State Parks 2012; Reclamation and DWR 2011). The Foothill Yokuts inhabited the western slopes of the Sierra Nevada foothills from the Fresno River to the Kern River (Spier 1978b; Reclamation and State Parks 2013). Yokuts were mobile hunters and gatherers with semipermanent villages and seasonal travel corridors to food sources.

The Yokuts probably traded with the Costanoan people from the coastal areas based upon the abalone and other mussel shells found in settlement sites (Reclamation and State Parks 2012).

*Dumna and Kechayi*

The Dumna and Kechayi lived along the San Joaquin River in the Sierra Nevada foothills near the present Millerton Lake (Reclamation and State Parks 2013).

### *17.3.2.4 Ethnography of the San Francisco Bay Area Region*

Native inhabitants of the San Francisco Bay Area Region include the Miwok, Cholvon Northern Valley Yokuts, and the Costanoan Indians (Reclamation 1997; CCWD et al. 2009; ECCCHCPA et al. 2006; EBMUD 2009; Reclamation 2005b; Santa Clara County 2012; San Benito County 2013).

#### 17.3.2.4.1 Miwok

In the San Francisco Bay Area Region, the Coast Miwok people lived along lower San Joaquin River and San Pablo Bay and in the interior of the present Contra Costa and Alameda counties (Reclamation 1997; ECCCHCPA et al. 2006; Kelly 1978). The Bay Miwok villages were located in the San Ramon Valley with other settlements on the western slopes of the Diablo Range. The Volvons, speakers of the Bay Miwok language, settled along Marsh Creek and Kellogg Creek on the northern side of the Diablo Range and near the present Los Vaqueros Reservoir (CCWD et al. 2009). The Miwok people may have held lands at the peak of Mount Diablo.

#### 17.3.2.4.2 Costanoan

The Costanoans (also known as Ohlone) are a linguistically defined group with several autonomous tribelets that speak related languages (Levy 1978b; Reclamation 1997; EBMUD 2009; Zone 7 2006; Santa Clara County 2012). The Costanoans inhabited coastal shorelines along San Francisco, San Pablo, and Suisun Bay and along the Pacific Ocean Coast from the Golden Gate to Monterey Bay and interior valleys that extended approximately 60 miles inland, including areas within Santa Clara and San Benito counties (Reclamation 1997; ECCCHCPA et al. 2006; San Benito County 2010).

#### *17.3.2.5 Ethnography of the Central Coast Region*

The Central Coast Region considered in this EIS includes the coastal areas of present San Luis Obispo and Ventura counties. This area was home to the Salinan, Chumash, and Tataviam people.

The Salinan territory extends from about the present location of Soledad (Monterey County) to San Luis Obispo (Hester 1978). The Chumash are considered to have been one of the most elaborate cultures in California. The Chumash culture is characterized by large villages with social ranking, intensive trade, craft specialization, and well-developed art styles (Grant 1978b; Greenwood 1978; Kroeber 1925; Moratto 1984; Reclamation 1997; San Luis Obispo County 2010; Santa Barbara 2010; Santa Barbara County 2010). The Chumash inhabited the central coastal area of California from approximately present San Luis Obispo to Malibu Canyon and inland to western San Joaquin Valley.

#### *17.3.2.6 Ethnography of the Southern California Region*

The coastal portion of the Southern California Region considered in this EIS includes the present Ventura, Los Angeles, Orange, and San Diego counties. The interior portion of the Southern California Region includes the present western and central Riverside County and western San Bernardino County.

##### 17.3.2.6.1 Prehistory of Southern California Region, Coastal Portion

The Chumash and Tataviam people lived in the present Ventura County and northern Los Angeles County areas. The ethnography of the Chumash people is similar to that described above for the Central Coast Region. The Tataviam people lived inland of the Chumash and Gabrielino on the upper reaches of the Santa Clara River drainage east of Piru Creek and extending over the Sawmill Mountains to the edge of the southwestern Antelope Valley (King and Blackburn 1978).

The Gabrielino and Juaneño people lived in the present Los Angeles and Orange counties areas. The Gabrielino (also known as Gabrielino Tongva or Gabrieleño) occupied the Southern California coast in the vicinity around Mission San Gabrielal areas. The Juaneño occupied the area around the mission (Bean and Smith 1978; Los Angeles 2005; Riverside County 2000). These people traded with other people in Southern California.

The Luiseño and Tipai-Ipai people lived in the present Orange and San Diego counties areas. The Luiseño occupied most of the San Luis Rey and Santa Margarita River drainages near San Luis Rey Mission (Bean and Shipek 1978). The Luiseño shared many cultural traits with the Gabrielino and Chumas people. The Tipai-Ipai (also known as Kumeyaay) occupied extreme Southern California and Northern Baja California in autonomous, seminomadic bands of patrilineal clans (Luomala 1978; San Diego County 2011b; CDFG 2009). The Ipai occupied the areas north of the San Diego River, and the Tipai occupied the area south of the San Diego River (San Diego County 2011b).

#### 17.3.2.6.2 Prehistory of Southern California Region, Interior Portion

The Cahuilla, Serrano, Tubatalabal, Kawaiisu, and Quechan people lived in present Riverside, eastern Los Angeles, southeastern Kern, and western San Bernardino counties. The Tubatalabal also lived in the southeastern San Joaquin Valley in present southeastern Kern County.

*Cahuilla*

The Cahuilla lived inland within present Riverside County. Villages were located in canyons or on alluvial fans close to food and water sources. The Cahuilla interacted frequently with other people in Southern California (Bean 1978; Riverside County 2000).

*Serrano*

The Serrano lived in the San Bernardino Mountains within present northeastern Los Angeles County and southwestern San Bernardino County and in the northwestern valleys and mountains of Riverside County. Villages were located close to food and water sources along perennial streams and lakes. The Serrano interacted frequently with other people in Southern California (Riverside County 2000; DWR 2009).

*Kawaiisu*

The Kawaiisu occupied a mountainous area between the Mojave Desert and the southern San Joaquin Valley, mostly in Kern County, and the Tehachapi Valley (Zigmond 1986; California State Parks 2014). The Kawaiisu lived in permanent winter villages and traveled during the warmer months into the Mojave Desert and Antelope Valley. They traded and interacted with neighboring groups, including the Chumash, Yokuts, and Tubatalabal people.

*Quechan*

The Quechan were Yuman people that occupied areas along the Colorado River and adjacent valleys, including present Coachella and Imperial valleys (Riverside County 2000). The Quechan had a strong tribal identity and traveled extensively for trade.

## 17.3.3 Historical Context

The historical context presented in this section is focused on historical activities and resources that affected and/or were affected by implementation of water resource actions of CVP and SWP water users. Changes in CVP and SWP operations under implementation of alternatives considered in this EIS could not only affect CVP and SWP facilities. These changes also could affect regional and local water supplies, reservoirs, and associated land uses of those that use CVP and SWP water.

### *17.3.3.1 Introduction to Historical Context*

Initial contact with Europeans and Americans occurred with Spanish missionaries and soldiers, who entered California from the south in 1769, eventually founding 21 missions along the California coast (Reclamation 1997). This period is characterized by the establishment of missions and military presidios, the development of large tracts of land owned by the missions, and subjugation of the local Indian population for labor. This way of life began to change in 1822 when Mexico became independent of Spain. The mission lands were divided by government grants into large ranchos often consisting of tens of thousands of acres. The owners of these large *estancias* built homes, often of adobe, and maintained large herds of cattle and horses.

During the Spanish and Mexican periods, explorers entered the region. Fort Ross on the Sonoma coast was established by the Russians from 1812 until 1841 to support hunting, fishing, and whaling businesses (Reclamation 1997). American explorer Jedediah Smith and Peter Skene Odgen, Chief Trader for the Hudson Bay Company, with other members of the Hudson Bay Company also came to California during this period.

In 1848, the Treaty of Guadalupe Hidalgo transferred the lands of California from the Mexican Republic to the United States and initiated what is called the American Period in California history (Reclamation 1997). During that same year, gold was discovered in the foothills of the Sierra Nevada, and thousands of hopeful miners as well as storekeepers, settlers, and farmers entered the region. Mining in the Trinity River Region was expanded for both gold and copper mines (Placer County 2007).

To support this growth, extensive transportation systems were created to support wagon routes, steamboats on the major rivers, and numerous railroads (Reclamation 1997). Many of the supply centers and shipment points along these transportation corridors developed into cities, towns, and settlements. Logging and ranching also expanded to meet the needs of the new settlers. American ranchers found Central California ideally suited for grazing large herds of stock. During the latter part of the 19th century, American ranchers amassed large tracts of former rancho land, and several great cattle empires were formed. As settlements grew, farming increased. A primary constraint to expansion of crop diversity and areas under cultivation was the lack of water. Irrigation was virtually unknown in California until the 1880s, when large-scale irrigation systems were developed to improve agriculture yields. With the development of irrigation and improved transportation, new crops were added to the grains obtained from dry farming, including vegetables, fruits, and nuts.

Irrigation capabilities further expanded in the 1950s and 1960s with the implementation of multiple water projects. The availability of water also expanded the agricultural and urban water supplies in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

#### *17.3.3.2 History of the Trinity River Region*

Explorers from the Philippines and Europe may have visited and interacted with the Yurok people as early as the late 1700s. Peter Skene Odgen and Jedediah Smith initially visited the Lower and Middle Klamath River reaches in the 1820s. In 1828, Jedediah Smith and his party of explorers were the first white men known to have visited the Trinity River watershed (USFWS et al. 1999).

Although the area was first used extensively by trappers, gold was discovered on the Trinity River in 1848, and by the late 1840s, gold mining was a major activity along the Trinity River (Hoover et al. 1990; Del Norte County 2003; USFWS et al. 1999). Weaverville was the center of gold mining activity after 1849 with numerous mining camps and settlements along the Trinity River. Mining continued along the Trinity River through the early and mid-1900s with large-scale dragline and bucket dredging operations beginning in 1939. Logging has occurred since the 1880s and continues in the Trinity River Region. These activities resulted in significant changes to rivers and may have caused the destruction of many prehistoric or historic archaeological sites (Hoover et al. 1990).

Increased activities within the Trinity River Region led to conflicts between the new residents and the Yurok and Hupa people. On November 16, 1855, the Klamath Indian Reservation was established by Executive Order for lands from the mouth of the Klamath River to a location upstream of Tectah Creek that extended 1 mile wide on either side of the river for the approximately 20-mile reach (DOI and CDFG 2012). The Hoopa Valley Reservation was established in 1864 and expanded in 1891 to include lands from the mouth of the Klamath River to the Hoopa Valley that extended 1 mile wide on either side of the river including portions of the Klamath Indian Reservation. In 1988, the Hoopa-Yurok Settlement Act (Public Law 100-580) partitioned portions of the previously established reservations into the Yurok Indian Reservation and Hoopa Valley Reservation and established the Resighini Rancheria.

### *17.3.3.3 History of the Central Valley Region*

#### 17.3.3.3.1 History of the Sacramento Valley

Europeans, Americans, and Canadians may have initially entered the Sacramento Valley in the late 1700s and early 1800s as part of missionary or military expeditions (Reclamation 1997, 2005a; Reclamation et al. 2006; Placer County 2007). By 1776, Jose Canizares explored areas located south of the present Sacramento community, and in 1813, there was a major battle between the Spanish and the Miwok people near the confluence of the Cosumnes River along the Sacramento River. Fur trappers moved through this area from the 1820s to 1840s.

The first settlements in this area occurred in the 1830s and 1840s on Mexican Land Grants. The New Helvetica Land Grant, which included more than 40,000 acres in the Sacramento Valley, was awarded to John Sutter in 1841 (DSC 2011).

Following the discovery of gold on the New Helvetica Land Grant in 1848 near present-day Coloma, numerous mining-related settlements were established in areas with the Nisenan, Maidu, Konkow, and Atsugewi people in the eastern portion of the Sacramento Valley and in areas with the Nomlaki and Wintu people in the western Sacramento Valley. Many of the Native Americans died after exposure to diseases from the new settlers, including malaria. Numerous other Native American died during battles against the new settlers.

Mining activities in the northern Sacramento Valley foothills and mountains near present Redding primarily were related to gold and copper (Reclamation 2013a). Mining activities in the central Sierra Nevada foothills primarily were related to gold. In 1848, mining started along the Trinity River and upper Sacramento River tributaries, primarily for copper and gold (Reclamation 2013a; Reclamation et al. 2006). Smelters, mills, and communities grew rapidly near the mining areas, including the town of Keswick, and communities were established within and adjacent to the present day Folsom Lake. The development of hydraulic mining in 1851 required establishment of substantial water diversions, flumes, and ditches to convey the water and displacement of vast amounts of sediment into the streams and along the banks of the waterways.

Logging also was a dominant industry in the western Sacramento Valley since the 1850s (Reclamation 1997, 2013a). The logging industry grew as the railroads were extended. Establishment of logging in the Sierra Nevada foothills and mountains also led to development of water infrastructure to move and/or mill the logs. One of the first water system infrastructures developed for these purposes was the original Folsom Dam constructed in 1893 (Reclamation et al. 2006).

Agricultural activities were successful throughout the Sacramento Valley to serve the mining communities (Reclamation 1997). The completion of the first transcontinental railroad in 1869 increased the number of settlers and allowed transport of crops from the Sacramento Valley to Nevada, Utah, and subsequently to other areas of the nation (Reclamation 2005b). The expanded agricultural markets expanded due to the establishment and development of commercial crops, accessibility to markets, and new farming techniques and irrigation.

Construction of hydroelectric power and water storage facilities in the Sacramento Valley foothills started in the early 1900s to provide hydropower and water supplies to local and regional users, as well as export to other portions of the state using CVP, SWP, City and County of San Francisco, and East Bay Municipal Utility District facilities.

#### 17.3.3.3.2 History of the San Joaquin Valley

The San Joaquin Valley area was not widely settled by Europeans or Mexicans when California lands were under Spanish rule (1769 to 1821) or Mexican rule (1821 to 1848). Numerous expeditions travelled through the San Joaquin Valley during this period but did not establish major settlements (Reclamation 2010). During the Spanish rule, several settlements occurred along Fresno Slough (Reclamation and State Parks 2012; Reclamation and DWR 2011). There were several settlements along the San Joaquin River and along the western boundary of the San Joaquin Valley during Mexican rule when ranches were established in the Coast Range foothills, including in Pacheco Pass and along Los Banos Creek.

In the latter half of the 19th century, agricultural settlements and mining camps were established in the San Joaquin Valley along the railroad corridors

(Reclamation 1997; Reclamation and DWR 2011). The town of Rootville, subsequently renamed Millerton in honor of Major Miller, was established near the present Millerton Lake with a military post, Camp Barbour (later named Fort Miller) to maintain order in the mining camps.

Initially, agricultural activities were related to ranching and dry farming. Livestock ranching expanded in the late 1860s (Reclamation et al. 2011b). With the increased availability of electric pumps, groundwater and surface water irrigation was used throughout the valley. Many irrigation districts were formed after the passage of the Wright Act in 1877 that provided methods to finance major irrigation projects. One of the first irrigation systems constructed in the eastern San Joaquin Valley was the "Main Canal" as part of the Miller and Lux's San Joaquin and Kings River Canal and Irrigation Company (Reclamation and State Parks 2013).

Historic resources are related to the settlement of the valley and include homesteads, transportation infrastructure (such as ship landings, ferry ports, and bridges), food processing and other industrial facilities, residential properties, commercial establishments, mining features (in the eastern portion), and government facilities (Reclamation 1997, 2010; Reclamation and DWR 2011).

#### 17.3.3.3.3 History of the Delta and Suisun Marsh

Communities were not established in the Delta and Suisun Marsh areas until the mid-1800s. There were numerous Spanish expeditions under Spanish rule. In the 1830s and 1840s, Mexico established land grants, including Rancho Suisun located west of present City of Fairfield (Reclamation et al. 2010).

Following the discovery of gold in the Sacramento Valley, settlements occurred in the Delta to provide support services and agricultural products for those traveling to the gold fields and the Sacramento and San Francisco areas. Passage of the Swamp and Overflow Act in 1850 led to the transfer of lands from the U.S. Government in the Delta to the State of California, which subsequently sold the land to individuals. The new settlers in the Delta constructed levees to protect the lands from periodic flooding and drained other lands to reduce the potential for mosquito-borne diseases. By the 1920s, numerous communities were established around food processing and packing houses that supported a wide range of crops such as asparagus, barley, celery, corn, winter grain, sugar beets, onions, and alfalfa for local dairy farms were introduced to the area (DSC 2011; Reclamation et al. 2010). By the 1950s, major food packers and processors moved from the Delta, and many communities became smaller. Recreational opportunities were established in the 1850s with duck hunting opportunities in the Suisun Marsh area.

### *17.3.3.4 History of the San Francisco Bay Area Region*

In 1579, Sir Francis Drake and other Spanish explorers led expeditions into the San Francisco Bay Area. However, in general, the Spanish did not settle Northern California until the 1700s when other Europeans established trading settlements for fur, mining, and other products. Initially, the Spanish confined their settlement to the coastline to establish military bases, or presidios (Hoover et al. 1990). Father Junipero Serra and other Franciscans worked with the Spanish explorers to establish missions along the Alta California coastal areas between present Sonoma County (San Francisco Solano established in 1823) to present Ventura County (San Buenaventura established in 1782), including three missions in areas that use CVP and SWP water (Mission San Jose established in 1797, Mission Santa Clara established in 1777, and Mission San Juan Bautista established in 1797).

San Jose was one the first towns established in Alta California as Pueblo de San José de Guadalupe (Santa Clara County 2012). The Spanish government awarded land grants in the San Francisco Bay Area Region (DWR 2008; EBMUD 2009; Hoover et al. 1990; Reclamation 2005b; San Benito County 2010; Zone 7 2006). In 1821, Mexico won independence from Spain, began to establish more secular communities around the missions, and divided many of the ranchos into smaller pueblos (Santa Clara County 2012). These actions supported growth in the present California coastal areas.

Following California statehood in 1849, ranching and farming communities were established in the interior valleys of the San Francisco Bay Area Region (Santa Clara County 2012; CCWD et al. 2009; ECCCHCPA et al. 2006). Starting in the late 1800s, expansion of the railroads in the area and use of improved irrigation systems led to the expansion of agriculture throughout the area. In mid-1900s, industrial expansion occurred in Contra Costa, Alameda, and Santa Clara counties.

#### *17.3.3.5 History of the Central Coast Region*

In 1542, Portuguese explorer Juan Rodríguez Cabrillo entered Santa Barbara Harbor (Puerto de Santa Bárbara). In 1587, Pedro de Unamuno brought his ship into Morro Bay, explored inland to the present site of the City of San Luis Obispo, and claimed the area for Spain. In 1595, Sebastián Rodríguez Cermeño entered San Luis Obispo Bay (Hoover et al. 1990). The explorations laid the foundation for the founding of five missions in the Central Coast Region considered in this EIS. Ranchos were granted throughout the region in the 1830s and 1840s.

Following the California statehood, ranching and farming continued to be the main economic activity of the Central Coast Region to the present.

#### *17.3.3.6 History of the Southern California Region*

In 1540, Hernando de Alarcón explored the inland areas of the Southern California Region with an expedition that had explored the Colorado River. In 1542, Cabrillo apparently became the first European to sight the coast of Southern California, including the Los Angeles area and Santa Catalina Island, although he did not make landfall (Hoover et al. 1990).

In 1769, Gaspar de Portolá explored a trail by land from present San Diego through present San Diego, Orange, and Los Angeles counties (Hoover et al. 1990). He camped near the Los Angeles River and the Indian Village of Yang-Na (within the present City of Los Angeles). In 1772, Pedro Fages made an inland journey from present San Diego through western Riverside County to San Luis Obispo (Hoover et al. 1990; Riverside County 2000). In 1776, friar Francisco Garcés explored from present San Gabriel Valley to the Antelope Valley. More than 20 missions were established along the Southern California coastline (Los Angeles 2005). Pueblos were established near the missions, including the Pueblo of Los Angeles in 1781.

The first known discovery of gold in California was made between 1775 and 1780 in the Potholes district of southeastern California in present Imperial County (Clark 1970). Other placer deposits were found in 1828 at San Ysidro in present San Diego County, and in 1835 and 1842 at San Francisquito Canyon and Placerita Canyon, respectively, in present Los Angeles County (Clark 1970; Vredenburgh 1991). Some of the mines continued to produce gold through the early 1990s.

Following the end of Spanish Rule, the Mexican Government deeded the extensive land holdings to ranchos to develop ranches and orchards (Riverside County 2000). Oranges and lemons became major agricultural crops between the 1850s and 1880s, and railroads were built to transport the products.

Water supply systems were constructed to provide water to missions and pueblo villages. One of the first systems was the Zanja Madre that was constructed in 1781 to convey water to the pueblo in the present City of Los Angeles (Los Angeles 2005; DWR 2009). The system was expanded in the 1850s and 1860s to convey water to vineyards and fruit orchards. During the late 1800s and early 1900s, numerous dams and conveyance facilities were constructed in the area to support the communities and agriculture.

### 17.3.4 Known Cultural Resources

The following subsections describe known cultural resources in the counties within the study area as determined through review of reports prepared for other projects in the study area. No physical or record surveys were conducted for this EIS because no site-specific construction actions were considered in this EIS. The EIS evaluates alternatives to continue the coordinated long-term operation of the CVP and SWP. The resources described in this subsection indicate the types of resources that occur in areas served by CVP and SWP water and adjacent areas. Therefore, some of the known resources presented in this chapter are located in portions of the counties that are not within the CVP and SWP water service areas.

#### *17.3.4.1 Known Cultural Resources of the Trinity River Region*

Within Trinity County, a cultural resources records search of the Trinity River Region was conducted for the Trinity River Mainstem Fishery Restoration EIS/Environmental Impact Report (EIR) (USFWS et al. 1999). The area covered included 660 feet on either side of the Trinity River from Trinity Lake to the eastern boundary of Hoopa Valley Indian Reservation and the inundation areas of the Trinity Lake and Lewiston Reservoir. More than 150 recorded cultural resources were identified along the mainstem of Trinity River within Trinity County, including 20 types of prehistoric and historic sites. Among these were Native American villages, camps, and lithic scatters; historic Indian sites; mines; ditches; cabins; structures; a school; USFWS stations and campgrounds; cemeteries; a rock wall; trails; a wagon road; and a bridge. Fifty-one sites are inundated within Trinity Lake and Lewiston Reservoir. Few of these sites have been evaluated for eligibility to be included in the National Register of Historic Places (NRHP). With respect to more recent historic sites in Trinity County, none of the sites listed in the NRHP, California State Historical Landmarks, California Register of Historical Resources (CRHR), and/or Points of Interest is located within or along banks of the Trinity River (CSPOHP 2014a).

Within Humboldt County, numerous culturally sensitive areas are located along the Lower Klamath and Lower Trinity rivers. The culturally sensitive areas include the areas along the riverbanks associated with religious and/or resource-producing important sites, in addition to specific known cultural resources. Many cultural resource locations are in the Hoopa Valley Indian Reservation and Yurok Reservation, including villages, cemeteries, ceremonial and gathering areas, and along ridgeline corridors that were used for traveling between villages (Humboldt County 2012). With respect to more recent historic sites in Humboldt County, none of the sites listed in the NRHP, California State Historical Landmarks, CRHR, and/or Points of Interest is located within or along banks of the Trinity or Klamath rivers (CSPOHP 2014b).

Within Del Norte County, numerous culturally sensitive areas are located along the Lower Klamath River, including areas within the Yurok Reservation and the Resighini Rancheria along the southern shoreline of the mouth of the Klamath River at the Pacific Ocean (Del Norte County 2003). The mouth of the Klamath River is of great spiritual significance for the Yurok people (Yurok Tribe 2005). The Yurok Tribe has suggested that the entire Klamath River, including the Lower Klamath River, be designated as a Cultural Riverscape and be submitted for consideration as a NRHP (Yurok Tribe 2005). With respect to more recent historic sites in Del Norte County, none of the sites listed in the NRHP, California State Historical Landmarks, CRHR, and/or Points of Interest is located within or along banks of the Klamath River (CSPOHP 2014c).

#### *17.3.4.2 Previously Recorded Cultural Resources in the Central Valley Region*

The Central Valley Region is rich in both historic- and prehistoric-period resources (Reclamation 1997), including large, deep midden sites (which generally contains waste materials that indicate human inhabitation) that provide information on prehistoric culture extending over thousands of years.

As described above, implementation of the alternatives considered in this EIS could affect cultural resources at CVP and SWP reservoir facilities and in areas that use CVP and SWP water that could experience land uses because of changes in CVP and SWP water supply availability.

#### 17.3.4.2.1 Cultural Resources at CVP and SWP Reservoir Facilities in the Sacramento Valley

Previous cultural resource studies were conducted at and/or near Shasta Lake, Lake Oroville, and Folsom Lake.

The studies near Shasta Lake surveyed approximately 8 percent of the study area and identified 261 cultural resources, including 190 prehistoric properties, 45 historic resources, and 26 properties with prehistoric and historic resources (Reclamation 2013a). The prehistoric sites include habitation sites, artifact and lithic scatters, caves used as shelter, and cemeteries. The historic sites included bridges, railways, a dam, buildings, ranches, orchards, mines, towns, and cemeteries. Several prehistoric and historic cemeteries located within the inundation area were moved prior to completion of the Shasta Lake complex. The Dog Creek Bridge is the only resource in this area that is listed on the NRHP. The Shasta and Keswick dams were determined to be NRHP-eligible.

The studies near Lake Oroville identified 261 cultural resources areas, including 234 prehistoric properties, 462 historic resources, and 91 properties with prehistoric and historic resources (DWR 2004, 2007). Within the Lake Oroville inundation area, 93 prehistoric properties and 19 historic sites were identified prior to the completion of the reservoir. The prehistoric sites include habitation sites, milling sites, quarries, artifact and lithic scatters, caves used as shelter, rock art, fishing and hunting grounds, battle sites, trails, and cemeteries. The historic sites included bridges, railways, a dam, buildings, ranches, orchards, mines, towns, and cemeteries.

Oroville Dam and peripheral dams, Thermalito Diversion Dam, Thermalito Forebay and Afterbay, Fish Barrier Dam, Hyatt Pumping-Generating Plant and Intake Structure, Thermalito Power Plant and Power Canal, Lake Oroville Visitor Center and Visitor Viewing Platform, and Feather River Fish Hatchery were determined to be NRHP-eligible.

The studies near Folsom Lake identified 185 prehistoric properties and 59 historic sites (Reclamation 2005b; Reclamation et al. 2006). The prehistoric sites include habitation sites, middens, groundstones, and artifact and lithic scatters. The historic sites included buildings, mining areas, and refuse dumps. Folsom Dam was determined to be NRHP-eligible.

#### 17.3.4.2.2 Cultural Resources at CVP and SWP Reservoir and Pumping Plant Facilities in the San Joaquin Valley

Previous cultural resource studies were conducted at and/or near New Melones Reservoir, San Luis Reservoir, and Millerton Lake and San Joaquin River downstream of Friant Dam.

The studies near New Melones Reservoir surveyed approximately 78 percent of the study area and identified 725 cultural resources within the New Melones Reservoir area or within 0.25 mile of this area (Reclamation 2010). The prehistoric sites include habitation sites, artifact and lithic scatters, mortars, caves, rock art, and cemeteries. The historic sites included bridges, buildings, ranches, orchards, towns, water and power systems, transportation infrastructure, and cemeteries. Many of the sites are located within the inundation area. However, substantial surveys were conducted prior to construction of New Melones Reservoir in the 1980s.

The studies near San Luis Reservoir identified 51 prehistoric and historic cultural resources (Reclamation and State Parks 2012). The prehistoric sites include habitation sites and artifact and lithic scatters. The historic sites included bridges, water infrastructure, buildings, ranches, orchards, towns, and cemeteries. One of the major historic sites in this area is the remnant locations of Rancho San Luis Gonzaga. Many portions of the ranch are located within the inundation area. However, many of the structures were moved to a site near Pacheco Pass. The remaining portions of the ranch were deeded to the State of California in 1992 to become part of the Pacheco State Park. Rancho San Luis Gonzaga, a historic stock ranch landscape, has been designated by the state to be a Historic District/Cultural Landscape that is potentially NRHP-eligible and CRHR-eligible.

Recent studies along the San Joaquin River identified 19 prehistoric sites within the seasonal inundation area of Millerton Lake (Reclamation and DWR 2011; Reclamation and State Parks 2013). Additional sites are located within the area of the lake that is constantly inundated. Some of the known sites include the remains of Kuyu Illik; the Dumna “head” village; the Kechaye/”Dumna” village of Sanwo Kianu; remains of Fort Miller, Millerton, and Collins Sulphur Springs; and prehistoric sites with housepits, mortars, grinding sticks, and rock alignments (Reclamation and State Parks 2013).

Along the San Joaquin River downstream of Friant Dam (which forms Millerton Lake) to the confluence of the Merced River, 84 prehistoric sites, 18 historic sites, and 7 sites with both prehistoric and historic resources were identified as part of the San Joaquin River Restoration Program. The prehistoric sites include habitation sites, artifact and lithic scatters, and bedrock milling features. The historic sites included bridges, buildings, ranches, orchards, towns, water and power systems, and transportation infrastructure.

The Friant Dam, Friant-Kern Canal, associated features (berms, siphons, control structures, inlets, outlets, and check structures), approximately 40 bridges that cross the canal, and Little Dry Creek Wasteway Facility are considered historic resources (Reclamation and State Parks 2013; Reclamation et al. 2011b). The Friant Dam and Friant-Kern Canal was determined to be NRHP-eligible.

#### 17.3.4.2.3 Cultural Resources in the areas that use CVP and SWP Water Supplies in the Central Valley

Numerous cultural and historical resources are in the Central Valley, as summarized in Table 17.1. Most of the cultural resources are located within areas that would not be affected by land use changes that could result from changes in CVP and SWP water supplies. The resources listed in Table 17.1 also include the sites described above near CVP and SWP facilities.

**Table 17.1 Previously Recorded Cultural and Historical Resources of the Central Valley Region**

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| Butte | 26 NRHP properties, 8 California Historical Landmarks, and 21 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014e). | 1,198 Known Prehistoric Site Types (Reclamation 1997). |
| Colusa | 7 NRHP properties, 3 California Historical Landmarks, and 3 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014g). | 115 Known Prehistoric Site Types (Reclamation 1997). |
| El Dorado | 18 NRHP properties, 30 California Historical Landmarks, 8 California Points of Historical Interest; numerous historic sites, such as mining features, building foundations, trash scatters, and bridges, were inundated by Folsom Lake (Reclamation 1997; CSPOHP 2014h). | 595 Known Prehistoric Site Types (Reclamation 1997). |
| Fresno | 38 NRHP properties, 8 California Historic Landmarks, and 13 of which are California Points of Historical Interest (Reclamation 1997; CSPOHP 2014i). | 2,603 Known Prehistoric Site Types (Reclamation 1997). |
| Glenn | 2 NRHP properties, 2 California Historical Landmarks, and 17 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014j). | 373 Known Prehistoric Site Types (Reclamation 1997). |
| Kern | 20 NRHP properties, 47 California Historic Landmarks, and 11 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014k). | 3,850 Known Prehistoric and Historic Site Types (Reclamation 1997). |
| Kings | 4 NRHP properties, 3 California Historic Landmarks; the San Luis Canal, the only CVP facility in Kings County, has no historic or architectural resources in its vicinity (Reclamation 1997; CSPOHP 2014l). | 56 Known Prehistoric Site Types (Reclamation 1997). |
| Madera | 2 NRHP property, 1 California Historic Landmarks, and 9 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014n). | 2,043 Known Prehistoric Site Types (Reclamation 1997). |
| Merced | 14 NRHP properties, 5 California Historic Landmarks, 1 CRHR properties, and 8 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014p). | 316 Known Prehistoric Site Types (Reclamation 1997). |

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| Napa | 76 NRHP properties, 17 California Historical Landmarks, and 13 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014q). | 700 Known Prehistoric Site Types (Reclamation 1997). |
| Placer | 18 NRHP properties, 20 California Historical Landmarks, 21 California Points of Historical Interest; numerous historic sites, such as mining features, building foundations, trash scatters, and bridges, were inundated by Folsom Lake, which is a CVP facility (Reclamation 1997; CSPOHP 2014s). | 627 Known Prehistoric Site Types (Reclamation 1997). |
| Plumas | 6 NRHP properties, 13 California Historical Landmarks, and 5 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014t). | 1,639 prehistoric sites in Plumas County (Plumas County 2012). |
| Sacramento | 90 NRHP properties, 56 California Historical Landmarks, 4 CRHR properties, 20 California Points of Historical Interest; numerous historic sites, such as mining features, building foundations, trash scatters, and bridges, were inundated by Folsom Lake; the Folsom Mining District surrounds Lake Natoma (Reclamation 1997; CSPOHP 2014u).<br>There are over 40 historic sites along the Sacramento River between Sutter County boundary and Freeport (Reclamation 2005b); including Natomas Main Drainage Canal, Town of Freeport, Sacramento Weir, Yolo Bypass, homes and farms, and a church.<br>There are 14 historic sites along the American River between Folsom Dam and the confluence with the Sacramento River (Reclamation 2005b). | 407 Known Prehistoric Site Types (Reclamation 1997). There are 24 prehistoric sites along the Sacramento River between Sutter County boundary and Freeport (Reclamation 2005b). There are 22 prehistoric sites along the American River between Folsom Dam and the confluence with the Sacramento River (Reclamation 2005b). |
| San Joaquin | 31 NRHP properties, 25 California Historic Landmarks, 3 CRHR properties, and 7 are California Points of Historical Interest (Reclamation 1997; CSPOHP 2014v). | 189 Known Prehistoric Site Types (Reclamation 1997). |

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| Shasta | 26 NRHP properties, 19 California Historical Landmarks, 1 CRHR properties, 15 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014w).<br>The Anderson-Cottonwood Irrigation District Diversion Dam has been determined to be eligible for NRHP listing (Reclamation 2013a). | 1,419 Known Prehistoric Site Types. Many of these sites occur along the Sacramento River near Redding and between Battle Creek and Table Mountain (Reclamation 2013a). |
| Solano | 23 NRHP properties, 14 California Historical Landmarks, and 9 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014x). | 300 Known Prehistoric Site Types (Reclamation 1997). |
| Stanislaus | 21 NRHP properties, 5 California Historic Landmarks, and 7 are California Points of Historical Interest; the former right-of-way for the Patterson and Western Railroad, which was constructed in 1916, bisects the Delta-Mendota Canal (Reclamation 1997; CSPOHP 2014y). | 280 Known Prehistoric Site Types (Reclamation 1997). |
| Sutter | 7 NRHP properties, 2 California Historical Landmarks, and 22 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014z). | 62 Known Prehistoric Site Types (Reclamation 1997). |
| Tehama | 10 NRHP properties, 3 California Historical Landmarks, and 1 California Point of Historical Interest (Reclamation 1997; CSPOHP 2014aa). | 1,415 Known Prehistoric Site Types (Reclamation 1997). |
| Tulare | 34 NRHP properties, 8 California Historic Landmarks, and no California Points of Historical Interest (Reclamation 1997; CSPOHP 2014ab). | 1,857 Known Prehistoric Site Types (Reclamation 1997). |
| Yolo | 21 NRHP properties, 2 California Historical Landmarks, 1 CRHR properties, and 8 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014ad). | 175 Known Prehistoric Site Types (Reclamation 1997). Includes possible fishing stations along Putah and Cache Creeks, the Sacramento, and ephemeral tributaries to these watercourses. |
| Yuba | 10 NRHP properties, 6 California Historical Landmarks, and 14 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014ae). | 1,112 Known Prehistoric Site Types (Reclamation 1997). |

#### 17.3.4.3 Previously Recorded Cultural Resources in the San Francisco Bay Area Region

The San Francisco Bay Area Region includes Alameda, Contra Costa, Santa Clara, and San Benito counties. Much of this region is highly urbanized and that development has affected archaeological resources. Numerous cultural and historical resources are in the San Francisco Bay Area Region, as summarized in Table 17.2. Most of the cultural resources are located within areas that would not be affected by land use changes that could result from changes in CVP and SWP water supplies.

**Table 17.2 Previously Recorded Cultural Resources of the San Francisco Bay Area Region**

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| Alameda | 141 NRHP properties, 34 California Historical Landmarks, 2 CRHR properties, and 4 California Points of Historical Interest (CSPOHP 2014af). | No comprehensive inventory of prehistoric sites in Alameda County (Zone 7 2006). |
| Contra Costa | 40 NRHP properties, 13 California Historical Landmarks, 1 CRHR property, and 12 California Points of Historical Interest (CSPOHP 2014ag). | No comprehensive inventory of prehistoric sites in Contra Costa County (Contra Costa County 2005). Up to 41 sites were identified in the Kellogg Creek Historic District near Los Vaqueros Reservoir (CCWD et al. 2009). |
| San Benito | 12 NRHP properties, 5 California Historic Landmarks, and 2 California Points of Historical Interest (Reclamation 1997; CSPOHP 2014ah). | 180 Known Prehistoric Site Types (Reclamation 1997). |
| Santa Clara | 101 NRHP properties, 41 California Historical Landmarks, and 58 California Points of Historical Interest (CSPOHP 2014ai; Santa Clara County 1994). | Between 1912 and 1960, 43 sites were recorded in the Santa Clara Valley portion of Santa Clara County (Santa Clara 2012). |

#### 17.3.4.4 Previously Recorded Cultural Resources in the Central Coast and Southern California Regions

The Central Coast Region includes San Luis Obispo and Santa Barbara counties. Within the Central Coast Region, the SWP provides water supplies to portions of San Luis Obispo and Santa Barbara counties. Within the Southern California Region, the SWP provides water supplies to portions of Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties. Numerous cultural and historical resources are in the Central Coast and Southern California regions, as summarized in Table 17.3. Most of the cultural resources are located within areas that would not be affected by land use changes that could result from changes in SWP water supplies.

**Table 17.3 Previously Recorded Cultural and Historical Resources of the Central Coast and Southern California Regions**

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| San Luis Obispo | 34 NRHP properties, 2 California Historical Landmarks, and 4 California Points of Historical Interest (CSPOHP 2014ao). | The San Luis Obispo County General Plan discusses several hundred prehistoric resources throughout San Luis Obispo County related to the Chumash people (San Luis Obispo County 2010). |
| Santa Barbara | 43 NRHP properties, 16 California Historical Landmarks, and 7 California Points of Historical Interest (CSPOHP 2014ap). | The 2010 Santa Barbara Conservation Element of the Comprehensive Plan noted prehistoric resources throughout Santa Barbara County related to the Chumash people (Santa Barbara County 2010). |
| Los Angeles | 431 NRHP properties, 90 California Historical Landmarks, 6 CRHR property, and 65 California Points of Historical Interest (CSPOHP 2014aj). | Over 4,196 prehistoric sites in Los Angeles County (SCAG 2011). |
| Orange | 108 NRHP properties, 24 California Historical Landmarks, and 20 California Points of Historical Interest (CSPOHP 2014ak). | Over 1,710 prehistoric sites in Orange County (SCAG 2011; Orange County 2005). |
| Riverside | 52 NRHP properties, 23 California Historical Landmarks, and 72 California Points of Historical Interest (CSPOHP 2014al). | Over 19,858 prehistoric sites in Orange County (SCAG 2011). Some of the Cahuilla, Serrano, and Luiseño communities were inundated within Lake Perris (Reclamation and DWR 2003). |
| San Bernardino | 56 NRHP properties, 39 California Historical Landmarks, 2 CRHR property, and 119 California Points of Historical Interest (CSPOHP 2014am). | Over 29,480 prehistoric sites in San Bernardino County, including the Calico “Early Man” Site (SCAG 2011). |
| San Diego | 130 NRHP properties, 63 California Historical Landmarks, 3 CRHR property, and 16 California Points of Historical Interest (CSPOHP 2014an). | The San Diego County General Plan discussed that there are many prehistoric sites within San Diego County; however, the number and locations are not identified to protect the resources (San Diego County 2011a). |

| County | Historic Site Types | Prehistoric Site Types |
|---|---|---|
| Ventura | 34 NRHP properties, 11 California Historical Landmarks, and 4 California Points of Historical Interest (CSPOHP 2014aq). | Over 1,806 prehistoric sites in San Bernardino County (SCAG 2011). |

# 17.4 Impact Analysis

This section describes the potential mechanisms for change in cultural resources and analytical methods, results of the impact analysis, potential mitigation measures, and potential cumulative effects.

## 17.4.1 Potential Mechanisms for Change and Analytical Tools

As described in Chapter 4, Approach to Environmental Analysis, the environmental consequences assessment considers changes in cultural resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison that could result in land disturbance or increased exposure of cultural resources sites.

### *17.4.1.1 Changes in the Potential for Land Disturbance*

Under Alternatives 1 through 5, No Action Alternative, and Second Basis of Comparison, CVP and SWP water supplies would continue to be provided within the currently designated service areas. Implementation of the alternatives does not include expansion of designated service areas or increased water contract amounts. Land use in 2030 would be consistent with existing general plan projections under all alternatives and the Second Basis of Comparison. The CVP and SWP water contract amounts would be the same under all alternatives and the Second Basis of Comparison. The alternatives would not result in expansion of municipal or agricultural lands, or associated disturbances of cultural resources because of expansion of development or cultivated lands in addition to the conditions projected under existing general plans. Therefore, changes in CVP and SWP water supply availability that would result in changes in land use and associated potential for disturbance of cultural resources are not analyzed in this EIS.

### *17.4.1.2 Changes in Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could result in increased periods of time when low water elevations occur in reservoirs that store CVP and SWP water, including the CVP and SWP reservoirs. The lowest reservoir elevations generally occur in September in dry and critical dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. The minimum and maximum elevations of the reservoir surface water under Alternatives 1 through 5, No Action Alternative, and Second Basis of Comparison would be the same as under current conditions.

#### *17.4.1.3 Effects Related to Cross Delta Water Transfers*

Water transfer programs have been used to provide water to existing agricultural and municipal service areas when other water supplies are not available. It is anticipated that water transfers under all alternatives and the Second Basis of Comparison would continue in this manner to provide water supplies to land uses projected under existing general plans which would not result in expansion of municipal or agricultural lands, or associated disturbances of cultural resources because of expansion of development or cultivated lands in addition to conditions projected under existing general plans. Therefore, effects related to cross Delta water transfers and associated potential for disturbance of cultural resources are not analyzed in this EIS.

### 17.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison (e.g., climate change, sea level rise, general plan development, and implementation of reasonable and foreseeable projects). Because of these changes, especially climate change and sea level rise, it is anticipated that reservoir elevations at the end of September would be lower, flows patterns in the rivers downstream of the reservoirs would be different than under recent condition, and CVP and SWP water deliveries would be less than under recent condition, as described in Chapter 5, Surface Water Resources and Water Supplies. In all regions, the minimum reservoir elevations under the No Action Alternative and Second Basis of Comparison would be similar to minimum elevations during recent conditions.

### 17.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative, and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of the following alternatives analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative

- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

#### *17.4.3.1 No Action Alternative*

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

##### 17.4.3.1.1 Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water

As described above, the minimum reservoir elevations in all regions under the No Action Alternative and the Second Basis of Comparison would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under the No Action Alternative and Second Basis of Comparison.

#### *17.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because cultural resource conditions under Alternative 1 are identical to cultural resource conditions under the Second Basis of Comparison, Alternative 1 is only compared to the No Action Alternative.

##### 17.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

As described above, the minimum reservoir elevations in all regions under Alternative 1 as compared to the No Action Alternative would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under Alternative 1 and the No Action Alternative.

##### 17.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *17.4.3.3 Alternative 2*

The cultural resources conditions under Alternative 2 would be identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 17.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to cultural resources conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 17.4.3.1, No Action Alternative.

#### *17.4.3.4 Alternative 3*

CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.

##### 17.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

As described above, the minimum reservoir elevations in all regions under Alternative 3 as compared to the No Action Alternative would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under Alternative 3 as compared to the No Action Alternative.

##### 17.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

As described above, the minimum reservoir elevations in all regions under Alternative 3 as compared to the Second Basis of Comparison would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under Alternative 3 and Second Basis of Comparison.

#### *17.4.3.5 Alternative 4*

The cultural resources conditions under Alternative 4 would be identical to the conditions under the Second Basis of Comparison. Therefore, Alternative 4 is only compared to the No Action Alternative.

##### 17.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in cultural resources conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 17.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *17.4.3.6 Alternative 5*

The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations.

##### 17.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

As described above, the minimum reservoir elevations in all regions under Alternative 5 as compared to the No Action Alternative would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under Alternative 5 as compared to the No Action Alternative.

#### 17.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Potential Exposure of Cultural Resources at Reservoirs that Store CVP and SWP Water*

As described above, the minimum reservoir elevations in all regions under Alternative 5 as compared to the Second Basis of Comparison would be within historic ranges and would not expose lands that are not currently exposed. Therefore, conditions of cultural resources would be similar under Alternative 5 and Second Basis of Comparison.

### *17.4.3.7 Summary of Impact Analysis*

The results of the impact analysis of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 17.4 and 17.5.

**Table 17.4 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects to cultural resources | None needed |
| Alternative 2 | No effects to cultural resources | None needed |
| Alternative 3 | No effects to cultural resources | None needed |
| Alternative 4 | No effects to cultural resources | None needed |
| Alternative 5 | No effects to cultural resources | None needed |

**Table 17.5 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects to cultural resources | None needed |
| Alternative 2 | No effects to cultural resources | None needed |
| Alternative 3 | No effects to cultural resources | None needed |
| Alternative 4 | No effects to cultural resources | None needed |
| Alternative 5 | No effects to cultural resources | None needed |

### *17.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5, as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Implementation of Alternatives 1 through 5 as compared to the No Action Alternative would not result in increased potential exposure or disturbance of cultural resources. Therefore, there would be no adverse impacts to cultural resources because of implementation of the alternatives; and no mitigation measures are needed.

#### *17.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Cultural Resources are summarized in Table 17.6.

**Table 17.6 Summary of Cumulative Effects on Cultural Resources with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions Included in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site | <u>These effects would be the same under all alternatives.</u><br>Community development would occur in accordance with general plan projections for 2030. Development within the Delta would be subject to the requirements of the Delta Protection Commission and Delta Stewardship Council. Future development projects are anticipated to potentially effect cultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to cultural resources.<br>Restoration plans for the ongoing programs would be completed. Development along river corridors in the Central Valley. Future restoration projects are anticipated to potentially affect cultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - Nimbus Fish Hatchery Fish Passage Project<br>- Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | minimize adverse impacts to cultural resources.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability. Future water supply projects are anticipated to potentially effect cultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to cultural resources. |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations | <u>These effects would be the same under all alternatives.</u><br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- San Luis Reservoir Low Point Improvement Project<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | reductions in CVP and SWP water deliveries.<br>Future development of the cumulative projects are anticipated to potentially affect cultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to cultural resources. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Community development and restoration projects for the ongoing programs would be completed.<br>Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans.<br>Future development projects are anticipated to potentially affect cultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to cultural resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

## 17.5 References

Bean, L. J. 1978. *Cahuilla*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 575-587 pp. Washington, D.C.: Smithsonian Institution.

Bean, L. J., and F. C. Shipek. 1978. *Luiseño*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 550-563 pp. Washington, D.C.: Smithsonian Institution.

Bean, L. J., and C. R. Smith. 1978. *Gabrielino*. Handbook of North American Indians, Volume. Edited by R. F. Heizer, 538-549 pp. Washington, D.C.: Smithsonian Institution.

Beardsley, R. K. 1948. Cultural Sequences in Central California Archaeology. *American Antiquity* 14(1):1-28.

_____. 1954. Temporal and Areal Relationships in Central California. *University of California Archaeological Survey Reports* 24-25. Berkeley.

Blackburn, H. C., and L. J. Bean. 1978. *Kitanemuk*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 564-569 pp. Washington, D.C.: Smithsonian Institution.

CALFED (CALFED Bay-Delta Program). 1996. *Draft Affected Environment Technical Report, Cultural Resources in the Delta Region*. Sacramento, California. September.

_____. 1997. *Affected Environment and Environmental Impacts, Cultural Resources, Draft Technical Report*. September.

California (State of California). 2011. *California's Legislature*. Summer.

California State Parks. 2014. *Antelope Valley Indian Museum*. Site accessed February 12, 2014. http://www.avim.parks.ca.gov/people/ph_kawaiisu.shtml.

CCWD et al. (Contra Costa Water District, Bureau of Reclamation, Western Area Power Administration). 2009. *Los Vaqueros Reservoir Expansion Project, Draft Environmental Impact Statement-Environmental Impact Report*. February.

CDFG (California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2009. *Draft Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement*. September.

Clark, William B. 1970, reprinted 1992. Gold Districts of California. *California Division of Mines and Geology Bulletin* 193. Sacramento.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020*. January.

Cook, S. F. 1978. *Historical Demography*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 91-98 pp. Washington, D.C.: Smithsonian Institution.

CSPOHP (California State Parks Office of Historic Preservation). 2014a. California Historical Landmarks – Trinity County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

_____. 2014b. California Historical Landmarks – Humboldt County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014c. California Historical Landmarks – Del Norte County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014d. California Historical Landmarks – Amador County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014e. California Historical Landmarks – Butte County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014f. California Historical Landmarks – Calaveras County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014g. California Historical Landmarks – Colusa County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014h. California Historical Landmarks – El Dorado County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014i. California Historical Landmarks – Fresno County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014j. California Historical Landmarks – Glenn County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014k. California Historical Landmarks – Kern County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014l. California Historical Landmarks – Kings County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014m. California Historical Landmarks – Lassen County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014n. California Historical Landmarks – Madera County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014o. California Historical Landmarks – Mariposa County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014p. California Historical Landmarks – Merced County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014q. California Historical Landmarks – Napa County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014r. California Historical Landmarks – Nevada County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014s. California Historical Landmarks – Placer County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014t. California Historical Landmarks – Plumas County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014u. California Historical Landmarks – Sacramento County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014v. California Historical Landmarks – San Joaquin County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014w. California Historical Landmarks – Shasta County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014x. California Historical Landmarks – Solano County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014y. California Historical Landmarks – Stanislaus County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014z. California Historical Landmarks – Sutter County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014aa. California Historical Landmarks – Tehama County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ab. California Historical Landmarks – Tulare County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ac. California Historical Landmarks – Tuolumne County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ad. California Historical Landmarks – Yolo County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ae. California Historical Landmarks – Yuba County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014af. California Historical Landmarks – Alameda County. Site accessed February 9, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ag. California Historical Landmarks – Contra Costa County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ah. California Historical Landmarks – San Benito County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ai. California Historical Landmarks – Santa Clara County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014aj. California Historical Landmarks – Los Angeles County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014ak. California Historical Landmarks – Orange County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014al. California Historical Landmarks – Riverside County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014am. California Historical Landmarks – San Bernardino County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

______. 2014an. California Historical Landmarks – San Diego County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

_____. 2014ao. California Historical Landmarks – San Luis Obispo County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

_____. 2014ap. California Historical Landmarks – Santa Barbara County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

_____. 2014aq. California Historical Landmarks – Ventura County. Site accessed January 31, 2014. http://ohp.parks.ca.gov/listedresources/

Cutter, Donald C. 1948. The Discovery of Gold in California. In "Geologic Guidebook Along Highway 49 – Sierran Gold Belt: The Mother Lode Country." Edited by Olaf P. Jenkins. *State of California Division of Mines Bulletin 141:13-17.* San Francisco.

Davis, J. T. 1961. *Trade Routes and Economic Exchange Among the Indians of California*. Archaeological Survey Reports Number 54. University of California Press. Berkeley, California.

Del Norte County. 2003. *Del Norte County General Plan*. January 28.

Dixon, R. B. 1910. The Chimariko Indians and Language. *University of California Publications in American Archaeology and Ethnology* 5(5):293-380. Berkeley, California.

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

Driver, H. 1939. Culture Element Distributions, X, Northwest California. *University of California Anthropological Records* 1(6):297-433. Berkeley, California.

DSC (Delta Stewardship Council). 2011. *Delta Plan Draft Program Environmental Impact Report*. November.

DuBois, C. A. 1935. Wintu Ethnography. *University of California Publications in American Archaeology and Ethnology* 36(1):1-148. Berkeley, California.

DWR (Department of Water Resources). 2004. *The Archaeological and Historical Site Inventory at Lake Oroville, Butte County*.

_____. 2007. *Draft Environmental Impact Report Oroville Facilities Relicensing—FERC Project No. 2100*. May.

_____. 2008. *Dutch Slough Tidal Marsh Restoration Project, Draft Environmental Impact Report.* November.

_____. 2009. *East Branch Extension Phase II, Final Environmental Impact Report*. January.

_____. 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR, Reclamation, USFWS, and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

EBMUD (East Bay Municipal Utility District). 2009. *Water Supply Management Program 2040 Draft Program Environmental Impact Report*. February.

ECCCHCPA et al. (East Contra Costa County Habitat Conservation Plan Association and U.S. Fish and Wildlife Service). 2006. *East Contra Costa Habitat Conservation Plan and Natural Community Conservation Plan Final Environmental Impact Statement – Environmental Impact Report*. October.

Farber, A. 1985. Alternative Approaches to the Shasta Complex and Adjacent Expressions: Assemblages, Cultural Ecology, and Taxonomies. *Journal of California and Great Basin Anthropology* 7(1):75-88.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Fredrickson, D. A. 1974. Cultural Diversity in Early Central California: A View from the North Coast Ranges. *Journal of California Anthropology* 1(1):41-53.

Gardner, J. K. 2002. Testing a Regional Model of Changing Settlement and Subsistence Patterns in the Western Mojave Desert: Results from the Coffee Break Site. 6. Salinas, California: Coyote Press Archives of Great Basin Prehistory.

_____. 2007. *The Potential Impact of the Medieval Climatic Anomaly on Human Populations in the Western Mojave Desert*. Coyote Press.

Garrett, B. L. n.d. Drowned Histories: Submerged Place in the Western United States. Site accessed on February 1, 2013. http://www.worldarchaeologicalcongress.org/students/jamaica/e_session/Garrett.htm.

Garth, T. R. 1978. *Atsugewi*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 236-243 pp. Washington, D.C.: Smithsonian Institution.

Gayton, A. H. 1948. Yokuts and Western Mono Ethnography. *University of California Anthropological Records* 10(1-2):1-302. Berkeley, California.

Gifford, E. W. 1932. The North Fork Mono. *University of California Publications in American Archaeology and Ethnology* 31(2):15-65. Berkeley, California.

Glassow, M. A. 1996. The Significance to California Prehistory of the Earliest Mortars and Pestles. *Pacific Coast Archaeological Society* 32(4):14-26.

_____. 1999. Measurement of Population Growth and Decline during California Prehistory. *Journal of California and Great Basin Anthropology* 21:45-66.

Glassow, M. A., L. Gamble, J. Perry, and G. Russell. 2007. *Prehistory of the Northern California Bight and the Adjacent Transverse Ranges*. California Prehistory: Colonization, Culture, and Complexity. Edited by Terry L. Jones and Kathryn A. Klar. Lanham, Maryland: AltaMira Press.

Goldschmidt, W. 1978. *Nomlaki*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 341-349 pp. Washington, D.C.: Smithsonian Institution.

Grant, C. 1978a. *Chumash: Introduction*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 505-508 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978b. *Eastern Coastal Chumash*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 509-519 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978c. *Island Chumash*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 524-529 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978d. *Interior Chumash*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 530-534 pp. Washington, D.C.: Smithsonian Institution.

Greengo, R., and D. Shutler. 1953. *Historical Background*. The Archaeology of the Napa Region. Edited by R. F. Heizer, 12(6):229-232. Berkeley, CA: University of California Anthropological Records.

Greenwood, R. S. 1978. *Obiseño and Purisimeño Chumash*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 520-523 pp. Washington, D.C.: Smithsonian Institution.

Gudde, E. G. 2009. California Gold Camps. Edited by E. K. Gudde. Berkeley, CA: University of California Press. April.

Harrington, J. P. 1942. Culture Element Distributions, XIX: Central California Coast. *University of California Anthropological Records* 7(1):1-46. Berkeley, California.

Harrington, J. P., and C. Merriam. 1967. *Chemariko Notes*. Ethnographic Notes on California Indian Tribes II. Berkeley, CA: University of California.

Heizer, R. F. 1949. The Archaeology of Central California I: The Early Horizon. *University of California Anthropological Records* 12(1)1-84. Berkeley, California.

_____. 1978. *Key to Tribal Territories (Map)*. Handbook of North American Indians, Volumes 8 and 10, California: ix. Edited by R. F. Heizer. Washington, D.C.: Smithsonian Institution.

Heizer, R. F., and F. Fenenga. 1939. Archaeological Horizons in Central California. *American Anthropologist* 41(3):378-399.

Hester, T. R. 1978. *Salinan*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 500-504 pp. Washington, D.C.: Smithsonian Institution.

Hoover, M. B., H. E. Rensch, E. G. Rensch, and W. N. Abeloe. 1990. Historic Spots in California, Fourth edition. Revised and updated by Douglas E. Kyle. Stanford University Press.

Humboldt County (County of Humboldt). 2012. *Humboldt County General Plan Update, Draft Environmental Impact Report*. April 2.

Jensen, P. M., and P. R. Reed. 1980. *A Cultural Resources Inventory and Anthropological Overview of the Northern Sacramento Valley and Southern Cascade Range, Special Publication*. District Office: U.S. Bureau of Land Management. Redding, California.

Johnson, J. J. 1978a. *Yana*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 361-369 pp. Washington, D.C.: Smithsonian Institution.

Johnson, P. J. 1978b. *Patwin*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 350-360 pp. Washington, D.C.: Smithsonian Institution.

Johnson, J. R., T. W. Stafford, Jr., H. O. Ajie, and D. P. Morris. 2002. *Arlington Springs Revisited*. Proceedings of the Fifth California Islands Symposium. Edited by D.R. Browne, K.L. Mitchell, and H.W. Chaney, 541–545 pp. Santa Barbara, California: Santa Barbara Museum of Natural History.

Kelly, I. 1978. *Coast Miwok*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 414-425 pp. Washington, D.C.: Smithsonian Institution.

King, C. D. 1990. Evolution of Chumash Society: A Comparative Study of Artifacts Used for Social System Maintenance in the Santa Barbara Channel Region Before A.D. 1804 p. New York, N.Y.: Garland Publishing.

King, C. D., and T. C. Blackburn. 1978. *Tataviam*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 535-537 pp. Washington, D.C.: Smithsonian Institution.

Kroeber, A. L. 1925. *Handbook of the Indians of California*. Bureau of American Ethnology Bulletin 78. Reprinted in 1976 by New York: Dover Publications, Inc.

_____. 1932. The Patwin and Their Neighbors. *University of California Publications in American Archaeology and Ethnology* 29(4):253-423. Berkeley, California.

_____. 1939. Cultural and Natural Areas of Native North America. *University of California Publications in American Archaeology and Ethnology* 38:1-240. Berkeley, California.

LaPena, F. R. 1978. *Wintu*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 324-340 pp. Washington, D.C.: Smithsonian Institution.

Lenihan, D. J., T. L. Carrell, S. Fosberg, L. Murphy, S. L. Ray, and J. A. Ware. 1981. *The Final Report of the National Reservoir Inundation Study, Volume I*. U.S. National Park Service. Santa Fe, New Mexico.

Levy, R. 1978a. *Eastern Miwok*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 398-413 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978b. *Costanoan*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 485-495 pp. Washington, D.C.: Smithsonian Institution.

Los Angeles (City of Los Angeles). 2005. *Integrated Resources Plan Draft Environmental Impact Report*. November.

Los Angeles County (County of Los Angeles). 2010. *One Valley One Vision Revised Draft Program Environmental Impact Report, County of Los Angeles Area Plan*. November.

_____. 2011. *Public Review Draft 4/5/11 Text-Only Version, Los Angeles County General Plan 2035*. April.

Luomala, K. 1978. *Tipai and Ipai*. Handbook of North American Indians, Volume 8. edited by R. F. Heizer, 592-609 pp. Washington, D.C.: Smithsonian Institution.

Mason, J. A. 1912. The Ethnology of the Salinan Indians. *University of California Publications in American Archaeology and Ethnology* 10(4):97-240. Berkeley, California.

_____. 1918. The Language of the Salinan Indians. *University of California Publications in American Archaeology and Ethnology* 14(1):1-154. Berkeley, California.

Meighan, C. W. 1955. Archaeology of the North Coast Ranges, California. *University of California Archaeological Survey Report* 30:1-39. Berkeley, California.

Meighan, C. W., and C. V. Haynes. 1970. The Borax Lake Site Revisited. *Science* 167:1213-1221.

Moratto, M. J. 1984. California Archaeology. San Francisco, CA: Academic Press, Inc.

Olmsted, D. L., and O. C. Stewart. 1978. *Achumawi*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 225-235 pp. Washington, D.C.: Smithsonian Institution.

Olsen, W. H., and F. A. Riddell. 1963. *The Archaeology of the Western Pacific Railroad Relocation*. Archaeological Report 7. Department of Parks and Recreation, Division of Beaches and Parks, Interpretative Services Section. Sacramento, California.

Orange County (County of Orange). 2005. *2005 Orange County General Plan.*

Parker, Patricia L., and Thomas F. King. 1998. *Guidelines for Evaluating and Documenting Traditional Cultural Properties, 1990, REVISED 1992; 1998*. National Register Bulletin, U.S. Department of the Interior, National Park Service.

Pilling, A. R. 1978. *Yurok*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 137-154 pp. Washington, D.C.: Smithsonian Institution.

Placer County. 2007. *North Fork American River Trail Project Draft Environmental Impact Report*. August.

Plumas County. 2012. *2035 Plumas County General Plan Update, Draft Environmental Impact Report*. November.

Ragir, S. R. 1972. *The Early Horizon in Central California Prehistory*. Contributions of the University of California Archaeological Research Facility 15. Berkeley, California.

Reclamation (Bureau of Reclamation). 1997. *Draft Central Valley Project Improvement Act – Programmatic Environmental Impact Statement.* September.

_____. 2005a. *Sacramento River Division Contractors, Long-Term Renewal Contract Final Environmental Assessment*. February.

_____. 2005b. *American River Division Long-Term Renewal Contract Final Environmental Assessment*. February.

_____. 2005c. *Contra Costa Water District Long-Term Renewal Contract Final Environmental Assessment*. February.

_____. 2010. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

_____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

_____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

_____. 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

_____. 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

_____. 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

_____. 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation and DWR (Bureau of Reclamation, and California Department of Water Resources). 2003. *Environmental Water Account Draft Environmental Impact Statement/Environmental Impact Report*. July.

_____. 2011. *San Joaquin River Restoration Program Environmental Impact Statement/Report*.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation and State Parks (Bureau of Reclamation and California Department of Parks and Recreation). 2013. *San Luis Reservoir State Recreation Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/ Environmental Impact Report*. June.

Reclamation and WAPA (Bureau of Reclamation and Western Area Power Administration). 2009. *Final Environmental Impact Statement: Delta-Mendota Canal/California Aqueduct Intertie – Central Valley Project, California, Volume I*.

Reclamation et al. (Bureau of Reclamation, U.S. Army Corps of Engineers, California Reclamation Board, Sacramento Area Flood Control Agency). 2006. *Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report*. December.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2010. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Draft Environmental Impact Statement/Environmental Impact Report*. October.

_____. 2011a. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*. November.

Riddell, F. A. 1978. *Maidu and Konkow*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 370-386 pp. Washington, D.C.: Smithsonian Institution.

Riverside County (County of Riverside). 2000. *Existing Setting Report, Riverside County Integrated Project*. March.

San Benito County (County of San Benito). 2010. *San Benito County General Plan Background Report, Public Review Draft*. November.

_____. 2013. 2035 *San Benito County General Plan Update Draft Program Environmental Impact Report*. November.

San Bernardino County (County of San Bernardino). 2012. *County of San Bernardino 2007 General Plan*. May.

San Diego County (County of San Diego). 2011a. *San Diego County General Plan*. August.

_____. 2011b. *San Diego County General Plan Update, Final Environmental Impact Report*. August.

San Luis Obispo County (County of San Luis Obispo). 2010. *County of San Luis Obispo General Plan Conservation and Open Space Element (including Appendices)*. May.

Santa Barbara (City of Santa Barbara). 2010. *Certified Final Program Environmental Impact Report for the Santa Barbara General Plan Update*. September.

Santa Barbara County (County of Santa Barbara). 2010. *2010 Santa Barbara Conservation Element of the Comprehensive Plan*. August.

Santa Clara County (County of Santa Clara). 1994. *Santa Clara County General Plan Draft Environmental Impact Report*. September.

_____. 2012. *Santa Clara Valley Habitat Plan, Final Environmental Impact Report/Environmental Impact Statement*.

SCAG (Southern California Association of Governments). 2011. *Draft Program Environmental Impact Report, 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy*. December.

Schenck, W. E. 1926. Historic Aboriginal Groups of the California Delta Region. *University of California Publications in American Archaeology and Ethnology* 23(2):123–146. Berkeley, California.

Shipley, W. F. 1978. *Native Languages of California*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 80-90 pp. Washington, D.C.: Smithsonian Institution.

Silver, S. 1978a. *Chimariko*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 205-210 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978b. *Shastan Peoples*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 211-224 pp. Washington, D.C.: Smithsonian Institution.

Silverstein, M. 1978. *Yokuts: Introduction*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 446-447 pp. Washington, D.C.: Smithsonian Institution.

SJRRP (San Joaquin River Restoration Program). 2011. *Friant-Kern Canal Capacity Restoration, Draft Environmental Assessment, San Joaquin River Restoration Program*. June.

Smith, C. R. 1978. *Tabatulabal*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 437-445. Washington, D.C.: Smithsonian Institution.

Smith, C. E., and Weymouth, W. D. 1952. *Archaeology of the Shasta Dam Area, California*. University of California Archaeological Survey Report 18. Berkeley, California.

Spier, R. F. G. 1978a. *Monache*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 426-436 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978b. *Foothill Yokuts*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 471-484 pp. Washington, D.C.: Smithsonian Institution.

Sutton, M. Q. 1988. An Introduction to the Archaeology of the Western Mojave Desert. Salinas, CA: Coyote Press Archives of California Prehistory 14.

_____. 1996. The Current Status of Archaeological Research in the Mojave Desert. *Journal of California and Great Basin Anthropology* 18(2):221-257.

Sutton, M. Q., M. E. Basgall, J. K. Gardner, and M. W. Allen. 2007. *Advances in Understanding Mojave Desert Prehistory*. California Prehistory, Colonization, Culture, and Complexity. Edited by T. L. Jones and K. A. Klar, 229-246pp. Lanham: AltaMira Press.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

_____. 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Treganza, A. E. 1958. Salvage Archaeology in the Trinity Reservoir Area, Northern California. *University of California Archaeological Survey Reports* 43:1-38. Berkeley, California.

_____. 1959. Salvage Archaeology in the Trinity Reservoir Area, Northern California: Field Season 1958. *University of California Archaeological Survey Reports* 46:1-32. Berkeley, California.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. *Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report*.

Ventura County (County of Ventura). 2005. *Final Subsequent Environmental Impact Report for Focused General Plan Update*. June.

Voegelin, E. 1938. Tubatulabal Ethnography. *University of California Publications in American Archaeology and Ethnology* 2(1):1-84. Berkeley, California.

Vredenburgh, L. 1991. *A Brief Sketch of the Mining History of the Western Mojave Desert and Southern Sierra Nevada*.

Wallace, W. J. 1978a. *Hupa, Chilula and Whilkut*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 164-179 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978b. *Southern Valley Yokuts*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 448-461 pp. Washington, D.C.: Smithsonian Institution.

_____. 1978c. *Northern Valley Yokuts*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 462-470 pp. Washington, D.C.: Smithsonian Institution.

Warren, C. N., and R. H. Crabtree. 1986. Prehistory of the Southwestern Area Handbook of North American Indians, Volume 11, California. Edited by W. L. d'Azevedo, 183-193 pp. Washington, D.C.: Smithsonian Institution.

Wilson, N. L., and A. H. Towne. 1978. *Nisenan*. Handbook of North American Indians, Volume 8. Edited by R. F. Heizer, 387-397 pp. Washington, D.C.: Smithsonian Institution.

Yurok Tribe. 2005. *Tribal Park Concept Plan*. August.

Zigmond, M. 1986. *Kawaiisu*. Handbook of North American Indians, Volume 11, Great Basin. Edited by W. L. d'Azevedo, 398-411 pp. Washington, D.C.: Smithsonian Institution.

Zone 7 (Zone 7 Water Agency). 2006. *Zone 7 Stream Management Master Plan Draft Environmental Impact Report*. March.

**Chapter 18**

# Public Health

## 18.1 Introduction

This chapter describes public health hazards in the study area related to changes in the environment that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives considered in this EIS could affect public health through changes in available water supplies from the Central Valley Project (CVP) and State Water Project (SWP); changes in irrigated crop acreage related to potential changes in operation of the CVP and SWP; changes in wetlands acreage related to potential changes in ecosystem restoration; and changes in water quality related to potential changes in operation of the CVP and SWP.

Changes in available water supplies, agricultural resources, wetlands, and water quality are described in more detail in Chapter 5, Surface Water Resources and Water Supplies; Chapter 12, Agricultural Resources; and Chapter 6, Water Quality, respectively.

## 18.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect public health throughout the study area. Some of the actions considered in the alternatives evaluated in this EIS could include facilities located on public agency lands; or actions implemented, funded, or approved by Federal and state agencies. These actions would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 18.3 Affected Environment

This section describes the following public health factors that could be potentially affected by the implementation of the alternatives considered in this EIS.

- Changes in available water supplies.
- Increases in the potential for mosquito-borne diseases due to an increase in wetlands.
- Changes in the potential for Valley Fever from disturbed soils when irrigation water supplies change.
- Changes in the potential for bioaccumulation of mercury in fish and shellfish.

Changes in the potential of direct or indirect exposure to high water quality concentrations of various constituents also may occur due to implementation of the alternatives. These direct changes to water quality and the related changes to drinking water safety and consumption of fish or shellfish exposed to high concentrations of constituents of concern are described in Chapter 6, Water Quality.

Public health effects that could occur due to construction activities are not discussed in this chapter, including increased exposure to naturally occurring asbestos, methane production from disturbance of peat soils, disturbance of oil and gas production fields, use and transport of hazardous wastes, and changes in wastewater or stormwater discharges. Although several of the alternatives include assumptions of constructed facilities, those actions will require subsequent planning and environmental documentation prior to implementation. The subsequent environmental documentation and related permits will evaluate public health effects associated with construction and implementation of those facilities.

### 18.3.1 Public Health Issues Related to Available Water Supplies

Water supply availability can affect public health in several ways. Potential direct effects to public health are related to reduction of municipal water supplies. Potential indirect effects to public health are related to reduction of industrial and irrigation water supplies which could affect the ability to earn an income to fund food, shelter, and other critical factors necessary for public health. Effects related to loss of jobs.

Availability of water supplies substantially decreased for CVP and SWP water users during recent droughts in 1976-1977, 1987-1992, and 2012-2014. In addition, as described in Chapter 5, Surface Water Resources and Water Supplies, the frequency of substantially reduced water supplies provided by the CVP and SWP have increased since the 1976-1977 drought due to changes in regulations and increased water demands by users with higher priorities for water use.

During the 2014 drought, CVP and SWP water supply allocations have been reduced substantially to protect future water supplies and the ability to meet existing regulations, as described in Chapter 5, Surface Water Resources and Water Supplies. The allocations were modified throughout the 2013-2014 winter with the allocations that are the most stringent in the history of the CVP and/or SWP operations, as summarized below (Reclamation 2014a, 2014b; DWR 2013, 2014).

- CVP North of Delta Water Users.
  - Sacramento River Settlement Contractors – allocated 40 percent of total contracted water supply.
  - Sacramento Valley Refuges that use CVP water supplies – allocated 40 percent of total contracted water supply.

  - Agricultural Water Service Contractors – allocated 0 percent of total contracted water supply.
  - Municipal and Industrial Water Service Contractors – allocated 50 percent of historic water use.
- CVP In-Delta Water Service Contractor: Contra Costa Water District – allocated 50 percent of historic water use.
- CVP South of Delta Water Users.
  - San Joaquin River Exchange and Settlement Contractors – allocated 65 percent of total contracted water supply.
  - San Joaquin Valley Refuges that use CVP water supplies – allocated 65 percent of total contracted water supply.
  - Agricultural Water Service Contractors – allocated 0 percent of total contracted water supply.
  - Municipal and Industrial Water Service Contractors – allocated 50 percent of historic water use.
- CVP Friant Division Contractors – allocated 0 percent of total contracted water supply.
- CVP Eastside Water Service Contractors: Water supplies delivered from New Melones Reservoir – allocated 55 percent of total contracted water supply.
- SWP Water Service Contractors – 5 percent of total contracted water supply.

Another potential indirect effect to public health is related to reduction of stored water in the CVP and SWP reservoirs which could affect the ability to provide enough water for firefighting,

#### 18.3.1.1 Public Health and Safety Related to Available Municipal and Industrial Water Supplies

The Department of the Interior, Bureau of Reclamation (Reclamation) current *Draft Municipal and Industrial Shortage Policy* (Reclamation 2005) describes that the CVP water service contractors should develop public health and safety volumes based California’s public health and safety criteria or criteria developed in coordination with Reclamation. Currently, California does not have a uniform set of public health and safety criteria for municipal and industrial water supplies. At this time, most of the urban communities have not adopted specific public health and safety criteria. However, in some of the recently completed Urban Water Management Plans, criteria have been identified to protect public health and safety that range from 25 to 50 percent of the total water demand, as described in Chapter 5, Surface Water Resources and Water Supplies (CCWD 2011; City of Folsom 2011; Metropolitan 2010). The Urban Water Management Plans indicate that during the critical periods with reductions in water supplies, municipal and industrial water uses will be focused on inside water uses with little or no outside irrigation water.

At this time, no specific volumes have been identified for public health and safety quantities for the CVP and/or SWP water users. During the 2014 drought, the Department of Water Resources (DWR) and Reclamation identified 1,500 cubic feet per second as a minimum amount of CVP and SWP Delta exports for public health and safety uses for municipal and industrial water supplies. This amount is also defined by the limitations of the CVP and SWP conveyance facilities, as described in Chapter 5, Surface Water Resources and Water Supplies.

As described above, in 2014, CVP and SWP water supply allocations are at historically low values. However, it is difficult to identify local public health and safety issues, non-agricultural related industrial job losses, and economic losses associated with reductions in CVP and/or SWP water supplies. The potential economic losses, socioeconomic effects, and environmental justice effects are described in Chapter 19, Socioeconomics, and Chapter 21, Environmental Justice.

#### *18.3.1.2 Public Health and Safety Related to Available Agricultural Water Supplies*

Agricultural water suppliers have developed responses to the reductions in agricultural water supplies from the CVP and SWP, as described in Chapter 12, Agricultural Resources. Historically, the number of employment opportunities that rely directly or indirectly on the availability of CVP and/or SWP water supplies for irrigation have declined in the areas where the water supplies have declined, communities within the Central Valley Region and Southern California Region, as described in Chapter 19, Socioeconomics.

#### *18.3.1.3 Public Health and Safety Related to Water Supply Availability for Wildland Firefighting*

Complex terrain, Mediterranean climate, productive natural plant communities, and ample natural and aboriginal ignition sources has caused California to be a complex wildfire-prone and fire-adapted landscape. While natural wildfires support ecosystem health and are critical to maintaining the structure and function of ecosystems, wildfires pose a significant threat to life, public health, infrastructure, properties, and natural resources.

In accordance with Public Resources Code sections 4201 to 4204 and Government Code sections 51175 to 51189, the California Department of Forestry and Fire Prevention (CAL FIRE) has mapped areas of significant fire hazards based on fuels, terrain, weather, and other relevant factors. The zones are referred to as Fire Hazard Severity Zones and represent the risks associated with wildland fires. Under CAL FIRE regulations, areas within very high fire-hazard risk zones must comply with specific building and vegetation requirements intended to reduce property damage and loss of life within these areas.

According to CAL FIRE, there is an increasing trend of acres burned statewide, with particular increase in conifer vegetation types (CAL FIRE FRAP 2010). Statewide, there are 21.3 million acres of land designated as high priority landscape. The high priority landscape areas include locations with high value water supplies and high threats of fire and large communities which should be protected to prevent wildfire threats to maintain ecosystem health, water supplies, and large communities. These areas include the upper Trinity River watershed in the Trinity River Region; the upper Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and Millerton Lake watersheds in the Central Valley Region; and communities in throughout the Southern California Region. Areas designated as high priority landscape occur within 46 of 58 counties. Many rural counties have significant numbers of communities and acreage in medium priority landscape, including 508 communities with some high priority landscape areas.

CAL FIRE manages the State Responsibility Areas, and local fire districts manage Local Responsibility Areas. First responders are typically the local fire districts. The U.S. Forest Service provides wildland fire protection both independently and cooperatively with the California Department of Forestry and Fire Protection. In addition, the U.S. Department of the Interior National Park Service and Bureau of Land Management provide resource management and fire protection on portions of Federal lands.

Firefighting actions frequently involve use of water from reservoirs located close to wildland fires in the Trinity River, Central Valley, Central Coast, and Southern California regions, including reservoirs owned by Reclamation and DWR.

### 18.3.2 Public Health Issues Related to Mosquito-Borne Diseases

There are more than 50 species of mosquitos in California, including members of the four major genera: 24 species of *Aedes*, 5 species of *Anopheles*, 11 species of *Culex*, and 4 species of *Culiseta* (CDPH et al. 2012). Not all of these species are known to transmit mosquito-borne viruses, as described below. There are approximately 15 mosquito-borne viruses that occur in California; however, the most significant viruses that cause human disease are St. Louis encephalitis virus (SLEV), western equine encephalomyelitis (WEEV), and West Nile virus (WNV) (CDPH et al. 2014). No cases of SLEV or WEEV have been reported in humans over the past few years in California. Malaria also is a mosquito-borne disease that is caused by a parasite instead of a virus.

The *Culex tarsalis* has been identified as part of transmission of SLEV, WEEV, and WNV, especially in rural areas. The *Culex pipiens* and *Culex quinquefasciatus* have been identified as part of the transmission of WNV and SLEV. The *Culex stigmatosoma* has been identified as part of the transmission of WNV and SLEV, especially among birds. The *Aedes melanimon, Aedes vexans*, and *Culex erythrothorax* have been identified as species involved in transmitting the virus between birds and mammals or between mammals.

Mosquitoes, especially *Culex tarsalis*, live in every area of California, and can be a threat to the health of humans and domestic animals throughout the state. The mosquito life cycle requires water for the egg, larva, and pupa stages. Some of the species are more associated with irrigated agriculture, and others are more associated with urban communities (CDPH et al. 2014). Most of the diseases are not treatable and vaccines are not available for humans. Methods to prevent mosquitoes from becoming adults and methods to prevent mosquitos from biting humans are the only available and practical methods to protect public health.

California Health and Safety Code (Sections 2001 – 4(d); 2002; and 2060(b)) describes that landowners are legally responsible to eliminate public nuisances from their properties, including mosquito breeding habitat (CDPH 2008; CDPH et al. 2012). Federal, state, and local agencies supplement the preventive activities of individual landowners toward protecting humans and domestic animals from mosquito-borne diseases. The California Department of Public Health (CDPH) monitors mosquito populations throughout the state. In 1915, the state legislature enacted the Mosquito Abatement Act to allow local mosquito abatement special districts. The local mosquito and vector control districts monitor mosquito populations and take actions such as eliminating breeding sites, using biological control (predators such as mosquitofish), and using chemical control, to reduce mosquito population size (CDPH 2013a).

#### *18.3.2.1 St. Louis Encephalitis Virus*

The SLEV is a mosquito-borne virus that circulates among birds and is transmitted to humans via mosquito bites CALSURV 2013a; CDPH 2007). Human infection with SLE can cause mild to severe fever and headaches due to inflammation of the brain. In severe cases, the illness can cause disorientation and comas and possibly cause death. Elderly can become more severely ill than young children with SLEV as compared to WEEV.

Since the SLEV was first recognized in 1933 in St. Louis, Missouri, outbreaks have been reported throughout the United States, Canada, and northern Mexico, generally between August and October (CALSURV 2013a). In 1984 and 1989, 29 human cases were reported in the San Joaquin Valley of the Central Valley Region. During the same time periods, 26 human cases were reported in the Los Angeles area of the Southern California Region. The last human case reported in California occurred in 1997 in Los Angeles County.

#### *18.3.2.2 Western Equine Encephalitis*

The WEEV is another mosquito-borne virus that circulates among birds and is transmitted to horses and humans by mosquitoes (CDPH 2007). Symptoms are similar to SLEV. Infants and small children are most severely afflicted with WEEV as compared to SLEV. There is a vaccine for horses, but not for humans. Historically, substantial number of horses died due to this disease as well as humans. Recently, there has not been a recorded case of WEEV in humans in California (CDPH et al. 2014).

#### *18.3.2.3 West Nile Virus*

West Nile virus (WNV) can cause mild to severe illness in human, other mammals, and birds.

The virus circulates among birds and is transmitted to humans primarily by *Culex* mosquitoes (CDPH et al. 2014). The WNV was first detected in North America in New York in 1999, and has subsequently spread to 48 states, Canada, and Mexico.

The WNV first appeared in humans in California in 2002 with the identification of one human case (CALSURV 2013b). In 2003, three human cases and one equine case were reported with numerous verified findings of WNV activity among dead birds and mosquitoes. In 2004, the WNV was reported in 58 counties, with 779 human cases, including 29 WNV-associated deaths (CALSURV 2013b). From 2003 through 2013, there were 4,004 reported human cases of WNV with 145 deaths; 16,299 reported bird deaths; and 1,202 reported cases involving horses (CDPH 2014a). In 2007, 2008, and between 2010 and 2013, the majority of reported human cases occurred in the six counties in Southern California Region, with most of the cases reported in Los Angeles County. Between 2007 and 2013, numerous human cases were reported in Butte, Sutter, Sacramento, Stanislaus, Fresno, Tulare, and Kern counties in the Central Valley Region. During this same period, no human cases were reported in the Trinity River Region; Lassen, Plumas, and Nevada counties in the Central Valley Region; San Benito County in the San Francisco Bay Area Region; and San Luis Obispo County in the Central Coast Region.

In humans, WNV may not result in any symptoms or only mild viral symptoms, including mild fever, headache, body aches, skin rash, and swollen lymph glands. Symptoms in less than 1 percent of people that are infected can include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis that are associated with meningitis or encephalitis.

#### *18.3.2.4 Malaria*

Malaria also is a mosquito-borne disease caused by a parasite that destroys the red blood cells of its host. People with malaria often experience fever, chills, and flu-like illness which can lead to death (CDPH et al. 2012). Malaria is no longer endemic in California, as well as the rest of the United States, due to intense mosquito control efforts and anti-malarial drugs. However, the disease is diagnosed every year, especially in people who have traveled outside the United States. In 2012, 92 human cases were reported in California (CDPH 2013). Of the 92 cases, 90 patients had traveled to countries characterized as endemic with malaria during the previous three years. The *Anopheles* mosquitoes can transmit the parasite to humans and are prevalent in California (CDPH et al. 2012).

### 18.3.3 Public Health Issues Related to Valley Fever

Valley fever is an illness that is caused by inhaling the spores of a fungus *Coccidioides immitis* (CDPH 2013c). This fungus lives in the top layers of some soils within 2 to 12 inches from the ground surface. When the soil is disturbed by digging, vehicles, cultivation, or wind, the fungal spores can be inhaled by persons within the area. Irrigated soils are less likely to contain the fungus than dry, previously undisturbed soils.

In most cases, symptoms in humans include mild cough and flu-like symptoms (CDPH 2013c). However, in about 40 percent of the reported cases, the illness can last for more than a month, make the person susceptible to pneumonia, and include cough, fever, chest pain, headache, muscle ache, rash, joint pain, and/or fatigue. In about 5 percent of the reported cases, the disease becomes "disseminated Valley Fever" and can cause meningitis and/or affect bones, joints, skin, or other organs. There are no vaccines to prevent Valley Fever.

The *Coccidioides immitis* is endemic in many areas of the southwestern United States, Mexico, Central America, and South America. In California, the fungus is found in many areas of the San Joaquin Valley and Southern California (CDPH 2011, 2014b). In California between 2001 and 2012, there were over 35,000 reported cases of Valley Fever. The number of incidences increased from 1,483 cases in 2001 to 4,094 cases in 2012. The highest number of cases reported during this period occurred in Kings, Kern, Fresno, Tulare, and Madera counties in the San Joaquin Valley within the Central Valley Region; San Luis Obispo County in the Central Coast Region; and Los Angeles County in the Southern California Region.

In general, the people who have the highest risk of exposure to the fungus include construction workers, archeologists, geologists, wildland fighters, military personnel, mining or gas/oil extraction workers, and agricultural workers in non-irrigated areas (CDPH 2013c). Other employees also may be at risk. For example, members of the cast and crew of a television film became ill with Valley Fever after working on an outdoor set in Ventura County (CDCP 2014).

In 2011, Fresno, Kern, Kings, San Joaquin, San Luis Obispo, and Tulare counties conducted an analysis of information related to Valley Fever incidences (Fresno County et al. 2011). The observations included:

- More incidences were reported in the western parts of Kern, Kings, Fresno, and San Joaquin counties than in other portions of the counties.
- More incidences were reported in northern San Luis Obispo County and southern Tulare County than other portions of the counties.
- In recent years, there was increased reporting of Valley Fever in the prison populations in Fresno and Kings counties. In Kern County, 8 percent of the reported cases between 2005 and 2008 were prison inmates. In Fresno County, incidences at Pleasant Valley State Prison were 43 percent of the total cases in the county between 2004 and 2010. In Kings County, incidences at state prisons were 58 percent of the total cases in the county between 2007 and 2010.

In 2012, the San Joaquin Valley Air Pollution Control District (SJVAPCD) evaluated causes for Valley Fever and options to reduce social and economic effects of Valley Fever in the San Joaquin Valley (SJVAPCD 2012). The analysis described that Valley Fever appears to be related to a fungus that forms in subsoil strata that are dry through a portion of the year. The analysis referred to other studies that correlated weather patterns with outbreaks of Valley Fever during dry periods following periods of heavy rainfall. The study also indicated that airborne *Coccidioides* spores do not generally come from irrigated agriculture. It appears that it is more likely that the spores are from non-irrigated lands, including undisturbed natural lands, undeveloped land, and grazing areas. The study indicated that additional monitoring or reduction of particulate matter of

10 microns, or $PM_{10}$, did not appear to be useful in reduction of the potential for Valley Fever. The study recommended additional funding to develop a vaccine for Valley Fever.

### 18.3.4 Public Health Issues Related to High Concentrations of Mercury in Fish and Shellfish

As described in Chapter 6, Water Quality, high concentrations of certain substances accumulate in fish and shellfish based upon the water quality. The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) evaluates concentrations of potentially toxic substances in edible tissues of fish and shellfish harvested in water bodies in California (OEHHA 2014a). Based upon the evaluation, general and specific safe eating guidelines are developed for the fish and shellfish, as summarized in Table 18.1. For the water bodies in the study area, the primary constituents that have triggered the development of safe eating guidelines are mercury, dieldrin, and/or polychlorinated biphenyl (PCB). Other constituents are present, including selenium; however, the concentrations do not exceed thresholds that would trigger safe eating guidelines. The OEHHA develops two separate guidelines: (1) Guidelines for Children from 1 to 17 years and Women from 18 to 45 years; and (2) Guidelines for Women over 45 years old and Men over 17 years old. The guidelines recommend the number of servings per week by fish or shellfish harvested from specific waters. A "serving size" is defined as "about the size and thickness of your hand" (OEHHA 2014a).

**Table 18.1 Summary of Safe Eating Guidelines for Fish and Shellfish from Water Bodies in the Study Area Based on Mercury and PCB (servings per week)**

| Region | Water Body | Fish and Shellfish[a] | Guidelines for Children and Women up to 45 Years Old[b] | Guidelines for Men and Women over 45 Years Old[b] |
|---|---|---|---|---|
| **Trinity River** | Trinity Lake | Rainbow Trout, Brown Trout, White Catfish | 2 | 5 |
| | | Largemouth Bass, Smallmouth Bass | Do not eat | 1 |
| | Lewiston Lake | Trout | 5 | 7 |
| **Central Valley** | Sacramento River and Northern Delta | American Shad, Chinook Salmon, Rainbow Trout, Steelhead Trout | 2 to 3 | 7 |
| | | Clams | 7 | 7 |
| | | Bluegill, other sunfish, carp or goldfish, catfish, crappie, Crayfish, Hardhead, Hitch, sucker | 1 | 3 |

| Region | Water Body | Fish and Shellfisha | Guidelines for Children and Women up to 45 Years Oldb | Guidelines for Men and Women over 45 Years Oldb |
|---|---|---|---|---|
| **Central Valley (continued)** | | Bass, Pikeminnow, White Sturgeon | Do not eat | 1 |
| | | Striped Bass | Do not eat | 2 |
| | Lake Oroville | Bluegill and Green Sunfish | 2 | 5 |
| | | Carp, Coho salmon | 1 | 2 |
| | | Largemouth Bass, Smallmouth Bass, Redeye, or Spotted Bass; Channel Catfish; White Catfish | Do not eat | 1 |
| | Lower Feather River | American Shad, Chinook Salmon, Steelhead Trout | 2 to 3 | 7 |
| | | Carp, sucker | 1 | 2 |
| | | Redear, other sunfish | 1 | 3 |
| | | Black Bass, catfish, Pikeminnow, Striped Bass, White Sturgeon | Do not eat | 1 |
| | Englebright Lake | Rainbow Trout | 2 | 7 |
| | | Bluegill, other sunfish | 1 | 2 |
| | | Largemouth Bass, Smallmouth Bass, Spotted Bass | Do not eat | 1 |
| | Rollins Reservoir | Catfish | 1 | 2 |
| | Camp Far West Reservoir | Bluegill, other sunfish | 1 | 3 |
| | | Largemouth Bass, Smallmouth Bass, Spotted Bass, catfish | Do not eat | 1 |
| | Folsom Lake | Bluegill, Green Sunfish, or other sunfish; Rout: 16 inches or less | 2 | 5 |

| Region | Water Body | Fish and Shellfisha | Guidelines for Children and Women up to 45 Years Oldb | Guidelines for Men and Women over 45 Years Oldb |
|---|---|---|---|---|
| **Central Valley (continued)** | | Catfish; Chinook Salmon; Largemouth Bass, Smallmouth Bass, Spotted Bass, trout: over 16 inches | Do not eat | 1 |
| | Lake Natoma | Bluegill, Green Sunfish, or other sunfish; trout: 16 inches or less | 2 | 5 |
| | | Chinook Salmon; Largemouth Bass, Smallmouth Bass, Spotted Bass, trout: over 16 inches | Do not eat | 1 |
| | | Catfish | Do not eat | Do not eat |
| | Lower American River | American Shad, Chinook Salmon, steelhead trout | 2 to 3 | 7 |
| | | Redear or other sunfish, sucker, white catfish | 1 | 2 |
| | | Striped Bass | Do not eat | 2 |
| | | Bass, Pikeminnow | Do not eat | 1 |
| | Lower Mokelumne River | American Shad, Chinook Salmon, steelhead trout | 2 to 3 | 7 |
| | | Clams | 7 | 7 |
| | | Bluegill or other sunfish, Crayfish, catfish | 1 | 2 |
| | | Striped Bass | Do not eat | 2 |
| | | Bass, Pikeminnow, White Sturgeon | Do not eat | 1 |
| | San Joaquin River (Friant Dam to Port of Stockton) | Chinook Salmon, steelhead trout | 2 | 7 |
| | | Bluegill or other sunfish | 2 | 5 |
| | | American Shad | 3 | 7 |
| | | Carp, catfish, sucker | 1 | 2 |

| Region | Water Body | Fish and Shellfisha | Guidelines for Children and Women up to 45 Years Oldb | Guidelines for Men and Women over 45 Years Oldb |
|---|---|---|---|---|
| **Central Valley (continued)** | | Striped Bass | Do not eat | 2 |
| | | Bass, white sturgeon | Do not eat | 1 |
| | Central and South Delta | American Shad, Chinook Salmon, Bluegill or other sunfish, steelhead trout | 2 | 7 |
| | | Catfish, Crayfish | 2 | 5 |
| | | Clams | 7 | 7 |
| | | Bass, carp, crappie, sucker | 1 | 2 |
| | | Striped Bass | Do not eat | 2 |
| | | White Sturgeon | Do not eat | 1 |
| **San Francisco Bay Area** | San Francisco Bay | Chinook Salmon | 2 | 7 |
| | | Brown Rockfish, Red Rock Crab | 2 | 5 |
| | | Jacksmelt | 2 | 2 |
| | | California Halibut | 1 | 2 |
| | | White Croaker | 1 | 1 |
| | | Sharks, Striped Bass, White Sturgeon | Do not eat | 1 |
| | | Surfperches | Do not eat | Do not eat |
| | San Pablo Reservoir | Crappie | 2 | 5 |
| | | Trout | 5 | 5 |
| | | Largemouth Bass, Smallmouth Bass, Spotted Bass | Do not eat | 1 |
| | | Carp, catfish | Do not eat | Do not eat |
| | Lafayette Reservoir | Crappie | 4 | 7 |
| | | Bass | 1 | 2 |
| | | Carp or Goldfish | Do not eat | 1 |

| Region | Water Body | Fish and Shellfisha | Guidelines for Children and Women up to 45 Years Oldb | Guidelines for Men and Women over 45 Years Oldb |
|---|---|---|---|---|
| **San Francisco Bay Area (continued)** | Lake Chabot | Redear or other sunfish | 2 | 4 |
| | | Channel Catfish | 1 | 1 |
| | | Bass | Do not eat | 1 |
| | | Carp | Do not eat | Do not eat |
| **Southern California Region** | Pyramid Lake | Rainbow Trout | 7 | 7 |
| | | Channel Catfish | 1 | 2 |
| | | Largemouth Bass, Smallmouth Bass | Do not eat | 1 |
| | | Bullhead | Do not eat | Do not eat |
| | Silverwood Lake | Rainbow Trout | 7 | 7 |
| | | Tule Perch | 1 | 1 |
| | | Largemouth Bass, Bluegill, Channel Catfish | Do not eat | 1 |
| | | Striped Bass, Blackfish, Tui Chub | Do not eat | Do not eat |
| **Statewide** | All Lakes and Reservoirs without Site-Specific Advice | Rainbow trout | 2 | 6 |
| | | Bullhead, catfish, Bluegill or other sunfish, Brown Trout: 16 inches or less | 1 | 2 |
| | | Bass, carp, Brown Trout: over 16 inches | Do not eat | 1 |
| | All Rivers, Estuaries, and Coastal Waters without Site-Specific Advice | American Shad, Chinook Salmon, steelhead trout | 2 to 3 | 7 |

| Region | Water Body | Fish and Shellfish[a] | Guidelines for Children and Women up to 45 Years Old[b] | Guidelines for Men and Women over 45 Years Old[b] |
|---|---|---|---|---|
| **Statewide (continued)** | | Striped Bass | Do not eat | 2 |
| | | White Sturgeon | Do not eat | 1 |

Sources: OEHHA 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2014h, 2014i, 2014j, 2014k, 2014l, 2014m, 2014n, 2014o, 2014p, 2014q, 2014r, 2014s, 2014t, 2014u, 2014v, 2014w

Notes:
a. All fish and shellfish names are as appears in the OEHHA guidelines.
b. The OEHHA guidelines refer to the total number of servings of fish per week for one water body, not just the total for a specific species. For example, OEHHA guidelines for Men eating fish from Trinity Lake would include no more than 5 servings of Rainbow Trout, Brown Trout, or White Catfish; OR 1 serving of Largemouth Bass or Smallmouth Bass.

Resident Delta fish accumulate mercury primarily through dietary exposure; larger, piscivorous (fish-eating) fish show the greatest levels of tissue mercury. In contrast to anadromous fish (migratory species), the resident fish experience constant exposure to local mercury sources. Resident species include larger fish with human health exposure (such as Largemouth Bass) and smaller, forage fish (such as Inland Silversides). Fish tissues are the ultimate route of exposure to mercury for humans who consume locally caught fish.

Historically, substantial levels of mercury contamination have occurred in fish throughout the Delta. Mercury concentrations in tissue of the larger piscivorous fish are lower in for fish in the central Delta as compared to fish from the Mokelumne, Cosumnes, Sacramento, and San Joaquin rivers (CVRWQCB 2010a, 2010b). Larger, piscivorous resident fish, in general, provide a good record of fish tissue mercury as a baseline condition for the Delta. Largemouth Bass were chosen because they are popular sport fish, top predators, live for several years, and tend to stay in the same area (exhibit high site fidelity). Consequently, they are excellent indicators of long-term average mercury exposure, risk, and spatial pattern for ecological and human health. Mercury in sport fish from the Delta region was reported for Largemouth Bass as a median tissue mercury concentration of 0.53 mg mercury per kilogram (Hg/kg) wet weight (Davis et al. 2003). Current fish tissue concentrations thus exceed both adopted regulatory standards and guidance from the U.S. Environmental Protection Agency (USEPA). In the 2010 Delta TMDL for methylmercury, the Central Valley Regional Water Quality Control Board (Central Valley RWQCB) established a fish tissue threshold (fillet concentrations, wet weight mercury) of 0.24 mg Hg/kg wet weight in trophic level 4 fish (adult, top predatory sport fish, such as Largemouth Bass) (Central Valley Water Board 2010a). These values are slightly lower than USEPA's national recommended water quality criterion for fish tissue of 0.3 mg Hg/kg wet weight for protection of human health and wildlife (USEPA

2001). Therefore, the Delta average for Largemouth Bass fillet concentrations in the study by Davis et al. exceeds both recommended safe consumption guidelines.

# 18.4 Impact Analysis

This section describes the potential mechanisms for change in conditions and analytical methods; results of impact analyses; potential mitigation measures; and cumulative effects.

## 18.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in public health factors related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change public health factors affected by CVP and SWP operations.

### *18.4.1.1 Changes in Public Health Factors Related to Available CVP and SWP Agricultural Water Supplies*

Changes in water supply availability to agricultural water users could result in reductions of irrigated acreage and related jobs. The availability of jobs can affect public health, as described in Section 18.3.2, Public Health Issues Related to Available Water Supplies. As described in Chapter 12, Agricultural Resources, agricultural acreage would be similar under Alternatives 1 through 5, No Action Alternative, and Second Basis of Comparison. Therefore, the change in public health conditions would be the same under all of the alternatives and the Second Basis of Comparison; and is not analyzed in this EIS.

### *18.4.1.2 Changes in Public Health Factors Related to Available Municipal Water Supplies*

As described in Section 18.3.2, Public Health Issues Related to Available Water Supplies, water supply availability can affect public health related to direct use within the household and indirect effects related to adequate water supplies for industrial and commercial water users that provide employment. As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 18, Socioeconomics, t municipal and industrial water users would rely upon alternate water supplies to meet water demands in 2030. Therefore, public health conditions related to availability of municipal and industrial water supplies would be the same under all of the alternatives and the Second Basis of Comparison; and is not analyzed in this EIS.

### *18.4.1.3 Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Stored water in water supply reservoirs is used for wildland firefighting in the California foothills and mountains, including water stored in CVP and SWP reservoirs. During drier periods, reduced storage levels could affect the availability of water for wildlife firefighting, as indicated in changes in CVP and SWP reservoir at the end of September in critical dry water years, as described in Chapter 5, Surface Water Resources and Water Supplies.

Reservoirs that store water in the San Francisco Bay Area, Central Coast, and Southern California regions are managed to store water supplies as part of short-term conveyance management or storage for regional and local water supplies using water from numerous sources and water for wildland firefighting is not known; and therefore, are not analyzed in this EIS.

#### 18.4.1.4 Changes in Public Health Factors Related to Wetlands Restoration and Mosquito-Borne Diseases

Wetlands provide habitat for mosquito breeding, especially in tidally-influenced wetlands with slow moving water and floodplains after the majority of the water recedes. Management practices (e.g., designing wetlands to provide flushing flows, use of biological controls) can reduce the nuisance and public health aspects of mosquito populations. The extent of seasonal floodplains and tidally-influenced wetlands in Yolo Bypass, Cache Slough, and Suisun Marsh areas would increase in a similar manner under all of the alternatives and the Second Basis of Comparison, as described in Chapter 3, Description of Alternatives. Therefore, the potential for changes in public health conditions related to mosquito populations would be the same under all of the alternatives and the Second Basis of Comparison; and is not analyzed in this EIS.

#### 18.4.1.5 Changes in Public Health Factors Related to Potential Valley Fever

As described above, recent studies have indicated that valley fever exposure appears to be related to cultivated lands, including lands that are idled due to agricultural practices or reduced water supply availability. Changes in CVP and SWP operations under the alternatives and the Second Basis of Comparison would not affect the extent of non-irrigated lands. Therefore, the potential for changes in public health conditions related to Valley Fever would be the same under all of the alternatives and the Second Basis of Comparison; and is not analyzed in this EIS.

#### 18.4.1.6 Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption

As described above, fish used for human consumption in the Delta have mercury levels that exceed OEHHA guidelines. Changes in CVP and SWP operations under the alternatives and the Second Basis of Comparison would change the accumulated mercury concentrations in fish in the Delta. As described in Chapter 6, Surface Water Quality, the bioavailability and toxicity of mercury is enhanced through the natural, bacterial conversion of mercury to methylmercury in marshlands or wetlands. These stagnant locations with reduced oxygen concentrations promote chemical reduction processes that make methylation possible. The methylmercury model is based upon the Total Maximum Daily Load translation equation for mercury developed by the Central Valley Regional

Water Quality Control Board. The model estimates fish tissue concentrations from waterborne concentrations of mercury in the Delta and evaluates the potential to cause exceedances of water quality or tissue benchmarks. The tissue concentrations associated with the Alternatives 1 through 5 were compared to the No Action Alternative and the Second Basis of Comparison.

### 18.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to public health that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *18.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies. Due to climate change and related lower snowfall, end of September low reservoir storage would be lower in critical dry years by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir. Therefore, the potential for reduced reservoir water supplies for wildland firefighting would be greater under the No Action Alternative and Second Basis of Comparison as compared to recent historical conditions.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives.

Under the No Action Alternative and Second Basis of Comparison, it is anticipated that mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions. Phase 1 of the Delta Mercury Program mandated by the Central Valley RWQCB is currently being completed to protect people eating one meal per week of larger fish from the Delta, including Largemouth Bass. Phase 1 is focused on studies and pilot projects to develop and evaluate management practices to control methylmercury from mercury sources in the Delta and Yolo Bypass; and to reduce total mercury loading to the San Francisco Bay. Following completion of Phase 1 in 2019, Phase 2 will be implemented through 2030. Phase 2 will focus on methylmercury control programs and reduction programs for total inorganic mercury. Due to the extent of these studies, it is not anticipated that changes in methylmercury or total mercury concentrations in fish tissue will be reduced by 2030. Future mercury reduction and control programs will reduce mercury sources and related fish tissue concentrations; however, that will occur after 2030.

### 18.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

### *18.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 18.4.3.1.1 Trinity River Region

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years (changes within 5 percent) at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under the No Action Alternative as compared to the Second Basis of Comparison.

#### 18.4.3.1.2 Central Valley Region

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years (changes within 5 percent) at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under the No Action Alternative as compared to the Second Basis of Comparison.

End of September surface water elevations at San Luis Reservoir in critical dry years would be 6 percent lower under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, the potential for water availability for wildland firefighting would be reduced at San Luis Reservoir under the No Action Alternative as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar (within 5 percent change) in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would increase by 7 percent over long-term conditions under the No Action Alternative as compared to the Second Basis of Comparison.

Under dry and critical dry years, mercury concentrations would increase by 7 to 8 percent at Rock Slough, intakes of the Banks and Jones pumping plants, and Victoria Canal. All values exceed the threshold of 0.24 mg/kg ww for mercury.

#### *18.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because CVP and SWP operations under Alternative 1 are identical to conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 18.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 1 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 1 as compared to the No Action Alternative.

End of September surface water elevations at San Luis Reservoir in critical dry years would be 7 percent higher under Alternative 1 as compared to the No Action Alternative. Therefore, the potential for water availability for wildland firefighting would be increased at San Luis Reservoir under Alternative 1 as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would decrease by 6 percent over the long-term conditions under Alternative 1 as compared to the No Action Alternative. Under dry and critical dry years, mercury concentrations would decrease by 6 to 8 percent at Rock Slough, intakes of the

Banks and Jones pumping plants, and Victoria Canal. All values exceed the threshold of 0.24 mg/kg ww for mercury.

##### 18.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *18.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 18.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to public health conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 18.4.3.1, No Action Alternative.

#### *18.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 18.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 3 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 3 as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar (within 5 percent change) in most locations in the Delta, except for San Joaquin River near Antioch and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would decrease by 6 percent over the long-term conditions under Alternative 3 as compared to the No Action Alternative. Mercury concentrations under the dry and critical dry years would be similar throughout the Delta. All values exceed the threshold of 0.24 mg/kg ww for mercury.

#### 18.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar throughout the Delta under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Chapter 6, Surface Water Quality. All values exceed the threshold of 0.24 mg/kg ww for mercury.

### *18.4.3.5 Alternative 4*

The public health conditions under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

#### 18.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in public health conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 12.4.4.2.1, Alternative 1 Compared to the No Action Alternative.

### *18.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 18.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 5 as compared to the No Action Alternative.

*Central Valley Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end of September reservoir elevations in critical dry years at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 5 as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar throughout the Delta under Alternative 5 as compared to the No Action Alternative, as summarized in Chapter 6, Surface Water Quality. All values exceed the threshold of 0.24 mg/kg ww for mercury.

#### 18.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years at Trinity Lake, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 5 as compared to the Second Basis of Comparison.

*Central Valley Region*

*Changes in Public Health Factors Related to Wildland Firefighting and CVP and SWP Reservoir Storage*

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end of September reservoir elevations in critical dry years at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, the potential for water availability for wildland firefighting would be similar under Alternative 5 as compared to the Second Basis of Comparison.

End of September surface water elevations at San Luis Reservoir in critical dry years would be 9 percent lower under Alternative 5 as compared to the Second Basis of Comparison. Therefore, the potential for water availability for wildland firefighting would be reduced at San Luis Reservoir under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would increase by 7 to 8 percent over long-term conditions under Alternative 5 as compared to the Second Basis of Comparison. During dry and critical dry years, mercury concentrations also would increase by 7 percent at intakes to Banks Pumping Plant and Jones Pumping Plant; and 13 percent at Rock Slough. All values exceed the threshold of 0.24 mg/kg ww for mercury.

### *18.4.3.7 Summary of Environmental Consequences*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 18.2 and 18.3, respectively.

**Table 18.2 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir; and a 7 percent increase at San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 6 percent decrease near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | None needed |
| Alternative 2 | No effects on public health issues. | None needed |
| Alternative 3 | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 6 percent decrease near San Joaquin River at Antioch and Montezuma Slough over the long-term conditions. | None needed |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta. | None needed |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 18.3 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir; and a 6 percent decrease at San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | Not considered for this comparison. |
| Alternative 1 | No effects on public health issues. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta. | Not considered for this comparison. |
| Alternative 4 | No effects on public health issues. | Not considered for this comparison. |
| Alternative 5 | Similar water supply availability for wildland firefighting at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir; and a 9 percent decrease at San Luis Reservoir.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

#### *18.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in changes in public health factors. Therefore, there would be no adverse impacts to public health factors; and no mitigation measures are required.

#### *18.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analyses for Alternatives 1 through 5 for Public Health are summarized in Table 18.4.

**Table 18.4 Summary of Cumulative Effects on Public Health with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs | These effects would be the same under all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce end of September storage in CVP and SWP reservoirs.<br>Mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions because Phases 1 and 2 of the Delta Mercury Program would be completed by 2030, as mandated by the Central Valley RWQCB, including methylmercury control programs and reduction programs for total inorganic mercury. Due to the extent of these programs, it is anticipated that the programs would be initiated; however, future reductions in mercury sources and related reductions of mercury and |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - Folsom Dam Water Control Manual Update<br>- FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | methylmercury concentrations in fish tissue would actually occur after 2030. |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project<br>- Semitropic Water Storage District Delta Wetlands | These effects would be the same under all alternatives.<br>Reasonably foreseeable storage projects would increase reservoir storage at Shasta Lake and Los Vaqueros Reservoir, and provide new reservoir storage at North-of-the-Delta Offstream Storage, Upper San Joaquin River Basin Storage, and Delta Wetlands. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - North Bay Aqueduct Alternative Intake<br>- San Luis Reservoir Low Point Improvement Project<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce end of September CVP and SWP reservoir storage as compared to past conditions. Mercury and methylmercury concentrations in fish tissue would be similar or greater than past conditions. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions. |

## 18.5 References

Alpers et al. (Alpers C, Eagles-Smith C, Foe C, Klasing S, Marvin-DiPasquale M, Slotton D, and Winham-Myers L). 2008. *Mercury conceptual model*. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

CAL FIRE FRAP (California Department of Forestry and Fire Protection, Fire and Resource Assessment Program). 2010. *California's Forests and Rangelands: 2010 Assessment*. Sacramento, CA.

CALSURV (California Vectorborne Disease Surveillance System). 2013a. *St. Louis Encephalitis Virus*. Site accessed February 25, 2013. http://www.calsurv.org/node/59

CALSURV (California Vectorborne Disease Surveillance System). 2013b. *West Nile Virus*. Site accessed February 25, 2013. http://www.calsurv.org/node/57

CALSURV (California Vectorborne Disease Surveillance System). 2013c. *Malaria*. Site accessed February 25, 2013. http://www.calsurv.org/node/47

CCWD (Contra Costa Water District). 2011. *Urban Water Management Plan*. June.

CDCP (Centers for Disease Control and Prevention). 2014. *Coccidioidomycosis Among Cast and Crew Members at an Outdoor Television Filming Event – California, 2012*. April 18.

CDPH (California Department of Public Health). 2007. *Mosquito-Borne Encephalitis/Encephalomyelitis*.

CDPH (California Department of Public Health). 2008. *Overview of Mosquito Control Practices in California*. July.

CDPH (California Department of Public Health). 2011. *Coccidioidomycosis Yearly Summary Report, 2001 – 2010*. September 10.

CDPH (California Department of Public Health). 2013a. *Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks, Supplement to California Mosquito-Borne Virus Surveillance and Response Plan*. June.

CDPH (California Department of Public Health). 2013b. *Vector-Borne Disease Section, 2012 Annual Report*. September.

CDPH (California Department of Public Health). 2013c. *Preventing Work-Related Coccidioidomycosis (Valley Fever)*. June.

CDPH (California Department of Public Health). 2014a. *The California Department of Public Health West Nile Virus Website, Latest West Nile Virus Activity in California; and WNV Activity by County (2007 -2013)*. Site accessed June 3, 2014. http://www.westnile.ca.gov/.

CDPH (California Department of Public Health). 2014b. *Epidemiologic Summary of Coccidioidomycosis in California, 2009 – 2012*. January 21.

CDPH et al. (California Department of Public Health and Mosquito and Vector Control Association of California). 2012. *Best Management Practices for Mosquito Control in California*. July.

CDPH et al. (California Department of Public Health and Mosquito and Vector Control Association of California). 2014. *California Mosquito-Borne Virus Surveillance & Response Plan*. April.

Central Valley RWQCB (Central Valley Regional Water Quality Control Board). 2010a. *Resolution No. R5-2010-0043, Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary*. April 22.

Central Valley RWQCB (Central Valley Regional Water Quality Control Board). 2010b. *Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury*. *Staff Report*. April.

City of Folsom. 2011. *2010 Urban Water Management Plan*. June.

Davis et al. (Davis, J.A., D. Yee, J.N. Collins, S.E. Schwarzbach, and S.N. Luoma). 2003. Potential for increased mercury accumulation in the estuary food web. *San Francisco Estuary and Watershed Science* 1.1 (2003): 1-36.

DWR (Department of Water Resources). 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

DWR (Department of Water Resources). 2014a. *Notice to State Water Project Contractors, 2014 State Water Project Allocation – Zero Percent, Number 14-02*. January 31.

DWR (Department of Water Resources). 2014b. *Notice to State Water Project Contractors, 2014 State Water Project Allocation Increase back to 5 Percent, Number 14-07*. April 18.

DWR, Reclamation, USFWS, and NMFS (California Department of Water Resources, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service). 2013. *Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. November.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Fresno County et al. (Fresno County, Kern County, Kings County, San Joaquin County, San Luis Obispo County, and Tulare County). 2011. *Epidemiology of Coccidioidomycosis in Six California Counties, 2011*.

Metropolitan (Metropolitan Water District of Southern California). 2010. *Regional Urban Water Management Plan*. November

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014a. *Fish, How to Follow Advisories*. Site accessed June 5, 2014. http://www.oehha.ca.gov/fish/advisory.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014b. *Fish, Safe Eating Guidelines for Fish from Trinity Lake and the East Fork Trinity River (Trinity County), Updated 03/18/09) Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/TrinRiverF2.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014c. *Fish, Safe Eating Guidelines for Trout from Lewiston Lake, Carrville Pond, and the Trinity River Upstream from Trinity Lake (Trinity County), [Updated 03/18/09] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/Lewiston.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014d. *Fish, Safe Eating Guidelines for Fish and Shellfish from the Sacramento River and Northern Delta (Solano, Sacramento, Yolo, Sutter, Colusa, Yuba, Glenn, Butte, Tehama, and Shasta Counties) [Updated 11/25/13] Based on Mercury and PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/srnd041108.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014e. *Fish, A Guide to Eating Fish from Lake Oroville (Butte County), [07/16/13]*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/nor_cal/orovilleAdv.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014f. *Fish, Safe Eating Guidelines for Fish from the Lower Feather River (Butte, Yuba, and Sutter Counties), [Updated*

*02/15/12] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/Featherdraft081006.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014g. *Fish, Safe Eating Guidelines for Fish from Englebright Lake (Placer and Nevada Counties), [03/18/09] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/englebright.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014h. *Fish, Safe Eating Guidelines for Fish from Rollins Reservoir (Nevada and Placer Counties), [Updated 03/18/09] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/rollins.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014i. *Fish, Safe Eating Guidelines for Fish from Camp Far West Reservoir (Yuba, Nevada, and Placer Counties), [Updated 03/18/09] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/campfarwest.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014j. *Fish, Health Advisory and Safe Eating Guidelines for Fish from Folsom Lake (Sacramento, El Dorado, and Placer Counties), [10/15/08] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/folnat101108.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014k. *Fish, Health Advisory and Safe Eating Guidelines for Fish from Lake Natoma (Sacramento, El Dorado, and Placer Counties), [10/15/08] Based on Mercury*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/LakeNatoma.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014l. *Fish, Safe Eating Guidelines for the Lower American River (Sacramento County), [Updated 02/15/12] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/fnatoma.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014m. *Fish, Safe Eating Guidelines for Fish from the Lower Mokelumne River and Nearby Creeks and Sloughs (Sacramento County), [Updated 02/15/12] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/CosMo042806.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014n. *Fish, Safe Eating Guidelines for Fish from the San Joaquin River Between Friant Dam and the Port of Stockton (San Joaquin, Stanislaus, Merced, Madera, and Fresno Counties), [Updated 11/26/13] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/sjrsd030907.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014o. *Fish, Safe Eating Guidelines for Fish and Shellfish from the Central and South Delta, [Updated 11/25/13] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/centralsouthdelta.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014p. *A Guide to Eating San Francisco Bay Fish and Shellfish, [11/04/11] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/nor_cal/2011SFbay.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014q. *Fish, Health Advisory and Safe Eating Guidelines for Fish from San Pablo Reservoir (Contra Costa County), [02/26/09] Based on Mercury or Dieldrin*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/spadvise022609.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014r. *Fish, Safe Eating Guidelines for Fish from Lafayette Reservoir (Contra Costa County), [03/08/09] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/lafayette.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014s. *Fish, Safe Eating Guidelines for Fish from Lake Chabot (Alameda County), [03/18/09] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/chabot.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014t. *Fish, Safe Eating Guidelines for Fish from Pyramid Lake (Los Angeles County), [03/06/13] Based on Mercury or PCBs*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/pyramidlake.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014u. *Fish, Guidelines for Eating Fish from Silverwood Lake (San Bernardino County), [08/10/13]*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/so_cal/silverwood.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014v. *Statewide Advisory for Eating Fish from California's Lakes and Reservoirs without Site-Specific Advice [08/01/13]*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/special_reports/advisorylakesres.html.

OEHHA (Office of Environmental Health Hazard, California Environmental Protection Agency). 2014w. *A Guide to Eating American Shad, Chinook (King) Salmon, Steelhead Trout, Striped Bass, and White Sturgeon Caught in California's Rivers, Estuaries, and Coastal Waters [02/15/12]*. Site accessed June 4, 2014. http://oehha.ca.gov/fish/special_reports/anadro021512.html.

Reclamation (Bureau of Reclamation). 2005. *FONSI and Final Environmental Assessment Central Valley Project M&I Water Shortage Policy*. December 19.

Reclamation (Bureau of Reclamation). 2013a. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2013b. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2014a. *Reclamation Announces Initial 2014 Central Valley Project Water Supply Allocation*. February 21.

Reclamation (Bureau of Reclamation). 2014b. *Reclamation Announces Update to 2014 Central Valley Project Water Supply for Exchange Contractors and Refuges South of the Delta*. May 13.

Reclamation (Bureau of Reclamation). 2014c. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014d. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014e. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014f. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

SJVAPCD (San Joaquin Valley Air Pollution Control District). 2012. *Memorandum to the Governing Board, District Options for Addressing Valley Fever*. May 2.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

Wiener et al. (Wiener, J. G., C. C. Gilmour, and D. P. Krabbenhoft). 2003. Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration. *Final Report to the California Bay-Delta Authority*.

Chapter 19

# Socioeconomics

## 19.1 Introduction

This Chapter describes socioeconomic conditions in the Study Area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect socioeconomic conditions through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) that would change CVP and SWP water supply availability to agricultural water users and municipal and industrial (M&I) water users. Changes in CVP and SWP operations also would result in changes to recreational resources at reservoirs that store CVP and SWP water.

Changes in agricultural production, including costs to provide Alternative water supplies when CVP and SWP water supplies are not available, are presented in Chapter 12, Agricultural Resources. Changes in reservoir recreational opportunities that would occur due to reduction in reservoir storage elevations are presented in Chapter 15, Recreational Resources. The results of these analyses are summarized in Section 19.4, Environmental Consequences, of this Chapter and considered in the determination of regional socioeconomics effects.

## 19.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect socioeconomic conditions in portions of the Study Area affected by or served by CVP and SWP water supplies. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 19.3 Affected Environment

This section describes socioeconomic conditions that could be potentially affected by implementation of the alternatives considered in this EIS. The socioeconomic conditions described in this Chapter are related to population, employment, income, and taxes.

Housing information is not described in this Chapter because implementation of the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5 would not result in changes to land use that would displace or relocate housing stocks. Land use would be the same under the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5, as described in Chapter 13, Land Use. The only changes in land use between recent historical conditions and conditions in 2030 for the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5 would occur due to ecosystem restoration on agricultural lands, open space, and public lands that do not support housing units.

### 19.3.1 Characterization of Socioeconomic Conditions

Characterization of the socioeconomic conditions within the Study Area is based upon publically available data sources. The data sources used include the U.S. Census Bureau, U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, California Department of Finance, California Employment Development Department, and California Board of Equalization. The data were summarized and used to compare historical and current trends in the socioeconomic conditions in the Study Area.

Population and income data used to characterize the socioeconomic conditions are reported from 2000 to 2012 by the California Department of Finance.

The employment data presented in this Chapter are reported from 2001 to 2008 and from 2008 to 2012 (the latest values from consistent data sources). The first period from 2001 to 2008 represents a period of time prior to implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and the 2009 National Marine Fisheries Service (NMFS) BO. The second period from 2008 to 2012 represents a period of time following implementation of the 2008 USFWS BO and 2009 NMFS BO.

There are two estimates of employment that are typically used to describe employment. The civilian labor force employment data compiled by the Bureau of Labor Statistics reflect the employment status of individuals that are covered by unemployment insurance by “place of residence,” and includes the self-employed, employees on unpaid leave of absence, unpaid family workers, and household workers. These data do not include sole proprietors, some self-employed, and some farm workers and domestic workers. Employment by industry data compiled by the Bureau of Economic Analysis, including farm employment, reflect jobs by “place of work” and include sole proprietors and active partners, self-employed, farm workers, and domestic workers. Individuals with more than one job are counted only once in civilian labor force data and counted in each job in the employment by industry data. Therefore, the employment by industry data are greater than the civilian labor force data.

### 19.3.2 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. Tribal lands along the Trinity or lower Klamath River within the Trinity River Region include the

Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria.

Trinity County includes extensive trails, lakes, and the Trinity River Scenic Byway, providing several venues for outdoor enthusiasts and travelers. The recreation and tourism industries are major contributors to the local economy of Trinity County (EDD 2013).

Humboldt County is the largest and most populous of the north coast counties. Its 2012 population of 134,728 ranked 35th among the 58 counties in California (EDD 2014a). Humboldt County encompasses 2.3 million acres, 80 percent of which is forestlands, protected redwoods and recreation areas (Humboldt County 2014). Humboldt County is the leading timber producing county in the state (CDFA 2014). As described in Chapter 13, Land Use, the portion of Humboldt County in the Trinity River Region evaluated in this EIS is located along the Trinity and Klamath rivers. This portion of the county includes the communities of Willow Creek and Orleans within Humboldt County; Hoopa in the Hoopa Valley Indian Reservation; and the communities of Weitchpec, Cappell, Pecwan, and Johnson's in the Yurok Tribe Indian Reservation (Humboldt County 2012).

Del Norte County is the northernmost county in California. The county includes Redwood National Park and other state parks making tourism a natural industry in the county (EDD 2014b). As described in Chapter 13, Land Use, the portion of Del Norte County in the Trinity River Region evaluated in this EIS is located along the lower Klamath River. Most of this area is located within the Yurok Indian Reservation, and includes the communities of Requa and Klamath (Del Norte County 2003).

##### *19.3.2.1 Population*

Population in the Trinity River Region, by county and for the region as a whole, is presented in Table 19.1. The population of Trinity River Region has increased, although at a small average annual growth rate for the period shown.

**Table 19.1 Population Characteristics in Trinity River Region**

| Area | Population 2000 | Population 2012 | Average Annual Growth Rate (percent) 2000-2012 |
|---|---|---|---|
| Trinity County | 13,022 | 13,471 | 0.3 |
| Humboldt County | 126,518 | 134,728 | 0.5 |
| Del Norte County | 27,507 | 28,527 | 0.3 |
| Total Trinity River Region | 167,047 | 176,726 | 0.5 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,427,946** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

Tribal enrollment for the Hoopa Valley Tribe, Yurok Tribe, Karuk Tribe, and Resighini Rancheria as reported by the Bureau of Indian Affairs is presented in Table 19.2. These values do not necessarily include all members that live within the area, and should be considered as representative of trends. Values were only available for the years of 2001, 2003, 2005, and 2013.

**Table 19.2 Tribal Enrollment in Trinity River Region**

| Tribe | 2001 | 2003 | 2005 | 2013 |
|---|---|---|---|---|
| Hoopa Valley Tribe | 1,893 | 1,893 | 1,893 | 1,719[a] |
| Yurok Tribe | 4,466 | 4,466 | 4,912 | Not available |
| Karuk Tribe | 3,165 | 3,165 | 3,427 | Not available |
| Resighini Rancheria | 90 | 175 | 111 | Not available |
| **TOTAL** | **9,614** | **9,699** | **10,343** | **–** |

Sources: BIA 2003, 2006, 2008, 2014
Note:
a. Value is reported as population, not enrollment, for Hoopa Valley Tribe in 2013.

#### *19.3.2.2 Employment*

Civilian labor force characteristics for the Trinity River Region are presented in Table 19.3. The civilian labor force (composed of employment and unemployment) in the Trinity River Region increased between 2001 and 2008 and between 2008 and 2012 (BLS 2014).

**Table 19.3 Civilian Labor Force and Unemployment Rates in Trinity River Region**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Trinity County | 5,394 | 4,855 | 5,019 | 9.3 | 12.7 | 15.8 |
| Humboldt County | 60,443 | 60,039 | 60,144 | 6.0 | 7.2 | 10.5 |
| Del Norte County | 10,221 | 11,376 | 11,381 | 8.0 | 8.8 | 13.4 |
| Total Trinity River Region | 76,058 | 76,270 | 76,544 | 6.5 | 7.8 | 11.2 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **5.4** | **7.2** | **10.5** |

Source: BLS 2014

Available labor force and unemployment rates for members of the tribes in the Trinity River Region are presented in Table 19.4. These individuals may or may not be included in the values presented in Table 19.3 because different sources are used for each table.

**Table 19.4 Available Labor Force and Unemployment Rates Related to the Tribes in Trinity River Region**

| Area | Civilian Labor Force | | | | Unemployment Rate (percent) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | 2003 | 2005 | 2013 | 2001 | 2003 | 2005 | 2013 |
| Hoopa Valley Tribe | 1,043 | 1,043 | 1,043 | NA | 40 | 40 | 40 | 42 |
| Yurok Tribe | 2,151 | 2,151 | 1,096 | NA | 74 | 74 | 74 | 38 |
| Karuk Tribe | 3,307 | 3,307 | 915 | NA | 14 | 14 | 63 | 29 |
| Resighini Rancheria | 37 | 44 | 45 | NA | 57 | 59 | 60 | NA |

Sources: BIA 2003, 2006, 2008, 2014
Note:
NA = Not Available

Total employment and the farm employment in 2001, 2008 and 2012 in the Trinity River Region counties are presented in Table 19.5. The Trinity River Region farm employment represents less than 1 percent of farm employment in the state and the lowest amount of farm employment in counties within the Study Area, as indicated in Figure 19.1.

**Table 19.5 Employment in Trinity River Region**

| Area | Total Employment | | | Farm Employment[a] | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Trinity County | 4,878 | 4,930 | 4,788 | 155 | 161 | 165 |
| Humboldt County | 68,596 | 71,552 | 68,861 | 1,662 | 1,383 | 1,227 |
| Del Norte County | 10,266 | 11,531 | 10,720 | 384 | 309 | 231 |
| Total Trinity River Region | 83,740 | 88,013 | 84,369 | 2,201 | 1,853 | 1,623 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a.

Note:
a. Farm employment includes employment numbers in forestry, fishing, and related activities.

#### *19.3.2.3 Income*

Per capita personal income for the Trinity River Region counties for 2000, 2008, and 2012 is presented in Table 19.6. Humboldt County had the highest per capita income, and Del Norte County had the lowest.

**Table 19.6 Per Capita Personal Income in Trinity River Region**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Trinity County | $20,489 | $28,861 | $34,027 | 4.4 | 4.2 |
| Humboldt County | $23,980 | $32,859 | $35,681 | 4.0 | 2.1 |
| Del Norte County | $18,563 | $26,420 | $30,016 | 4.5 | 3.2 |
| Total Trinity River Region | $22,818 | $31,497 | $34,647 | 4.1 | 2.4 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$43,647** | **3.5** | **1.4** |

Source: BEA 2014e

#### *19.3.2.4 Local Government Finances*

The sales tax rates, as of April 1, 2014, were 7.5 percent in all three counties in the Trinity River Region (BOE 2014). Total annual taxable sales within the Trinity River Region in 2000, 2008, and 2012 are presented in Table 19.7. The region's total taxable sales represents less than one tenth of one percent of total annual state taxable sales.

**Table 19.7 Total Taxable Sales in Trinity River Region**

| Area | Total Taxable Sales (millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Trinity County | $61 | $74 | $87 | 2.6 | 3.9 |
| Humboldt County | $1,293 | $1,693 | $1,768 | 3.4 | 1.1 |
| Del Norte County | $176 | $232 | $226 | 3.5 | -0.6 |
| Total Trinity River Region | $1,530 | $1,999 | $2,081 | 3.4 | 1.0 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

Total property tax charges (secured and unsecured) within the Trinity River Region in Fiscal Year 2011-2012 were $160.2 million (California State Controller 2012). The Humboldt County share of the total property tax revenues was the largest at $126 million. The Del Norte and Trinity counties contributions to the total were $19 million and $13 million, respectively.

## 19.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, and Delta and Suisun Marsh subregions.

### *19.3.3.1 Sacramento Valley*

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, and El Dorado counties. Sacramento, Yolo, and Solano counties also are located within the Sacramento Valley; however, these counties are discussed below as part of the Delta and Suisun Marsh subsection. Other counties in Sacramento Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties.

The Sacramento Valley includes major agricultural counties, including Glenn, Colusa, Sutter and Placer counties, as described in Chapter 12, Agricultural Resources. The region also includes some of the leading major timber producing counties of the state. Shasta County is the second and Plumas County is the fifth among the leading timber producing counties in the state.

#### 19.3.3.1.1 Population

Population characteristics in the Sacramento Valley portion of the Central Valley Region are presented in Table 19.8. Among the counties evaluated in the Sacramento Valley portion of the Central Valley Region, Placer County had the highest average annual population growth rate between 2000 and 2012; and Plumas County was the only county with a reduction in population.

**Table 19.8 Population Characteristics in Central Valley Region – Sacramento Valley**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| Shasta County | 163,256 | 177,516 | 0.8 |
| Plumas County | 20,824 | 19,901 | -0.4 |
| Tehama County | 56,039 | 62,985 | 1.1 |
| Glenn County | 26,453 | 28,105 | 0.6 |
| Colusa County | 18,804 | 21,552 | 1.2 |
| Butte County | 203,171 | 220,465 | 0.7 |
| Yuba County | 60,219 | 72,642 | 1.6 |
| Nevada County | 92,033 | 97,366 | 0.5 |
| Sutter County | 78,930 | 94,620 | 1.7 |
| Placer County | 248,399 | 351,463 | 3.2 |
| El Dorado County | 156,299 | 180,483 | 1.3 |
| Sacramento Valley Subtotal | 1,124,427 | 1,333,615 | 1.4 |
| Total Central Valley Region | 6,214,316 | 7,408,750 | 1.5 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

### 19.3.3.1.2 Employment

Civilian labor force characteristics for the counties in the Sacramento Valley portion of the Central Valley Region are presented in Table 19.9. The civilian labor force increased between 2001 and 2012. The data for 2008 represents the employment situation immediately following the recent economic recession that started in 2007. The average unemployment rate in the civilian labor force increased from 2001 to 2012. The average unemployment rate in the Sacramento Valley portion of the Central Valley Region between 2001 and 2012 has been higher than the state unemployment rate; and lower than for the counties in the Central Valley Region.

**Table 19.9 Civilian Labor Force and Unemployment Rates in Central Valley Region – Sacramento Valley**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Shasta County | 77,647 | 82,675 | 81,245 | 6.3 | 10.0 | 13.4 |
| Plumas County | 9,958 | 9,824 | 9,478 | 7.6 | 10.5 | 14.7 |
| Tehama County | 24,574 | 25,185 | 25,251 | 6.5 | 9.2 | 13.9 |
| Glenn County | 11,239 | 12,196 | 12,841 | 8.8 | 10.4 | 14.7 |
| Colusa County | 9,130 | 10,505 | 11,860 | 12.8 | 13.7 | 20.0 |
| Butte County | 95,216 | 102,952 | 102,063 | 6.6 | 8.4 | 12.2 |
| Yuba County | 24,862 | 27,729 | 27,772 | 8.5 | 11.8 | 16.9 |
| Nevada County | 46,947 | 50,428 | 50,742 | 4.4 | 6.5 | 9.4 |
| Sutter County | 38,457 | 41,100 | 42,810 | 9.7 | 12.3 | 17.6 |
| Placer County | 139,106 | 177,243 | 178,818 | 4.0 | 6.4 | 9.4 |
| El Dorado County | 84,064 | 90,732 | 90,525 | 4.3 | 6.9 | 10.4 |
| Sacramento Valley Subtotal | 561,200 | 630,569 | 633,405 | 5.8 | 8.3 | 12.0 |
| Total Central Valley Region | 3,519,870 | 3,885,435 | 3,990,083 | 6.8 | 8.7 | 12.6 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008, and 2012 in the Sacramento Valley portion of the Central Valley Region are presented in Table 19.10. The contribution of farm employment to the total employment in the Sacramento Valley portion of the Central Valley Region declined between 2001 and 2008 and increased slightly by 2012.

**Table 19.10 Employment in Central Valley Region – Sacramento Valley**

| Area | Total Employment | | | Farm Employment | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Shasta County | 85,937 | 91,883 | 86,696 | 1,821 | 1,781 | 1,751 |
| Plumas County | 10,813 | 10,524 | 9,493 | 288 | 140 | 138 |
| Tehama County | 23,760 | 24,284 | 22,669 | 2,716 | 2,332 | 3,042 |
| Glenn County | 11,526 | 11,987 | 11,856 | 2,873 | 1,927 | 2,049 |
| Colusa County | 9,770 | 10,863 | 11,266 | 2,943 | 1,954 | 1,831 |
| Butte County | 99,757 | 105,703 | 101,805 | 5,293 | 4,618 | 4,527 |
| Yuba County | 26,162 | 26,473 | 26,861 | 2,494 | 1,722 | 1,623 |
| Nevada County | 51,323 | 57,968 | 55,898 | 1,161 | 1,153 | 1,089 |
| Sutter County | 39,489 | 43,764 | 43,329 | 5,454 | 4,165 | 4,427 |
| Placer County | 158,070 | 192,171 | 188,729 | 2,064 | 1,925 | 1,844 |
| El Dorado County | 78,052 | 95,608 | 90,435 | 1,937 | 1,849 | 1,737 |
| Sacramento Valley Subtotal | 594,659 | 671,228 | 649,037 | 29,044 | 23,566 | 24,058 |
| Total Central Valley Region | 3,616,241 | 3,997,557 | 3,923,230 | 256,672 | 226,321 | 230,832 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a

Note:

Farm employment includes employment numbers in forestry, fishing, and related activities.

The annual farm employment for the Sacramento Valley portion of the Central Valley Region declined in 2004 and remained relatively stable through 2012, as shown in Figure 19.2. The overall trend in farm employment is influenced by the farm employment trends in Butte, Sutter, Tehama, Colusa, and Glenn counties, as shown in Figure 19.3. The decrease in farm employment is related to the reduction in cultivated acreage during this period, as described in Chapter 12, Agricultural Resources.

The farm employment numbers presented in Table 19.10 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in the Central Valley Region; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and processing of food and fiber grown on farms. As a result, employment both directly on farm and indirectly dependent on farming is higher than the values displayed in Table 19.10.

#### 19.3.3.1.3 Income

The average per capita personal incomes for the counties in the Sacramento Valley portion of the Central Valley Region are presented in Table 19.11. Per capita personal incomes increased by an average annual rate of between 3 and 6 percent from 2000 to 2008. Following the economic downturn that started in 2007, the average annual growth in per capita personal income slowed between 2008 and 2012, except in Tehama County.

**Table 19.11 Per Capita Personal Income in Central Valley Region – Sacramento Valley**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Shasta County | $25,385 | $34,995 | $37,593 | 4.1 | 1.8 |
| Plumas County | $26,415 | $38,401 | $43,085 | 4.8 | 2.9 |
| Tehama County | $19,461 | $25,805 | $30,094 | 3.6 | 3.9 |
| Glenn County | $20,210 | $32,054 | $38,568 | 5.9 | 4.7 |
| Colusa County | $24,656 | $39,568 | $45,800 | 6.1 | 3.7 |
| Butte County | $23,143 | $32,379 | $35,696 | 4.3 | 2.5 |
| Yuba County | $19,537 | $27,655 | $32,835 | 4.4 | 4.4 |
| Nevada County | $32,253 | $44,960 | $47,924 | 4.2 | 1.6 |
| Sutter County | $25,581 | $33,117 | $36,243 | 3.3 | 2.3 |
| Placer County | $38,034 | $49,436 | $52,544 | 3.3 | 1.5 |
| El Dorado County | $37,397 | $50,052 | $54,533 | 3.7 | 2.2 |
| Average in Sacramento Valley Counties | $29,317 | $40,177 | $43,873 | 4.0 | 2.2 |
| Central Valley Region | $28,163 | $37,207 | $40,619 | 3.5 | 2.2 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

#### 19.3.3.1.4 Local Government Finances

As of April 1, 2014, the county sales tax rates in the counties within the Sacramento Valley portion of the Central Valley Region was 7.5 percent for all counties except Nevada County (BOE 2014). The Nevada County sales tax rate was 7.625 percent. These rates include the state, county, local and district taxes.

The total annual taxable sales in the Sacramento Valley portion of the Central Valley Region in 2000, 2008, and 2012 are presented in Table 19.12. The total taxable sales represent about 3 percent of total annual state taxable sales. The lower rates of growth for the period 2008 to 2012 may be attributable to the effects of the recession that started in 2007 and a decline in employment, as discussed above.

**Table 19.12 Total Taxable Sales in Central Valley Region – Sacramento Valley**

| Area | Total Taxable Sales (millions) | | | Average Annual Growth Rate | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Shasta County | $2,055 | $2,641 | $2,642 | 3.2 | 0.0 |
| Plumas County | $187 | $222 | $197 | 2.1 | -2.9 |
| Tehama County | $470 | $684 | $748 | 4.8 | 2.3 |
| Glenn County | $231 | $318 | $327 | 4.1 | 0.7 |
| Colusa County | $223 | $329 | $337 | 5.0 | 0.6 |
| Butte County | $2,039 | $2,678 | $2,714 | 3.5 | 0.3 |
| Yuba County | $392 | $515 | $486 | 3.5 | -1.4 |
| Nevada County | $997 | $1,187 | $1,105 | 2.2 | -1.8 |
| Sutter County | $1,021 | $1,287 | $1,367 | 2.9 | 1.5 |
| Placer County | $4,742 | $6,635 | $7,066 | 4.3 | 1.6 |
| El Dorado County | $1,324 | $1,788 | $1,740 | 3.8 | -0.7 |
| Sacramento Valley Subtotal | $13,680 | $18,283 | $18,729 | 3.7 | 0.6 |
| Central Valley Region | $83,363 | $109,401 | $114,959 | 3.5 | 1.2 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

Combined (secured and unsecured) property tax revenues in each of the counties in the Sacramento Valley portion of the Central Valley Region for Fiscal Year 2011-2012 are presented in Table 19.13. Total property tax revenues from these counties accounted for about 3 percent of the total state property tax revenues.

**Table 19.13 Property Tax Revenues, Fiscal Year 2011-2012, in Central Valley Region – Sacramento Valley**

| Area | Property Tax Revenues (millions) |
|---|---|
| Shasta County | $168 |
| Plumas County | $41 |
| Tehama County | $48 |
| Glenn County | $30 |
| Colusa County | $36 |
| Butte County | $203 |
| Yuba County | $62 |
| Nevada County | $183 |
| Sutter County | $103 |
| Placer County | $692 |
| El Dorado County | $300 |
| Sacramento Valley Subtotal | $1,866 |
| Central Valley Region | $9,874 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2012

#### *19.3.3.2 San Joaquin Valley*

The San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern counties. San Joaquin County also is located within the San Joaquin Valley; however, this county is discussed below as part of the Delta and Suisun Marsh subsection. Other counties in the San Joaquin Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Calaveras, Mariposa, and Tuolumne counties.

The San Joaquin Valley includes the major agricultural counties, of Fresno, Kern, Kings and Tulare, as described in Chapter 12, Agricultural Resources.

##### 19.3.3.2.1 Population

Population characteristics in the San Joaquin Valley portion of the Central Valley Region are presented in Table 19.14. Among the counties in the San Joaquin Valley portion of the Central Valley Region, Kern County had the highest average annual population growth rate between 2000 and 2012; and Stanislaus and Kings counties had the lowest growth rate.

**Table 19.14 Population Characteristics in Central Valley – San Joaquin Valley**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| Stanislaus County | 446,997 | 519,339 | 1.3 |
| Madera County | 123,109 | 152,325 | 1.8 |
| Merced County | 210,554 | 260,029 | 1.8 |
| Fresno County | 799,407 | 943,493 | 1.4 |
| Tulare County | 368,021 | 451,540 | 1.7 |
| Kings County | 129,461 | 151,774 | 1.3 |
| Kern County | 661,653 | 849,977 | 2.1 |
| San Joaquin Valley Subtotal | 2,739,202 | 3,328,477 | 1.6 |
| Total Central Valley Region | 6,062,064 | 7,238,742 | 1.5 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

##### 19.3.3.2.2 Employment

Civilian labor force characteristics for the counties in the San Joaquin Valley portion of the Central Valley Region are presented in Table 19.15. The civilian labor force increased between 2001 and 2012. The data for 2008 represents the employment situation immediately following the recession that started in 2007. The average unemployment rate in the civilian labor force increased from 2001 to 2012. The average unemployment rates for the San Joaquin Valley portion of the Central Valley Region between 2001 and 2012 have been higher than for the entire Central Valley Region and the state.

**Table 19.15 Civilian Labor Force and Unemployment Rates in Central Valley Region – San Joaquin Valley**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Stanislaus County | 214,292 | 231,965 | 239,461 | 8.3 | 11.0 | 15.2 |
| Madera County | 53,956 | 65,100 | 68,167 | 9.6 | 9.4 | 13.6 |
| Merced County | 91,825 | 102,251 | 111,322 | 10.1 | 12.5 | 17.0 |
| Fresno County | 389,805 | 430,163 | 442,453 | 10.7 | 10.5 | 15.2 |
| Tulare County | 175,357 | 199,124 | 207,634 | 11.4 | 10.8 | 15.8 |
| Kings County | 50,233 | 58,801 | 60,886 | 10.7 | 10.5 | 15.3 |
| Kern County | 297,982 | 359,573 | 396,657 | 8.6 | 9.8 | 13.3 |
| San Joaquin Valley Subtotal | 1,273,450 | 1,446,977 | 1,526,580 | 9.8 | 10.5 | 14.9 |
| Total Central Valley Region | 3,448,061 | 3,807,278 | 3,911,569 | 6.8 | 8.7 | 12.6 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008 and 2012 in the San Joaquin Valley portion of the Central Valley Region are presented in Table 19.16. The contribution of farm employment to the total employment declined between 2001 and 2008, and then increased slightly in 2012, except in Tulare County. In Tulare County, farm employment increased between 2001 and 2008 and decreased between 2008 and 2012.

**Table 19.16 Employment in Central Valley Region – San Joaquin Valley**

| Area | Total Employment | | | Farm Employment | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Stanislaus County | 208,016 | 221,632 | 214,446 | 18,708 | 16,000 | 15,784 |
| Madera County | 50,975 | 59,354 | 59,027 | 6,296 | 4,750 | 5,186 |
| Merced County | 82,803 | 92,891 | 93,766 | 14,147 | 12,029 | 8,075 |
| Fresno County | 401,025 | 446,939 | 437,934 | 56,655 | 50,798 | 51,277 |
| Tulare County | 168,523 | 191,195 | 186,875 | 42,851 | 38,080 | 36,369 |
| Kings County | 48,960 | 57,513 | 55,008 | 4,705 | 4,061 | 6,620 |
| Kern County | 311,946 | 369,152 | 386,642 | 46,307 | 47,661 | 52,583 |
| San Joaquin Valley Subtotal | 1,272,248 | 1,438,676 | 1,433,698 | 189,669 | 173,379 | 175,894 |
| Total Central Valley Region | 3,616,241 | 3,997,557 | 3,923,230 | 256,672 | 226,321 | 230,832 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a

Note:
Farm employment includes employment numbers in forestry, fishing, and related activities.

Annual farm employment for the San Joaquin Valley portion of the Central Valley Region declined in 2004 and continued to fluctuate through 2012, as shown in Figure 19.2. Farm employment in the San Joaquin Valley portion of the Central Valley Region represents a major portion of the overall farm employment in the Central Valley.

Within the counties in the San Joaquin Valley portion of the Central Valley Region, farm employment declined between 2003 and 2006 and remained about the same between 2007 and 2012. The overall trend in farm employment is influenced by the farm employment trends in Fresno, Kern, and Tulare counties, as shown in Figure 19.4. The decrease in farm employment is related to the reduction in cultivated acreage during this period, as described in Chapter 12, Agricultural Resources.

The farm employment numbers presented in Table 19.16 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in the Central Valley; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and processing of food and fiber grown on farms. As a result, employment both directly on farm and indirectly dependent on farming is higher than the values displayed in Table 19.16.

Total farm-dependent employment is not reported in the U.S. Bureau of Economic Analysis or the U.S. Bureau of Labor Statistics; however, the employment values can be estimated by studies of local economies. A study of the local economy in four counties of the San Joaquin Valley found that, for every on-farm job, about two and one-half additional jobs are supported because of inputs purchased for farming operations (NEA 1997). This estimate includes the associated effects of workers on those farms and businesses spending their incomes on other purchases; however, the estimated values do not include employment in the processing sector. Another study indicated that the employment multiplier of the agricultural production and processing industry is 1.92, or that for every 100 agricultural production and processing jobs in the San Joaquin Valley, 92 other jobs were created in the San Joaquin Valley (UCAIC 2009).

San Joaquin Valley employment also includes employment associated with adult prison facilities. The San Joaquin Valley portion of the Central Valley Region includes eight (or about 24 percent) of the 33 adult prison facilities operated by the California Department of Corrections and Rehabilitation. These prisons are home to about a quarter of the total prison population in the state and employ about a quarter of the total prison staff in the state. Employment for these prisons is summarized in Table 19.17.

**Table 19.17 California State Prisons in Central Valley Region - San Joaquin Valley**

| Prison Facility | Location | Staff |
|---|---|---|
| Central California Women's Facility | Chowchilla, Madera County | 1,064 |
| Valley State Prison | Chowchilla, Madera County | 1,021 |
| Pleasant Valley State Prison | Coalinga, Fresno County | 1,357 |
| Avenal State Prison | Avenal, Kings County | 1,475 |
| California State Prison | Corcoran, Kings County | 2,003 |
| Wasco State Prison | Wasco, Kern County | 1,523 |
| North Kern State Prison | Delano, Kern County | 1,393 |
| Kern Valley State Prison | Delano, Kern County | 1,545 |

Sources: CDCR 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2014h

Federal prisons are located at Atwater in Merced County, Mendota in Fresno County, and Taft in Kern County within the San Joaquin Valley portion of the Central Valley Region (BOP 2014).

### 19.3.3.2.3 Income

The average per capita personal income in the San Joaquin Valley portion of the Central Valley Region was lower than that for the entire Central Valley Region, as presented in Table 19.18. The average per capita personal income in the San Joaquin Valley portion of the Central Valley Region was a little more than two-thirds of the average per capita personal income in the Central Valley Region and the state. With the exception of Stanislaus County, most counties in the San Joaquin Valley portion of the Central Valley Region had higher annual average growth in per capita personal income between 2000 and 2008 than the entire Central Valley Region and the state.

**Table 19.18 Per Capita Personal Income in Central Valley Region – San Joaquin Valley**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Stanislaus County | $24,284 | $31,093 | $34,138 | 3.1 | 2.4 |
| Madera County | $18,983 | $26,693 | $31,169 | 4.4 | 4.0 |
| Merced County | $19,976 | $26,963 | $30,630 | 3.8 | 3.2 |
| Fresno County | $23,001 | $30,977 | $34,074 | 3.8 | 2.4 |
| Tulare County | $20,070 | $28,035 | $31,307 | 4.3 | 2.8 |
| Kings County | $16,912 | $26,339 | $31,835 | 5.7 | 4.9 |
| Kern County | $21,507 | $29,527 | $34,453 | 4.0 | 3.9 |
| Average in San Joaquin Valley Counties | $21,755 | $29,505 | $33,303 | 3.9 | 3.1 |
| Central Valley Region | $28,183 | $37,198 | $40,601 | 3.5 | 2.2 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

#### 19.3.3.2.4 Local Government Finances

As of April 1, 2014, the county sales tax rates in the counties within the San Joaquin Valley portion of the Central Valley ranged from 7.5 percent in Merced, Kern, and Kings counties to 8.225 percent in Fresno County (BOE 2014).

The total annual taxable sales for the counties in the San Joaquin Valley portion of the Central Valley Region in 2000, 2008, and 2012 are presented in Table 19.19. The contribution of the area to California total annual taxable sales increased between 2000 and 2012. The lower rates of growth for the period 2008 to 2012 may be attributable to the effects of the recession that started in 2007 and a decline in employment, as discussed above.

**Table 19.19 Total Taxable Sales in Central Valley Region – San Joaquin Valley**

| Area | Total Taxable Sales (millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Stanislaus County | $5,195 | $6,729 | $7,178 | 3.3 | 1.6 |
| Madera County | $881 | $1,327 | $1,356 | 5.2 | 0.5 |
| Merced County | $1,740 | $2,388 | $2,512 | 4.0 | 1.3 |
| Fresno County | $8,472 | $11,729 | $12,021 | 4.2 | 0.6 |
| Tulare County | $3,222 | $4,755 | $5,499 | 5.0 | 3.7 |
| Kings County | $888 | $1,389 | $1,386 | 5.8 | -0.1 |
| Kern County | $6,938 | $12,086 | $14,666 | 7.2 | 5.0 |
| Total San Joaquin Valley | $27,337 | $40,403 | $44,619 | 5.0 | 2.5 |
| Central Valley Region | $81,975 | $107,699 | $113,368 | 3.5 | 1.3 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

The combined (secured and unsecured) property tax revenues in each of the counties in the San Joaquin Valley portion of the Central Valley Region for Fiscal Year 2011-2012 are presented in Table 19.20. Total property tax revenues from these counties accounted for about 6 percent of the total state property tax revenues.

**Table 19.20 Property Tax Revenues, Fiscal Year 2011-2012, in Central Valley Region – San Joaquin Valley**

| Area | Property Tax Revenues (millions) |
|---|---|
| Stanislaus County | $426 |
| Madera County | $128 |
| Merced County | $197 |
| Fresno County | $755 |
| Tulare County | $327 |
| Kings County | $104 |
| Kern County | $1,102 |
| San Joaquin Valley Subtotal | $3,039 |
| Central Valley Region | $9,874 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2012

#### *19.3.3.3 Delta and Suisun Marsh*

The Delta and Suisun Marsh portion of the Central Valley Region includes Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties. These counties include some of the leading agricultural areas in the state. In addition to agriculture, this area includes important transportation infrastructures including inland shipping ports (Port of West Sacramento and Port of Stockton); major employment centers (cities of Sacramento, West Sacramento, Fairfield, Stockton, and Concord); and water-based recreation activities (e.g., boating, fishing, and water skiing).

##### 19.3.3.3.1 Population

Population characteristics in the counties of the Delta and Suisun Marsh portion of the Central Valley Region are presented in Table 19.21. San Joaquin County had the highest average annual population growth rate between 2000 and 2012, and Solano County had the lowest growth rate.

**Table 19.21 Population Characteristics in Central Valley Region – Delta and Suisun Marsh**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| Sacramento County | 1,223,499 | 1,433,525 | 1.3 |
| Yolo County | 168,660 | 204,349 | 1.6 |
| Solano County | 394,930 | 415,787 | 0.4 |
| San Joaquin County | 563,598 | 692,997 | 1.7 |
| Contra Costa County | 948,816 | 1,066,602 | 1.0 |
| Delta and Suisun Marsh Subtotal | 3,299,503 | 3,813,260 | 1.2 |
| Total Central Valley Region | 6,062,064 | 7,238,742 | 1.5 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

### 19.3.3.3.2 Employment

Civilian labor force characteristics for the Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties are presented in Table 19.22. The civilian labor force in these counties increased between 2001 and 2012. The data for 2008 represents the employment situation immediately following the recession in 2007.

**Table 19.22 Civilian Labor Force and Unemployment Rates in Central Valley Region – Delta and Suisun Marsh**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Sacramento County | 624,693 | 680,373 | 680,349 | 4.5 | 7.2 | 10.6 |
| Yolo County | 88,331 | 98,438 | 98,475 | 5.1 | 7.4 | 11.5 |
| Solano County | 197,178 | 211,369 | 217,024 | 4.6 | 6.8 | 10.1 |
| San Joaquin County | 266,288 | 293,190 | 298,468 | 7.5 | 10.4 | 15.2 |
| Contra Costa County | 508,730 | 524,519 | 535,782 | 4.1 | 6.2 | 9.0 |
| Delta and Suisun Marsh Subtotal | 1,685,220 | 1,807,889 | 1,830,098 | 4.9 | 7.4 | 10.8 |
| Total Central Valley Region | 3,448,061 | 3,807,278 | 3,911,569 | 6.8 | 8.7 | 12.6 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008, and 2012 in the Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties are presented in Table 19.23. The contribution of farm employment to the total employment declined slightly between 2001 and 2008, and then increased slightly between 2008 and 2012.

**Table 19.23 Employment in Central Valley Region – Delta and Suisun Marsh**

| Area | Total Employment | | | Farm Employment | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Sacramento County | 739,256 | 806,976 | 784,386 | 5,176 | 4,019 | 3,924 |
| Yolo County | 110,902 | 122,054 | 117,609 | 5,244 | 5,364 | 5,745 |
| Solano County | 162,874 | 174,565 | 169,096 | 3,321 | 2,144 | 2,116 |
| San Joaquin County | 260,809 | 286,171 | 277,260 | 21,088 | 16,939 | 17,496 |
| Contra Costa County | 475,493 | 497,887 | 492,144 | 3,130 | 910 | 1,599 |
| Delta and Suisun Marsh Subtotal | 1,749,334 | 1,887,653 | 1,840,495 | 37,959 | 29,376 | 30,880 |
| Total Central Valley Region | 3,616,241 | 3,997,557 | 3,923,230 | 256,672 | 226,321 | 230,832 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a

Note:

Farm employment includes employment numbers in forestry, fishing, and related activities.

Annual farm employment for the Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties declined in 2004, slightly increased in 2006, and continued to fluctuate through 2012, as shown in Figure 19.5. Within these counties, farm employment started to decline in 2004 and began to increase slightly in 2006, as shown in Figure 19.5. The overall trend in farm employment in the Delta and Suisun Marsh portion of the Central Valley Region is influenced by the farm employment trends in San Joaquin County. The decrease in farm employment is related to the reduction in cultivated acreage during this period, as described in Chapter 12, Agricultural Resources.

The farm employment numbers presented in Table 19.23 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in many counties in the Central Valley Region; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and processing of food and fiber grown on farms. As a result, employment both directly on farm and indirectly dependent on farming is higher than the values displayed in Table 19.23.

#### 19.3.3.3.3 Income

The average per capita personal income in the Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties was about 15 percent higher than the average per capita personal income in the entire Central Valley Region, as presented in Table 19.24. San Joaquin and Contra Costa counties experienced the lowest average annual growth rates in per capita personal income between 2000 and 2008. Between 2008 and 2012, Yolo County was the only county with a slightly higher average annual growth rate as compared to the entire Central Valley Region.

**Table 19.24 Per Capita Personal Income in Central Valley Region – Delta and Suisun Marsh**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Sacramento County | $29,406 | $38,782 | $41,837 | 3.5 | 1.9 |
| Yolo County | $27,093 | $37,488 | $41,811 | 4.1 | 2.8 |
| Solano County | $28,373 | $39,178 | $42,354 | 4.1 | 2.0 |
| San Joaquin County | $25,147 | $31,250 | $33,024 | 2.8 | 1.4 |
| Contra Costa County | $45,576 | $58,547 | $61,638 | 3.2 | 1.3 |
| Average in Delta and Suisun Marsh Counties | $33,079 | $42,861 | $45,829 | 3.3 | 1.7 |
| Central Valley Region | $28,183 | $37,198 | $40,601 | 3.5 | 2.2 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

#### 19.3.3.3.4 Local Government Finances

As of April 1, 2014, the county sales tax rates in the Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties ranged between 7.5 percent in Yolo to 8 percent in San Joaquin (BOE 2014).

Total annual taxable sales for Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties in 2000, 2008, and 2012 are presented in Table 19.25. Between 2000 and 2008 Yolo, Solano, and San Joaquin counties experienced average annual growth in total taxable sales that were higher than the entire Central Valley Region and the state. Between 2008 and 2012, Sacramento County experienced negative average annual growth in total taxable sales.

**Table 19.25 Total Taxable Sales in Central Valley Region – Delta and Suisun Marsh**

| Area | Total Taxable Sales (millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Sacramento County | $16,594 | $19,332 | $19,090 | 1.9 | -0.3 |
| Yolo County | $2,416 | $3,347 | $3,475 | 4.2 | 0.9 |
| Solano County | $4,424 | $6,033 | $6,038 | 4.0 | 0.0 |
| San Joaquin County | $6,582 | $8,696 | $9,011 | 3.5 | 0.9 |
| Contra Costa County | $12,331 | $13,308 | $13,997 | 1.0 | 1.3 |
| Delta and Suisun Marsh Counties | $42,347 | $50,715 | $51,611 | 2.3 | 0.4 |
| Central Valley Region | $81,975 | $107,699 | $113,368 | 3.5 | 1.3 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

The combined (secured and unsecured) property tax revenues in Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties for Fiscal Year 2011-2012 are presented in Table 19.26. Total property tax revenues from these counties accounted for about 9 percent of the total state property tax revenues.

**Table 19.26 Property Tax Revenues, Fiscal Year 2011-2012, in Central Valley Region – Delta and Suisun Marsh**

| Area | Property Tax Revenues (millions) |
|---|---|
| Sacramento County | $1,539 |
| Yolo County | $270 |
| Solano County | $497 |
| San Joaquin County | $684 |
| Contra Costa County | $1,979 |
| Delta and Suisun Marsh Counties | $4,969 |
| Central Valley Region | $9,874 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2012

## 19.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. Contra Costa County also is part of the San Francisco Bay Area Region. However, for this chapter, Contra Costa County is discussed under Section 19.3.4.3, Delta and Suisun Marsh.

### *19.3.4.1 Population*

Population characteristics in the San Francisco Bay Area Region are presented in Table 19.27. The population of the San Francisco Bay Area Region grew slightly less than a quarter million, or at an average annual growth rate of less than one half of one percent between 2000 and 2012.

**Table 19.27 Population Characteristics in San Francisco Bay Area Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| Alameda County | 1,443,939 | 1,530,176 | 0.5 |
| Santa Clara County | 1,682,585 | 1,813,696 | 0.6 |
| San Benito County | 53,234 | 56,137 | 0.4 |
| Napa County | 124,279 | 137,731 | 0.9 |
| Total San Francisco Bay Area Region | 3,304,037 | 3,537,740 | 0.6 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

#### 19.3.4.2 Employment

Civilian labor force characteristics for the counties in the San Francisco Bay Area Region are presented in Table 19.28. The civilian labor force in the counties within the San Francisco Bay Area Region declined between 2001 and 2008, and then increased between 2008 and 2012. The data for 2008 represents the employment situation immediately following the onset of the recession in 2007.

**Table 19.28 Civilian Labor Force and Unemployment Rates in San Francisco Bay Area Region**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Alameda County | 778,472 | 757,566 | 775,855 | 4.8 | 6.2 | 9.0 |
| Santa Clara County | 939,501 | 870,251 | 910,983 | 5.1 | 6.0 | 8.4 |
| San Benito County | 27,461 | 24,870 | 26,611 | 6.3 | 9.6 | 13.9 |
| Napa County | 70,447 | 75,670 | 77,843 | 3.6 | 5.1 | 7.8 |
| Total San Francisco Bay Area Region | 1,815,881 | 1,728,357 | 1,791,292 | 4.9 | 6.1 | 8.7 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008 and 2012 in the San Francisco Bay Area Region are presented in Table 19.29. The contribution of farm employment to total employment in the San Francisco Bay Area Region declined slightly between 2001 and 2008, and remained relatively stable between 2008 and 2012.

**Table 19.29 Employment in San Francisco Bay Area Region**

| Area | Total Employment | | | Farm Employment | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Alameda County | 886,316 | 906,403 | 894,625 | 1,704 | 1,475 | 1,291 |
| Santa Clara County | 1,226,987 | 1,176,129 | 1,187,799 | 5,969 | 4,436 | 2,643 |
| San Benito County | 21,722 | 21,827 | 21,116 | 1,969 | 1,244 | 1,073 |
| Napa County | 84,369 | 91,837 | 93,050 | 4,835 | 5,730 | 3,148 |
| Total San Francisco Bay Area Region | 2,219,394 | 2,196,196 | 2,196,590 | 14,477 | 12,885 | 8,155 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a

Note:
Farm employment includes employment numbers in forestry, fishing, and related activities.

As shown in Table 19.29, overall farm employment has declined by 45 percent between 2001 and 2012, as presented in Figure 19.1. The decrease in farm employment is related to the reduction in cultivated acreage during this period, as described in Chapter 12, Agricultural Resources.

#### *19.3.4.3 Income*

The average per capita personal incomes for the counties in the San Francisco Bay Area Region are presented in Table 19.30. Among the four counties in this region, San Benito County had the lowest per capita personal income. Santa Clara County had the lowest average annual per capita growth rate between 2000 and 2008. All counties experienced smaller average annual per capita growth rates between 2008 and 2012 compared to the 2000 to 2008 period.

**Table 19.30 Per Capita Personal Income in San Francisco Bay Area Region**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Alameda County | $39,613 | $50,302 | $54,683 | 3.0 | 2.1 |
| Santa Clara County | $55,588 | $59,927 | $66,535 | 0.9 | 2.6 |
| San Benito County | $29,608 | $36,100 | $38,030 | 2.5 | 1.3 |
| Napa County | $38,854 | $51,712 | $54,807 | 3.6 | 1.5 |
| Total San Francisco Bay Area Region | $47,546 | $55,050 | $60,493 | 1.8 | 2.4 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

#### *19.3.4.4 Local Government Finances*

As of April 1, 2014, the county sales tax rates in the San Francisco Bay Area region ranged between 7.5 percent in San Benito and 9.0 percent in Alameda (BOE 2014).

Total annual taxable sales for the counties in the San Francisco Bay Area Region in 2000, 2008, and 2012 are presented in Table 19.31. Between 2000 and 2008 all counties in the region, except Santa Clara County, experienced small increases in average annual growth in total taxable sales. All counties experienced increasing growth rates between 2008 and 2012. Santa Clara County had the highest annual average growth rate in total taxable sales among all the counties in the region during this period.

**Table 19.31 Total Taxable Sales in San Francisco Bay Area Region**

| Area | Total Taxable Sales (Millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Alameda County | $23,764 | $23,863 | $25,182 | 0.1 | 1.4 |
| Santa Clara County | $37,304 | $32,274 | $36,220 | -1.8 | 2.9 |
| San Benito County | $476 | $505 | $530 | 0.7 | 1.2 |
| Napa County | $1,908 | $2,549 | $2,719 | 3.7 | 1.6 |
| Total San Francisco Bay Area Region | $63,451 | $59,191 | $64,651 | -0.9 | 2.2 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

The combined (secured and unsecured) property tax revenues in each of the counties in the San Francisco Bay Area Region for Fiscal Year 2011-2012 are presented in Table 19.32. Total property tax revenues in the four counties accounted for about 13 percent of the total state property tax revenues.

**Table 19.32 Property Tax Revenues, Fiscal Year 2011-2012, in San Francisco Bay Area Region**

| Area | Property Tax Revenues (millions) |
|---|---|
| Alameda County | $2,830 |
| Santa Clara County | $3,973 |
| San Benito County | $68 |
| Napa County | $327 |
| Total San Francisco Bay Area Region | $7,198 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2014

## 19.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. San Luis Obispo and Santa Barbara counties are among the top 15 counties in total agricultural production in the state.

### *19.3.5.1 Population*

Population characteristics in the Central Coast Region are presented in Table 19.33. The population of the Central Coast Region grew by an average annual growth rate of about one half of one percent between 2000 and 2012.

**Table 19.33 Population Characteristics in Central Coast Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| San Luis Obispo County | 246,681 | 271,502 | 0.8 |
| Santa Barbara County | 399,347 | 426,351 | 0.5 |
| Total Central Coast Region | 646,028 | 697,853 | 0.6 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

### *19.3.5.2 Employment*

Civilian labor force characteristics for the counties in the Central Coast Region are presented in Table 19.34. The civilian labor force in the Central Coast Region increased between 2000 and 2012.

**Table 19.34 Civilian Labor Force and Unemployment Rates in Central Coast Region**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| San Luis Obispo County | 126,176 | 136,615 | 138,650 | 4.0 | 5.7 | 9.3 |
| Santa Barbara County | 203,039 | 218,429 | 225,635 | 4.4 | 5.4 | 8.8 |
| Total Central Coast Region | 329,215 | 355,044 | 364,285 | 4.3 | 5.6 | 5.9 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008, and 2012 in the Central Coast Region are presented in Table 19.35. Farm employment accounted for less than ten percent of total employment during this period.

**Table 19.35 Employment in Central Coast Region**

| Area | Total Employment | | | Farm Employment | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| San Luis Obispo County | 140,320 | 155,093 | 156,757 | 7,775 | 6,866 | 7,374 |
| Santa Barbara County | 243,955 | 260,056 | 257,841 | 15,228 | 16,483 | 18,075 |
| Total Central Coast Region | 384,275 | 415,149 | 414,598 | 23,003 | 23,349 | 25,449 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a
Note: Farm employment includes employment numbers in forestry, fishing, and related activities.

The farm employment numbers presented in Table 19.35 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in many counties in the Central Coast Region; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and processing of food and fiber grown on farms. As a result, employment both directly on farm and indirectly dependent on farming is higher than the values displayed in Table 19.35.

#### *19.3.5.3 Income*

Per capita personal incomes for the counties in the Central Coast Region are lower than those for the state. Both San Luis Obispo and Santa Barbara had average annual per capita personal income growth rates between 2000 and 2008 that were among the highest in the state. Per capita personal income for each of the two counties in the Central Coast Region in 2000, 2008 and 2012 are presented in Table 19.36.

**Table 19.36 Per Capita Personal Income in Central Coast Region**

| | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| **Area** | **2000** | **2008** | **2012** | **2000-2008** | **2008-2012** |
| San Luis Obispo County | $28,671 | $40,204 | $43,698 | 4.3 | 2.1 |
| Santa Barbara County | $33,317 | $45,997 | $47,862 | 4.1 | 1.0 |
| Central Coast Region | $31,540 | $43,735 | $46,241 | 4.2 | 1.4 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

#### *19.3.5.4 Local Government Finances*

As of April 1, 2014, the county sales tax rates in the San Luis Obispo and Santa Barbara counties were 7.5 percent and 8.0 percent, respectively (BOE 2014).

Total annual taxable sales for San Luis Obispo and Santa Barbara counties in the Central Coast Region in 2000, 2008, and 2012 are presented in Table 19.37. The Central Coast Region's average annual growth in total taxable sales were higher than for the state.

**Table 19.37 Total Taxable Sales in Central Coast Region**

| | Total Taxable Sales (Millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| **Area** | **2000** | **2008** | **2012** | **2000-2008** | **2008-2012** |
| San Luis Obispo County | $2,925 | $3,974 | $5,026 | 3.9 | 6.0 |
| Santa Barbara County | $4,823 | $5,884 | $6,051 | 2.5 | 0.7 |
| Central Coast Region | $7,748 | $9,858 | $11,077 | 3.1 | 3.0 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

The combined (secured and unsecured) property tax revenues in the Central Coast Region for Fiscal Year 2011-2012 are presented in Table 19.38. Total property tax revenues in the two counties accounted for about 2 percent of the total state property tax revenues.

**Table 19.38 Property Tax Revenues, Fiscal Year 2011-2012, in Central Coast Region**

| Area | Property Tax Revenues (millions) |
|---|---|
| San Luis Obispo County | $443 |
| Santa Barbara County | $695 |
| Central Coast Region | $1,138 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2014

## 19.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

### *19.3.6.1 Population*

Population characteristics in Southern California Region are presented in Table 19.39. Among the counties in the Southern California Region, Riverside County had the highest average annual population growth rate, and Los Angeles County had the lowest average annual population growth rate between 2000 and 2012.

**Table 19.39 Population Characteristics in Southern California Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2012 | 2000-2012 |
| Ventura County | 753,197 | 829,065 | 0.8 |
| Los Angeles County | 9,519,330 | 9,889,520 | 0.3 |
| Orange County | 2,846,289 | 3,057,879 | 0.6 |
| San Diego County | 2,813,833 | 3,128,734 | 0.9 |
| Riverside County | 1,545,387 | 2,234,193 | 3.1 |
| San Bernardino County | 1,710,139 | 2,059,699 | 1.6 |
| Total Southern California Region | 19,188,175 | 21,199,090 | 0.8 |
| **STATE OF CALIFORNIA** | **33,873,086** | **37,668,804** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

### *19.3.6.2 Employment*

Civilian labor force characteristics for the counties in the Southern California Region are presented in Table 19.40. The civilian labor force in the Southern California Region increased between 2001 and 2012. The average unemployment rates for the Southern California Region have been lower than for the state.

**Table 19.40 Civilian Labor Force and Unemployment Rates in Southern California Region**

| Area | Civilian Labor Force (subject to unemployment insurance) | | | Unemployment Rate (percent) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Ventura County | 399,325 | 429,444 | 440,649 | 4.8 | 6.3 | 9.0 |
| Los Angeles County | 4,752,839 | 4,934,756 | 4,879,674 | 5.7 | 7.5 | 10.9 |
| Orange County | 1,513,234 | 1,618,079 | 1,618,677 | 4.0 | 5.3 | 7.6 |
| San Diego County | 1,409,726 | 1,548,233 | 1,599,133 | 4.2 | 6.0 | 8.9 |
| Riverside County | 711,134 | 912,717 | 944,458 | 5.5 | 8.5 | 12.2 |
| San Bernardino County | 763,221 | 863,293 | 860,895 | 5.1 | 8.0 | 12.0 |
| Total Southern California Region | 9,549,479 | 10,306,522 | 10,343,486 | 5.1 | 7.0 | 10.2 |
| **STATE OF CALIFORNIA** | **17,152,106** | **18,392,000** | **18,494,881** | **4.9** | **7.2** | **10.5** |

Source: BLS 2014

Total employment and farm employment in 2001, 2008, and 2012 in the Southern California Region are presented in Table 19.41. Farm employment accounted for less than one percent of total employment.

**Table 19.41 Employment in Southern California Region**

| Area | Total Employment | | | Farm Employment[1] | | |
|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2012 | 2001 | 2008 | 2012 |
| Ventura County | 399,928 | 436,031 | 431,196 | 21,329 | 23,430 | 24,826 |
| Los Angeles County | 5,440,785 | 5,695,501 | 5,669,105 | 11,082 | 8,709 | 7,589 |
| Orange County | 1,845,392 | 1,999,036 | 1,963,080 | 7,888 | 4,713 | 3,183 |
| San Diego County | 1,723,801 | 1,901,598 | 1,887,077 | 17,871 | 15,718 | 14,778 |
| Riverside County | 677,214 | 866,247 | 864,308 | 20,892 | 15,669 | 15,024 |
| San Bernardino County | 730,150 | 881,700 | 864,432 | 6,050 | 3,931 | 3,688 |
| Total Southern California Region | 10,817,270 | 11,780,113 | 11,679,198 | 85,112 | 72,170 | 69,088 |
| **STATE OF CALIFORNIA** | **19,411,367** | **20,820,306** | **20,653,860** | **479,283** | **438,013** | **443,764** |

Source: BEA 2014a

Note:

Farm employment includes employment numbers in forestry, fishing, and related activities.

#### *19.3.6.3 Income*

Among the six counties in this region, San Bernardino County had the lowest per capita personal income in 2000 and 2008, as presented in Table 19.42. In 2012, Riverside County had the lowest per capita personal income.

**Table 19.42 Per Capita Personal Income in Southern California Region**

| Area | Per Capita Personal Income | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Ventura County | $34,296 | $46,634 | $48,837 | 3.9 | 1.2 |
| Los Angeles County | $29,878 | $42,881 | $44,474 | 4.6 | 0.9 |
| Orange County | $38,357 | $49,436 | $52,342 | 3.2 | 1.4 |
| San Diego County | $33,779 | $47,197 | $49,719 | 4.3 | 1.3 |
| Riverside County | $24,528 | $30,842 | $31,742 | 2.9 | 0.7 |
| San Bernardino County | $22,624 | $30,220 | $32,072 | 3.7 | 1.5 |
| Total Southern California Region | $30,801 | $41,078 | $44,004 | 3.7 | 1.7 |
| **STATE OF CALIFORNIA** | **$33,404** | **$44,003** | **$46,477** | **3.5** | **1.4** |

Source: BEA 2014e

### *19.3.6.4 Local Government Finances*

As of April 1, 2014, the county sales tax rates in the Southern California Region ranged from 7.5 percent in Ventura County to 9.0 percent in Los Angeles County (BOE 2014).

Total annual taxable sales for the counties in the Southern California Region in 2000, 2008, and 2012 are presented in Table 19.43. The counties in this region have had higher average annual growth rates in total taxable retail sales compared to the state. Between 2000 and 2008, Riverside and San Bernardino led the region with higher average annual growth rates. However, between 2008 and 2012, the two counties experienced declining growth rates.

**Table 19.43 Total Taxable Sales in Southern California Region**

| Area | Total Taxable Sales (millions) | | | Average Annual Growth Rate (percent) | |
|---|---|---|---|---|---|
| | 2000 | 2008 | 2012 | 2000-2008 | 2008-2012 |
| Ventura County | $9,096 | $11,322 | $11,958 | 2.8 | 1.4 |
| Los Angeles County | $106,674 | $131,882 | $135,296 | 2.7 | 0.6 |
| Orange County | $44,462 | $53,607 | $55,231 | 2.4 | 0.7 |
| San Diego County | $36,245 | $45,329 | $47,947 | 2.8 | 1.4 |
| Riverside County | $16,979 | $26,004 | $28,096 | 5.5 | 2.0 |
| San Bernardino County | $18,885 | $27,778 | $29,532 | 4.9 | 1.5 |
| Total Southern California Region | $232,342 | $295,921 | $308,059 | 3.1 | 1.0 |
| **STATE OF CALIFORNIA** | **$441,854** | **$531,654** | **$407,714** | **2.3** | **-6.4** |

Sources: BOE 2000, 2008, 2012

The combined (secured and unsecured) property tax revenues in the Southern California Region for Fiscal Year 2011-2012 are presented in Table 19.44. Total property tax revenues accounted for about 55 percent of the total state property tax revenues.

**Table 19.44 Property Tax Revenues, Fiscal Year 2011-2012, in Southern California Region**

| Area | Property Tax Revenues (millions) |
|---|---|
| Ventura County | $1,230 |
| Los Angeles County | $14,191 |
| Orange County | $5,046 |
| San Diego County | $4,646 |
| Riverside County | $2,812 |
| San Bernardino County | $2,132 |
| Southern California Region | $30,057 |
| **STATE OF CALIFORNIA** | **$55,459** |

Source: California State Controller 2012

### 19.3.7 Ocean Salmon Fishery

The ocean salmon fishery along the southern Oregon and northern California coast are affected by the population of salmon that rely upon the northern California rivers, including the Sacramento and San Joaquin rivers. Changes in CVP and SWP water operations would affect the flow patterns and water quality of the Sacramento and San Joaquin rivers; and the survivability of the salmon that use those rivers for habitat, as described in Chapter 9, Fish and Aquatic Resources. This section discusses the economic contributions of the Pacific Coast salmon fishery.

Management of the California ocean salmon fishery is a combined effort of the California Department of Fish and Wildlife (CDFW) and the Pacific Fishery Management Council (PFMC), a regional council of the National Oceanic and Atmospheric Administration. The California Department of Fish and Wildlife manages salmon harvest from the shoreline to three nautical miles off the California coast. From three nautical miles to two hundred nautical miles offshore is managed by the PFMC. The PFMC is responsible for developing the Pacific Coast Salmon Fishery Management Plan (FMP) that guides management of the ocean commercial and recreational fishery in California, Oregon, and Washington (PFMC 2014a). The annual ocean salmon fishery regulations promote the maximum amount of harvest while ensuring that suitable population levels are maintained (NOAA 2014).

#### *19.3.7.1 Commercial Ocean Fisheries for Salmon along the Southern Oregon and Northern California Coasts*

The commercial ocean salmon fishery plays a large role in the overall California commercial ocean industry, as shown in Table 19.45. The total harvest value for Chinook salmon ranked fourth among all commercially harvested ocean species in 2012. The harvest value rank of Chinook salmon in California between 2001 and 2012 as compared to the other commercially harvested ocean species are presented in Table 19.46.

**Table 19.45 Top Ten Species by Total Value for Commercially Harvested Ocean Species in California in 2012**

| Rank | Species | Total Value |
|---|---|---|
| 1 | Dungeness Crab | $85,643,530 |
| 2 | California Market Squid | $63,883,456 |
| 3 | California Spiny Lobster | $13,706,721 |
| **4** | **Chinook Salmon** | **$12,841,853** |
| 5 | Sablefish | $8,987,599 |
| 6 | Pacific Oyster | $8,736,923 |
| 7 | Sea Urchins | $8,320,111 |
| 8 | Spot Shrimp | $4,462,204 |
| 9 | Pacific Sardine | $4,248,504 |
| 10 | Kumamoto Oyster | $3,170,760 |

Sources: NMFS 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2014h, 2014i, 2014j

**Table 19.46 Chinook Salmon Total Harvest Value Ranking as compared to Other Commercially Harvested Ocean Species in California**

| Year | Total Value of Chinook Salmon Landings | Rank |
|---|---|---|
| 2001 | $4,760,786 | 7 |
| 2002 | $7,610,882 | 4 |
| 2003 | $12,153,111 | 3 |
| 2004 | $17,770,036 | 3 |
| 2005 | $12,804,188 | 3 |
| 2006 | $5,260,526 | 4 |
| 2007 | $7,835,240 | 4 |
| 2008 | Season Closed | |
| 2009 | Season Closed | |
| 2010 | $1,214,959 | 19 |
| 2011 | $5,096,433 | 7 |
| 2012 | $12,841,853 | 4 |

Source: NMFS 2014k

Annual revenues from commercial ocean salmon fishery in California have fluctuated with changes in salmon prices and total landings. The dollar per dressed pound for Chinook salmon paid to the commercial operator can change within a season, across seasons, and at different ports, as presented in Table 19.47. Prices for Chinook salmon have increased over the past years; however, the costs for fuel, labor, and equipment maintenance also have increased.

**Table 19.47 Average Annual Commercial Chinook Salmon Prices**

| Year | Average Annual California Price (dollar per dressed pound) | Average Annual Oregon Price (dollar per dressed pound) |
|---|---|---|
| 2001 | $1.98 | $1.61 |
| 2002 | $1.55 | $1.54 |
| 2003 | $1.91 | $1.97 |
| 2004 | $2.87 | $3.45 |
| 2005 | $2.97 | $3.17 |
| 2006 | $5.13 | $5.48 |
| 2007 | $5.18 | $5.66 |
| 2008 | Season Closed | $7.31 |
| 2009 | Season Closed | Season Closed |
| 2010 | $5.46 | $5.49 |
| 2011 | $5.17 | $5.96 |
| 2012 | $5.34 | $5.75 |

Source: PFMC 2014b (Tables D-4, D-5)

The total value of landings for the commercial ocean fishery in southern Oregon and California are presented in Table 19.48.

**Table 19.48 Value of Landings for Salmon for the Commercial Ocean Salmon Fishery**

| Year | Total Value, California | Total Value, Oregon |
|---|---|---|
| 2001 | $4,773 | $4,721 |
| 2002 | $7,776 | $5,391 |
| 2003 | $12,181 | $7,222 |
| 2004 | $17,895 | $9,919 |
| 2005 | $12,913 | $8,503 |
| 2006 | $5,350 | $2,701 |
| 2007 | $7,902 | $2,822 |
| 2008 | Season Closed | $51,118 |
| 2009 | Season Closed | $51,118 |
| 2010 | $1,246 | $2,791 |
| 2011 | $5,133 | $2,401 |
| 2012 | $13,521 | $4,271 |

Sources: PFMC 2014b (Tables D-4, D-5); PacFIN 2014

The economic contribution of the California commercial ocean salmon fishery extends beyond the revenues received by fishermen. Supporting industries include fish processors, boat manufacturers, repair and maintenance. The economic contribution of the commercial ocean salmon fishery can be estimated through the use of Input-Output models. Economic contributions are estimated by PFMC using an Input-Output model, the Fishery Economic Assessment Model (FEAM), as summarized in Table 19.49 for the commercial ocean salmon fishery by management area.

**Table 19.49 Estimated Total Economic Impact for the Commercial Fishery by PFMC**

| Year | Economic Values by Management Areas ($1,000) | | | | | |
|---|---|---|---|---|---|---|
| | KMZ – Oregon | KMZ – California | Fort Bragg | San Francisco | Monterey | Total |
| 2001 | $635 | $328 | $1,033 | $10,857 | $2,297 | $15,150 |
| 2002 | $806 | $797 | $3,730 | $15,516 | $4,179 | $25,028 |
| 2003 | $699 | $259 | $15,160 | $15,795 | $2,491 | $34,404 |
| 2004 | $1,502 | $2,373 | $7,434 | $23,356 | $5,257 | $39,922 |
| 2005 | $1,259 | $582 | $5,420 | $13,496 | $7,083 | $27,840 |
| 2006 | $378 | $0 | $2,471 | $6,389 | $985 | $10,223 |
| 2007 | $780 | $1,156 | $3,407 | $8,131 | $1,658 | $15,132 |
| 2008 | $72 | $0 | $0 | $0 | $0 | $72 |
| 2009 | $42 | $0 | $0 | $0 | $0 | $42 |
| 2010 | $367 | $35 | $1,780 | $140 | $161 | $2,483 |
| 2011 | $504 | $505 | $4,952 | $2,225 | $979 | $9,165 |
| 2012 | $698 | $725 | $4,706 | $10,653 | $5,759 | $22,541 |
| 2013 | $1,252 | $2,146 | $12,909 | $19,181 | $4,010 | $39,498 |

Source: PFMC 2014b (Tables IV-16, IV-17)

Notes:

All values estimated using the Fishery Economic Assessment Model, and presented as 2013 dollars.

Southern Oregon values include data for Brookings, Oregon which may include values from landings outside of the KMZ.

a. KMZ –Oregon represents the area from Humbug Mountain to the Oregon-California Border, and includes landings at the Brookings port and season length and quota values for the entire area including Chetco River Ocean Terminal Area between Twin Rocks and the Oregon-California border.

b. KMZ –California represents the area from Oregon-California Border to Humboldt South Jetty, and includes landings at the Crescent City and Eureka ports.

Fisherman and industries that rely on the commercial ocean salmon fishery have access to financial assistance from the federal government in years of low revenue or closure. The fishery can be declared a failure by the Department of Commerce after requests are sent by state or local officials and certain criteria have been met. After a fishery failure is declared, disaster relief can be provided in the form of monetary compensation, community grants, low-interest loans, habitat restoration, or fishery capacity reduction. Disaster relief related to the California commercial ocean salmon fishery has occurred six times between 1994 and 2009, as summarized in Table 19.50 (CRS 2013). Direct payments may involve a minimum amount to any permit holder and additional amounts based upon past landing values (Hackett and Hansen 2008). Disaster relief funds distribution is conducted by the PFMC and the California Salmon Council.

**Table 19.50 Disaster Relief Monies and Programs for the Commercial Ocean Salmon Fishery in California**

| Year | Programs | Dollar Value |
|---|---|---|
| 1994 | Fishery capacity reduction, habitat restoration jobs, and data collection jobs | $12 Million |
| 1995 | Similar programs as in 1994 | $13 Million |
| 1998 | Fishery capacity reduction | $3.5 Million |
| 2007 | Direct payments to fisherman and businesses dependent on the Klamath River salmon | $60.4 Million |
| 2008 | Direct payments to fisherman and businesses dependent on the Sacramento River salmon | $170 Million |
| 2009-2010 | Continuation of 2008 programs | Remainder of the 2008 $170 Million |

Source: CRS 2013

### *19.3.7.2 Ocean Sport Fisheries for Salmon along the Southern Oregon and Northern California Coasts*

The PFMC and CDFW also manages the ocean sport fishery. The economic contribution of the ocean sport salmon fishery can be estimated through the use of Input-Output models. Economic contributions are estimated by PFMC using an Input-Output model, the Fishery Economic Assessment Model (FEAM), as summarized in Table 19.51.

**Table 19.51 Estimated Total Economic Impact for the Recreational Fishery by PFMC**

| Year | Economic Values by Management Areas ($1,000) | | | | | |
|---|---|---|---|---|---|---|
| | KMZ – Oregon | KMZ-California | Fort Bragg | San Francisco | Monterey | Total |
| 2001 | $1,052 | $1,136 | $2,101 | $7,683 | $3,079 | $15,051 |
| 2002 | $775 | $1,026 | $2,221 | $9,646 | $4,752 | $18,420 |
| 2003 | $608 | $743 | $1,677 | $6,990 | $2,288 | $12,306 |
| 2004 | $751 | $1,229 | $2,175 | $11,310 | $4,439 | $19,904 |
| 2005 | $501 | $794 | $1,759 | $8,554 | $3,234 | $14,842 |
| 2006 | $426 | $743 | $1,450 | $5,812 | $1,947 | $10,378 |
| 2007 | $437 | $977 | $1,170 | $4,119 | $1,427 | $8,130 |
| 2008 | $189 | $0 | $26 | $0 | $0 | $215 |
| 2009 | $241 | $276 | $0 | $0 | $0 | $517 |
| 2010 | $229 | $201 | $421 | $1,712 | $1,140 | $3,703 |
| 2011 | $241 | $744 | $972 | $3,367 | $1,778 | $7,102 |
| 2012 | $732 | $1,614 | $970 | $6,069 | $2,947 | $12,332 |

Source: PFMC 2014b (Tables IV-16, IV-17)

Notes:
All values estimated using the Fishery Economic Assessment Model, and presented as 2013 dollars.
Southern Oregon values include data for Brookings, Oregon which may include values from landings outside of the KMZ.

a. KMZ –Oregon represents the area from Humbug Mountain to the Oregon-California Border, and includes landings at the Brookings port and season length and quota values for the entire area including Chetco River Ocean Terminal Area between Twin Rocks and the Oregon-California border.
b. KMZ –California represents the area from Oregon-California Border to Humboldt South Jetty, and includes landings at the Crescent City and Eureka ports.

### 19.3.8 Ocean Salmon Fisheries for the Yurok and Hoopa Valley Tribes

The salmon populations are extremely important to the Yurok Tribe and Hoopa Valley Tribe as part of their lives, cultural traditions, ceremonies, and community health (Reclamation 2012). Fifty percent of the total available salmon in the Trinity River is the federally protected harvest for the Yurok and Hoopa Valley tribes (DOI 1993). Each tribe determines the use of the harvest. Historical landing data for the Yurok and Hoopa Valley tribes are presented in Table 19.52 (Reclamation 2012).

**Table 19.52 Salmon Landings by the Yurok Tribe and Hoopa Valley Tribe**

| Year | Spring Run Chinook Salmon | Fall Run Chinook Salmon | Total |
|---|---|---|---|
| 2001 | 19,640 | 39,044 | 58,684 |
| 2002 | 15,136 | 24,700 | 39,836 |
| 2003 | 9,065 | 30,078 | 39,143 |
| 2004 | 8,682 | 25,971 | 34,653 |
| 2005 | 7,302 | 8,087 | 15,389 |
| 2006 | 4,409 | 10,698 | 15,107 |
| 2007 | 5,849 | 27,594 | 33,443 |
| 2008 | 3,439 | 22,901 | 26,340 |
| 2009 | 3,562 | 28,565 | 32,127 |
| 2010 | 5,023 | 30,315 | 35,338 |
| 2011 | 5,005 | 28,084 | 33,089 |
| 2012 | 6,477 | 101,662 | 108,139 |
| 2013[a] | 4,972 | 63,030 | 68,002 |

Source: PFMC 2014b (Table B-5)
Note:
a. 2013 data are preliminary.
Includes landings at the Klamath River estuary, along the Klamath River from the estuary to Weitchpec (at the confluence of the Klamath and Trinity rivers), and along the Trinity River.

## 19.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in socioeconomic factors; results of the impact analysis; potential mitigation measures; and cumulative effects.

This Chapter includes the analysis of overall regional economic changes and economic changes related to changes in CVP and SWP water supplies for M&I water users. More detailed discussions of changes in agricultural production are presented in Chapter 12, Agricultural Resources.

### 19.4.1 Potential Mechanisms and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact assessment considers changes in socioeconomic factors related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change water supply availability for CVP and SWP water users, recreational opportunities at reservoirs that store CVP and SWP water, and salmon from the Delta watershed that are relied upon by commercial, sport, and tribal fisherman.

#### *19.4.1.1 Regional Changes in Irrigated Agricultural Production Value*

Changes in CVP and SWP operations could change the extent of total agricultural production value as compared to the No Action Alternative and the Second Basis of Comparison. As described in Chapter 12, Agricultural Resources, there was no changes in agricultural production in the Central Valley under long-term conditions (over the 81-year model simulation period). Therefore, this analysis only addresses regional economic changes during dry and critical dry years.

This analysis uses model output from the Statewide Agricultural Production (SWAP) model and the IMPLAN model. The SWAP model, **a**s described in Chapter 12, is a regional model of irrigated agricultural production and economics that simulates the decisions of producers (farmers) in the Central Valley Region. The model selects the crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs. The SWAP model incorporates CVP and SWP water supplies, other local water supplies represented in the CalSim II model, and groundwater. As conditions change within a SWAP subregion (e.g., the quantity of available project water supply declines), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. The model also fallows land when that appears to be the most cost-effective response to resource conditions. The analysis only reduces groundwater withdrawals based upon an optimization of agricultural production costs. The analysis does not restrict groundwater withdrawals based upon groundwater overdraft or groundwater quality conditions.

As described in Chapter 7, Groundwater Resources and Groundwater Quality, The Sustainable Groundwater Management Act (SGMA) requires preparation of Groundwater Sustainability Plans (GSPs) by 2020 or 2022 for most of the groundwater basins. The GSPs will identify methods to implement measures that will achieve sustainable groundwater operations by 2040 or 2042. The analysis in this Chapter is focused on conditions that would occur in 2030. If local agencies fully implement GSPs prior to the regulatory deadline, increasing groundwater use would be less of an option for agricultural water users. However, to achieve sustainable conditions, some measures could require several years to design and construct new water supply facilities, and sustainable groundwater conditions are not required until the 2040s. Therefore, it was assumed that Central Valley agriculture water users would not reduce groundwater use by 2030, and that groundwater use would increase in response to reduced CVP and SWP water supplies.

As described in Chapter 12, the impact to irrigated acreage and agricultural production is relatively small. Most of the change in CVP or SWP irrigation supplies would be offset by changes in groundwater pumping, with only small changes in crop acreage in production. However, this is an aggregate result for the Central Valley. Individual growers that rely on CVP or SWP supply and have no access to groundwater would have their irrigated acreage affected by larger amounts. Some of their change in production can and would be offset by changes on other farms that have access to groundwater or other surface supplies. Over time, growers without the buffer of access to groundwater could be driven to sell to or merge with other farming operations. From the larger, regional perspective, total value of production is estimated to change relatively little.

The regional economic analysis was conducted using the results of the impact analysis on agricultural production and M&I water use. The incremental impact results, estimated by the SWAP and CWEST economic models, were input into the regional IMPLAN models as the direct change caused by each of Alternative as compared to the No Action Alternative and the Second Basis of Comparison. Changes in economic effects depend upon loss of production or expenditures for water supplies, interactions within the regional economy, and “leakage” of economic activity between regions. Economic linkages create multiplier effects in a regional economy in the IMPLAN input-output model based upon estimates of county-level final demands and final payments developed from published data, national average matrix of technical coefficients, and mathematical relationships. IMPLAN uses information from the U.S. Department of Commerce’s Bureau of Economic Analysis, U.S. Department of Labor’s Bureau of Labor Statistics, and other federal and state government agencies. Data is collected for 440 different industrial sectors of the national economy per the North American Industry Classification System based on the primary commodity or service produced. Data sets are provided for the IMPLAN model for each county in the United States. In this analysis counties were grouped into the Central Valley Region (does not include Contra Costa County), San Francisco Bay Area Region (does include Contra Costa County), Central Coast Region, and Southern California Region.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. IMPLAN measures the initial impact to the economy based on average expenditure patterns, but does not consider long-term adjustments if labor and capital move into alternative uses.

Irrigated acreage occurs in the San Francisco Bay Area, Central Coast, and Southern California regions that use CVP and SWP water. This irrigated acreage is not included in the SWAP model simulation; and therefore, is not evaluated quantitatively in this EIS. However, changes in irrigated acreage in response to reductions in CVP and SWP water deliveries are assumed to occur in a similar manner as projected for the Central Valley Region.

As described in this chapter, the SWAP and IMPLAN models are annual-time step models that use information from the monthly-time step model. The model results represent long-term responses and must be used in a comparative manner to reduce the effects of use of monthly assumptions and other assumptions that are indicative of real-time operations, but do not specific match real-time observations. The CalSim II model output includes minor fluctuations of up to 5 percent due to model assumptions and approaches. Therefore, if the quantitative changes between a specific alternative and the No Action Alternative and/or Second Basis of Comparison are 5 percent or less, the conditions under the specific alternative would be considered to be "similar" to conditions under the No Action Alternative and/or Second Basis of Comparison.

#### *19.4.1.2 Regional Changes in Municipal and Industrial Water Supplies and Water Supply Costs*

Changes in CVP and SWP operations could change availability of water supplies for M&I water in the study area, related costs of additional supplies or shortages, and changes in regional economics as compared to the No Action Alternative and the Second Basis of Comparison. The quantitative analyses of regional changes related to changes in M&I water supplies and associated costs, employment, and economic output are analyzed using the California Water Economics Spreadsheet Tool (CWEST) model and the IMPLAN model.

Changes in M&I water supplies were evaluated using a regional economic model that was specifically modified to address water supply and cost changes to CVP and SWP M&I water users. The CWEST is a regional model that considers the economic costs to M&I water users including the cost of CVP and SWP water supplies, regional surface water supplies (including recycled water), conveyance costs, shortage costs, and changes in groundwater pumping costs. The model operations on an annual time step. Annual supplies are calculated for each water user based upon annual CVP and/or SWP water supplies, local surface water and groundwater supplies, surface water and groundwater storage, wastewater effluent and stormwater recycling water treatment, and desalination water treatment.

CVP and SWP water supply inputs are provided for the 81-year hydrologic period from the CalSim II model. The CWEST model analyzes the changes in annual conditions over the 81-long-term condition, and averages the overall costs for each Alternative over the 81-long-term condition. The CWEST model evaluates responses to changes in CVP and SWP water supplies differently for wet, above normal, and below normal water year types as compared to dry and critical dry water year types.

The goal of the CWEST model is to minimize the cost for the water providers and end-users to meet 2030 water demand. In years when the combination of average existing water supplies (either for the wetter or drier conditions) are greater than the 2030 water demand, the CWEST model assumes any overage water amount would be placed into surface water or groundwater storage, if available. If storage is not available, groundwater pumping would be reduced so that the other available supplies can be utilized. The CWEST model assumes that local surface water, other imported water supplies, recycled water use, and desalinated water use would not be reduced. However, during wet years, total CVP and SWP water deliveries may not be delivered if groundwater pumping is reduced to zero and local storage facilities are full.

In years when annual supplies are less than the 2030 water demand, the model assumes that water users with local surface water and groundwater storage would first fully utilize those supplies, and participate in temporary water transfers or a similar annual option if necessary. If shortage and transfer costs occur frequently, the model can select to purchase additional fixed-yield supplies, such as additional recycled water, desalination water treatment, or groundwater capacity. The model optimizes these long-term supply decisions to provide the lowest-cost water supply portfolio to meet 2030 demands throughout the 81-year hydrologic period.

The CWEST model local supply amounts and costs for this EIS are primarily based upon information presented in 2010 Urban Water Management Plans (UWMPs) developed by the CVP and SWP contractors (see Appendix 5D, Municipal and Industrial Water Demands and Supplies). The assumptions related to future water supplies presented in the UWMPs were evaluated to determine if the projects were reasonable and certain to occur by 2030. Projects that had undergone environmental review, were under design, or under construction were considered to exist in 2030 water supply assumptions in the CWEST model. Projects described in the UWMPs were considered as options to increase fixed-yield supplies. Existing and future water supplies considered for municipalities by 2030 are presented in Appendix 5B, Future Municipal Water Supplies for CVP and SWP Water Users. For smaller water users that are not addressed in an UWMP, information was obtained from water master plans and integrated regional water management plans.

CWEST calculates the change in the cost of water supplies plus end-user shortage costs. It does not calculate the total cost of water supplies. To provide a basis for understanding the relative importance of a change in costs, annual operating expenses were obtained from the fiscal year 2011-12 reports for special districts, counties, and cities published by the State Controllers' office (2013, 2014, 2014a). These operating expenses were updated to 2014 dollars using the California urban consumer price index. The cost change from CWEST, divided by the operating expense, provides a reasonable indication of the relative importance of cost changes for urban water providers.

The level of 2014 operating expense for each region includes:

- Central Valley Region
  - Sacramento Valley - $257 million
  - San Joaquin Valley - $297 million
- San Francisco Bay Area Region - $415 million
- Central Coast Region - $38 million

- Southern California Region (also known as “South Coast”) - $1,613 million

The CWEST model assumes that groundwater pumping would occur up to the amounts included in the UWMPs for wetter and drier conditions. As described above for agricultural production, it is assumed that full implementation of SGMA would not occur by 2030. Therefore, it was assumed that water users that are not currently operating groundwater resources in accordance with adjudication or other types of agreements, would not reduce groundwater use by 2030.

The IMPLAN model, described above, also is used to analyze changes in regional economics related to M&I water supplies. Increased costs of water supply are estimated from CWEST results. It is assumed that these costs must be passed on to regional water users. Regional water users are assumed to reduce their spending by an amount equal to the water supply cost increase. This reduced spending is distributed over regional industries according to coefficients provided by IMPLAN.

As described in this chapter, the CWEST and IMPLAN models are annual-time step models that use information from the monthly-time step model. The model results represent long-term responses and must be used in a comparative manner to reduce the effects of use of monthly assumptions and other assumptions that are indicative of real-time operations, but do not specific match real-time observations. The CalSim II model output includes minor fluctuations of up to 5 percent due to model assumptions and approaches. Therefore, if the quantitative changes between a specific alternative and the No Action Alternative and/or Second Basis of Comparison are 5 percent or less, the conditions under the specific alternative would be considered to be “similar” to conditions under the No Action Alternative and/or Second Basis of Comparison.

#### *19.4.1.3 Changes in Local Government Finances*

Changes in CVP and SWP operations would not result in major changes in land use, as described in Chapter 13, Land Use. Therefore, changes to collection of local taxes and fees are not anticipated under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison. Therefore, changes in local government finances are not evaluated in this EIS.

#### *19.4.1.4 Changes in Recreational Economics*

Reservoirs that store CVP and SWP water provide a wide diversity of recreational experiences on the water surface, as described in Chapter 15, Recreational Resources. However, changes to recreational economic opportunities under the alternatives primarily would occur due to changes in surface water elevations at San Luis Reservoir and reduced Striped Bass fishing opportunities under Alternatives 3 and 4.

This EIS does not quantitatively analyze potential changes in recreation user days or recreation spending because specific projects or responses to the changes in reservoir elevations are not considered under the purpose and need of this EIS. The qualitative analysis presented in this Chapter is based upon potential changes in recreational use related to changes under the alternatives as compared to the No

Action Alternative and the Second Basis of Comparison, as described in Chapter 15, Recreational Resources.

#### *19.4.1.5 Changes in Commercial, Sport, and Tribal Salmon Fishing Opportunities*

Changes in CVP and SWP operations under the alternatives could change the salmon population as compared to the No Action Alternative and the Second Basis of Comparison. Commercial, sport, and tribal fishing primarily relies upon Fall-run Chinook Salmon because the populations of other runs of salmon are substantially lower. Specific population changes for Fall-run Chinook Salmon are not projected in this EIS. Therefore, this Chapter presents a qualitative analysis of potential changes in socioeconomic factors under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

#### *19.4.1.6 Effects of Cross Delta Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future socioeconomic conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 19.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to socioeconomics that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *19.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives.

#### *19.4.2.2 Population Projections under the No Action Alternative and Second Basis of Comparison*

The 2030 population projections for each region addressed in this EIS are presented in Tables 19.53 through 19.59.

**Table 19.53 Population Projections in Trinity River Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2012 | 2030 | 2012-2030 |
| Trinity County | 13,471 | 15,309 | 0.7 |
| Humboldt County | 134,728 | 143,811 | 0.4 |
| Del Norte County | 28,527 | 31,252 | 0.5 |
| Total Trinity River Region | 176,726 | 190,373 | 0.4 |
| **STATE OF CALIFORNIA** | **37,427,946** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.54 Population Projections in Central Valley Region – Sacramento Valley**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2012 | 2030 | 2012-2030 |
| Shasta County | 177,516 | 210,997 | 0.9 |
| Plumas County | 19,901 | 20,390 | 0.1 |
| Tehama County | 62,985 | 75,522 | 1.0 |
| Glenn County | 28,105 | 33,318 | 0.9 |
| Colusa County | 21,552 | 28,112 | 1.4 |
| Butte County | 220,465 | 276,009 | 1.2 |
| Yuba County | 72,642 | 97,037 | 1.6 |
| Nevada County | 97,366 | 111,836 | 0.8 |
| Sutter County | 94,620 | 131,390 | 1.7 |
| Placer County | 351,463 | 454,124 | 1.4 |
| El Dorado County | 180,483 | 230,503 | 1.3 |
| Sacramento Valley Subtotal | 1,333,615 | 1,669,238 | 1.3 |
| Total Central Valley Region | 7,408,750 | 9,677,315 | 1.5 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.55 Population Projections in Central Valley – San Joaquin Valley**

| Area | Population 2012 | Population 2030 | Average Annual Growth Rate (percent) 2012-2030 |
|---|---|---|---|
| Stanislaus County | 519,339 | 666,446 | 1.4 |
| Madera County | 152,325 | 219,908 | 2.1 |
| Merced County | 260,029 | 359,798 | 1.8 |
| Fresno County | 943,493 | 1,232,151 | 1.5 |
| Tulare County | 451,540 | 636,606 | 1.9 |
| Kings County | 151,774 | 209,440 | 1.8 |
| Kern County | 849,977 | 1,276,155 | 2.3 |
| San Joaquin Valley Subtotal | 3,328,477 | 4,600,505 | 1.8 |
| Total Central Valley Region | 7,238,742 | 9,468,443 | 1.5 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.56 Population Projections in Central Valley Region – Delta and Suisun Marsh**

| Area | Population 2012 | Population 2030 | Average Annual Growth Rate (percent) 2012-2030 |
|---|---|---|---|
| Sacramento County | 1,433,525 | 1,731,061 | 1.1 |
| Yolo County | 204,349 | 250,420 | 1.1 |
| Solano County | 415,787 | 490,381 | 0.9 |
| San Joaquin County | 692,997 | 935,709 | 1.7 |
| Contra Costa County | 1,066,602 | 1,263,049 | 0.9 |
| Delta and Suisun Marsh Subtotal | 3,813,260 | 4,670,621 | 1.1 |
| Total Central Valley Region | 7,238,742 | 9,468,443 | 1.5 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.57 Population Projections in San Francisco Bay Area Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2012 | 2030 | 2012-2030 |
| Alameda County | 1,530,176 | 1,650,596 | 0.4 |
| Santa Clara County | 1,813,696 | 2,048,021 | 0.7 |
| San Benito County | 56,137 | 59,259 | 0.3 |
| Napa County | 137,731 | 158,538 | 0.8 |
| Total San Francisco Bay Area Region | 3,537,740 | 3,916,413 | 0.6 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.58 Population Projections in Central Coast Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2000 | 2030 | 2012-2030 |
| San Luis Obispo County | 271,502 | 311,388 | 0.8 |
| Santa Barbara County | 426,351 | 469,070 | 0.5 |
| Total Central Coast Region | 697,853 | 780,457 | 0.6 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

**Table 19.59 Population Projections in Southern California Region**

| Area | Population | | Average Annual Growth Rate (percent) |
|---|---|---|---|
| | 2012 | 2030 | 2012-2030 |
| Ventura County | 829,065 | 956,324 | 0.8 |
| Los Angeles County | 9,889,520 | 11,138,280 | 0.7 |
| Orange County | 3,057,879 | 3,385,762 | 0.6 |
| San Diego County | 3,128,734 | 3,665,358 | 0.9 |
| Riverside County | 2,234,193 | 3,145,948 | 1.9 |
| San Bernardino County | 2,059,699 | 2,588,990 | 1.3 |
| Total Southern California Region | 21,199,090 | 24,880,663 | 0.9 |
| **STATE OF CALIFORNIA** | **37,668,804** | **44,574,756** | **0.9** |

Sources: DOF 2013a, 2013b, 2014

### 19.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this Chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following Alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

#### *19.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 19.4.3.1.1 Trinity River Region

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under the No Action Alternative as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under the No Action Alternative and the Second Basis of Comparison. There are no municipal and industrial CVP or SWP water service contractors in the Trinity River Region.

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under the No Action Alternative as compared to the Second Basis of Comparison as described in Chapter 15, Recreational Resources.

*Regional Changes related to Changes in Salmon Fishing*

Trinity River flows would be similar under the No Action Alternative as compared to the Second Basis of Comparison. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

##### 19.4.3.1.2 Central Valley Region

*Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under the No Action Alternative than under the Second Basis of Comparison. It is anticipated that groundwater use would increase in response to reduced CVP and SWP water supplies in 2030 because sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be reduced by less than 1 percent ($1.6 million/year in the Sacramento Valley and $0.5 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping of approximately 6 percent. The agricultural production value under dry and critical dry conditions also would be reduced by less than 1 percent ($11.3 million/year in the Sacramento Valley and $20.3 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping.

The overall reduction in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.60 and 19.61, respectively.

**Table 19.60 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under the No Action Alternative as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -87 | -21 | 0 | -108 | -11.3 | -1.3 | 0.0 | -12.7 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | -1 | 0 | -1 | 0.0 | -0.1 | 0.0 | -0.2 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| Transportation, Warehousing & Utilities | 0 | -1 | 0 | -2 | 0.0 | -0.4 | -0.1 | -0.5 |
| Wholesale Trade | 0 | -1 | -1 | -2 | 0.0 | -0.2 | -0.1 | -0.3 |
| Retail Trade | 0 | 0 | -4 | -4 | 0.0 | 0.0 | -0.3 | -0.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | -0.1 | -0.1 |
| Financial Activities | 0 | -7 | -2 | -9 | 0.0 | -1.6 | -0.8 | -2.5 |
| Services | 0 | -3 | -12 | -15 | 0.0 | -0.3 | -1.0 | -1.3 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| **Total** | **-87** | **-36** | **-19** | **-142** | **-11.3** | **-4.2** | **-2.5** | **-18.1** |

**Table 19.61 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under the No Action Alternative as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -139 | -53 | 0 | -192 | -20.3 | -2.3 | -0.1 | -22.7 |
| Mining & Logging | 0 | -1 | 0 | -1 | 0.0 | -0.3 | 0.0 | -0.3 |
| Construction | 0 | -2 | 0 | -2 | 0.0 | -0.2 | 0.0 | -0.2 |
| Manufacturing | 0 | -1 | 0 | -2 | 0.0 | -1.8 | -0.3 | -2.1 |
| Transportation, Warehousing & Utilities | 0 | -3 | -1 | -4 | 0.0 | -0.8 | -0.2 | -1.0 |
| Wholesale Trade | 0 | -2 | -1 | -3 | 0.0 | -0.4 | -0.2 | -0.5 |
| Retail Trade | 0 | 0 | -7 | -8 | 0.0 | 0.0 | -0.6 | -0.6 |
| Information | 0 | 0 | 0 | -1 | 0.0 | -0.1 | -0.1 | -0.2 |
| Financial Activities | 0 | -12 | -3 | -15 | 0.0 | -2.7 | -1.5 | -4.1 |
| Services | 0 | -5 | -21 | -26 | 0.0 | -0.5 | -1.7 | -2.2 |
| Government | 0 | -1 | 0 | -1 | 0.0 | -0.2 | -0.1 | -0.3 |
| **Total** | **-139** | **-79** | **-35** | **-254** | **-20.3** | **-9.2** | **-4.9** | **-34.4** |

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley. The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under the No Action Alternative than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis are described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies (e.g., cities of Huron and Coalinga) and would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.62 and 19.63 for the Sacramento and San Joaquin Valley, respectively.

**Table 19.62 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under the No Action Alternative as Compared to the Second Basis of Comparison**

| Differences in Total | No Action Alternative | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 447 | 463 | -16 |
| Delivery Cost ($1,000) | $8,031 | $8,317 | -$287 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $213 | $207 | $6 |
| Transfer Costs ($1,000) | $739 | $517 | $222 |
| Shortage Costs ($1,000) | $69 | $68 | $1 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,858 | -$3,916 | $58 |
| Excess Water Savings ($1,000) | -$2,275 | -$2,563 | $288 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,919** | **$2,630** | **$288** |

Note: In 2012 dollars

**Table 19.63 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under the No Action Alternative as Compared to the Second Basis of Comparison**

| Differences in Total | No Action Alternative | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 214 | 237 | -23 |
| Delivery Cost ($1,000) | $3,460 | $3,854 | -$394 |
| Assumed New Supply Deliveries (TAF) | 2 | 0 | 2 |
| Annualized New Supply Costs ($1,000) | $429 | $15 | $414 |
| Water Storage Costs ($1,000) | $942 | $820 | $122 |
| Lost Water Sales Revenues ($1,000) | $361 | $322 | $39 |
| Transfer Costs ($1,000) | $2,673 | $2,623 | $50 |
| Shortage Costs ($1,000) | $115 | $102 | $13 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$15,377 | -$16,011 | $634 |
| Excess Water Savings ($1,000) | -$1,029 | -$1,318 | $289 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$8,427** | **-$9,593** | **$1,166** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.64 and 19.65, respectively. The M&I average annual water supply operating expenses would increase by 0.11 and 0.39 percent in the Sacramento Valley and the San Joaquin Valley, respectively; and therefore, the results would be similar.

**Table 19.64 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under the No Action Alternative as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | -1.7 | -1.6 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.4 | -0.3 | 0.1 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 29.0 | -2.5 | 26.5 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 3.1 | -22.2 | -19.1 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 286.4 | 2.8 | -18.0 | 271.2 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 1.0 | -27.1 | -26.1 |
| Retail Trade | 0 | 0 | -1 | -1 | 0.0 | 0.9 | -46.6 | -45.6 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 3.4 | -20.6 | -17.2 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | 13.0 | -147.7 | -134.6 |
| Services | 0 | 0 | -2 | -1 | 0.0 | 30.8 | -154.7 | -123.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.2 | -3.8 | -3.7 |
| **Total** | **1** | **1** | **-3** | **-1** | **286.4** | **84.8** | **-445.2** | **-74.0** |

Note: In 2012 dollars

**Table 19.65 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under the No Action Alternative as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | -6.7 | -6.7 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.4 | -6.4 | -6.8 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -13.3 | -5.6 | -18.9 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -1.4 | -46.4 | -47.8 |
| Transportation, Warehousing & Utilities | -1 | 0 | 0 | -1 | -140.8 | -1.4 | -44.7 | -186.9 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -0.4 | -39.0 | -39.3 |
| Retail Trade | 0 | 0 | -1 | -1 | 0.0 | -0.4 | -97.4 | -97.8 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -1.0 | -27.0 | -28.0 |
| Financial Activities | 0 | 0 | -1 | -1 | 0.0 | -4.3 | -263.7 | -268.0 |
| Services | 0 | 0 | -3 | -3 | 0.0 | -11.7 | -292.3 | -303.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | -12.9 | -13.0 |
| **Total** | **-1** | **0** | **-6** | **-7** | **-140.8** | **-34.3** | **-842.0** | **-1,017.2** |

Note:
In 2012 dollars

*Regional Changes to Recreational Opportunities*

Recreational opportunities would decrease at San Luis Reservoir by 6 percent under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 15, Recreation Resources. Therefore, it is anticipated that recreational economic factors would be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to socioeconomic factors were identified as adverse in the seller's service area related to loss of income to farm workers and the associated agriculturally-related businesses and retail enterprises if crop idling methods were used to provide transfer water. The analysis also identified that local sales taxes could decline due to the loss of household income. If groundwater substitution was used to provide transfer water, agricultural production values could decline due to additional cost of pumping. However, income from the water transfer could increase operating income for the sellers. The regional impact would depend upon the extent of lands involved in the water transfer program in any specific year.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 19.4.3.1.3 San Francisco Bay Area Region

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the San Francisco Bay Area Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under the No Action Alternative as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under the No Action Alternative than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by $7.276 million, or 1.75 percent, as presented in Table 19.66; and therefore, the results would be similar under the No Action Alternative and Second Basis of Comparison.

**Table 19.66 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Differences in Total | No Action Alternative | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 396 | 445 | -48 |
| Delivery Cost ($1,000) | $11,044 | $12,515 | -$1,471 |
| Assumed New Supply Deliveries (TAF) | 18 | 16 | 2 |
| Annualized New Supply Costs ($1,000) | $599 | $234 | $365 |
| Water Storage Costs ($1,000) | $1,577 | $1,963 | -$386 |
| Lost Water Sales Revenues ($1,000) | $4,286 | $1,595 | $2,691 |
| Transfer Costs ($1,000) | $5,722 | $1,154 | $4,568 |
| Shortage Costs ($1,000) | $1,410 | $523 | $887 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$493 | -$792 | $298 |
| Excess Water Savings ($1,000) | -$225 | -$549 | $324 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$23,919** | **$16,643** | **$7,276** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.67.

**Table 19.67 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | -7.9 | -7.8 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 1.6 | -5.0 | -3.4 |
| Construction | 0 | 1 | 0 | 1 | 0.0 | 158.8 | -37.1 | 121.7 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 28.8 | -478.0 | -449.1 |
| Transportation, Warehousing & Utilities | 5 | 0 | -1 | 4 | 1,492.4 | 11.2 | -183.5 | 1,320.1 |
| Wholesale Trade | 0 | 0 | -1 | -1 | 0.0 | 5.0 | -350.6 | -345.7 |
| Retail Trade | 0 | 0 | -6 | -6 | 0.0 | 4.2 | -567.2 | -563.0 |
| Information | 0 | 0 | -1 | -1 | 0.0 | 16.8 | -306.6 | -289.8 |
| Financial Activities | 0 | 0 | -5 | -4 | 0.0 | 55.8 | -1,740.5 | -1,684.7 |
| Services | 0 | 1 | -20 | -19 | 0.0 | 133.7 | -2,162.8 | -2,029.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.7 | -55.1 | -54.4 |
| **Total** | **5** | **3** | **-35** | **-27** | **1,492.4** | **416.7** | **-5,894.3** | **-3,985.2** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs (up to 10 to 18 percent) that store CVP and SWP water; and would result in reduced recreational economic factors under the No Action Alternative as compared to the Second Basis of Comparison.

*Regional Changes to Salmon Fishing*

Changes in commercial and sport ocean salmon fishing primarily would be related to the presence of fall-run Chinook Salmon from Central Valley hatcheries. It is assumed that the production of hatchery fish would be similar under the No Action Alternative and the Second Basis of Comparison. However, survival of the fall-run Chinook Salmon hatchery fish to the Pacific Ocean could be related to changes in CVP and SWP operations. As described in Chapter 9, Fish and Aquatic Resources, there would be little change in through-Delta survival by emigrating natural juvenile fall-run Chinook Salmon under the No Action Alternative as compared to the Second Basis of Comparison. It is assumed that the survival of the hatchery juvenile fall-run Chinook Salmon would be similar to the survival of the natural juvenile fall-run Chinook Salmon. Therefore, the availability of fish for commercial and sport ocean salmon fishing and the associated economic conditions for the fishing industry would be similar under the No Action Alternative and the Second Basis of Comparison.

#### 19.4.3.1.4 Central Coast Region

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Central Coast Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under the No Action Alternative as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under the No Action Alternative than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by 0.7 percent, as presented in Table 19.68; and therefore, the results would be similar under the No Action Alternative and Second Basis of Comparison.

**Table 19.68 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Differences in Total | No Action Alternative | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 44 | 54 | -10 |
| Delivery Cost ($1,000) | $6,663 | $8,174 | -$1,510 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,068 | -$8,643 | $575 |
| Excess Water Savings ($1,000) | -$2,970 | -$4,176 | $1,206 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,374** | **-$4,645** | **$271** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.69.

**Table 19.69 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.6 | -4.0 | -3.4 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 6.4 | -9.3 | -2.9 |
| Construction | 0 | 2 | 0 | 2 | 0.0 | 201.9 | -9.7 | 192.2 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 26.8 | -51.8 | -25.0 |
| Transportation, Warehousing & Utilities | 6 | 0 | 0 | 6 | 1,510.8 | 17.0 | -56.2 | 1,471.6 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 4.8 | -58.6 | -53.8 |
| Retail Trade | 0 | 0 | -1 | -1 | 0.0 | 6.1 | -118.5 | -112.4 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 12.0 | -39.0 | -27.0 |
| Financial Activities | 0 | 0 | -1 | -1 | 0.0 | 68.9 | -352.0 | -283.2 |
| Services | 0 | 2 | -5 | -3 | 0.0 | 167.1 | -447.4 | -280.3 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.9 | -13.2 | -12.3 |
| **Total** | **6** | **4** | **-8** | **2** | **1,510.8** | **512.7** | **-1,159.9** | **863.6** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs that store CVP and SWP water (up to 10 to 18 percent) that store CVP and SWP water; and would result in reduced recreational economic factors under the No Action Alternative as compared to the Second Basis of Comparison..

### 19.4.3.1.5 Southern California Region

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Southern California Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under the No Action Alternative as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under the No Action Alternative than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies would increase by 2.14 percent, as presented in Table 19.70; and therefore, the results would be similar under the No Action Alternative and Second Basis of Comparison.

**Table 19.70 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Differences in Total | No Action Alternative | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 1,932 | 2,394 | -461 |
| Delivery Cost ($1,000) | $239,692 | $296,795 | -$57,103 |
| Assumed New Supply Deliveries (TAF) | 47 | 11 | 35 |
| Annualized New Supply Costs ($1,000) | $12,688 | $4,032 | $8,656 |
| Water Storage Costs ($1,000) | $7,598 | $2,824 | $4,774 |
| Lost Water Sales Revenues ($1,000) | $14,614 | $1,119 | $13,495 |
| Transfer Costs ($1,000) | $11,484 | $3,705 | $7,779 |
| Shortage Costs ($1,000) | $17,319 | $353 | $16,966 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$57,474 | -$91,507 | $34,033 |
| Excess Water Savings ($1,000) | -$4,629 | -$10,573 | $5,944 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$241,291** | **$206,749** | **$34,542** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.71.

**Table 19.71 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California Region under the No Action Alternative as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 2 | 0 | 0.0 | -12.5 | 272.7 | 260.2 |
| Mining & Logging | 0 | -1 | 1 | 0 | 0.0 | -164.2 | 369.0 | 204.8 |
| Construction | 0 | -43 | 3 | 0 | 0.0 | -5,205.5 | 395.5 | -4,810.0 |
| Manufacturing | 0 | -2 | 10 | 0 | 0.0 | -1,452.6 | 6,814.5 | 5,361.9 |
| Transportation, Warehousing & Utilities | -175 | -2 | 12 | -175 | -43,673.4 | -592.0 | 2,602.9 | -41,662.5 |
| Wholesale Trade | 0 | -1 | 20 | 0 | 0.0 | -275.3 | 4,339.0 | 4,063.8 |
| Retail Trade | 0 | -2 | 58 | 0 | 0.0 | -170.6 | 5,106.3 | 4,935.7 |
| Information | 0 | -1 | 6 | 0 | 0.0 | -637.5 | 2,962.1 | 2,324.6 |
| Financial Activities | 0 | -9 | 52 | 0 | 0.0 | -2,528.7 | 17,797.9 | 15,269.1 |
| Services | 0 | -46 | 212 | 0 | 0.0 | -5,542.2 | 20,430.6 | 14,888.4 |
| Government | 0 | 0 | 3 | 0 | 0.0 | -29.8 | 587.3 | 557.5 |
| **Total** | **-175** | **-108** | **378** | **-175** | **-43,673.4** | **-16,611.0** | **61,677.8** | **1,393.5** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs that store CVP and SWP water, (up to 10 to 18 percent) that store CVP and SWP water; and would result in reduced recreational economic factors under the No Action Alternative as compared to the Second Basis of Comparison..

### *19.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 as compared to the No Action Alternative and the Second Basis of Comparison. However, because socioeconomic factors under Alternative 1 are identical to socioeconomic factors under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 19.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 1 as compared to the No Action Alternative.

#### *Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under Alternative 1 as compared to the No Action Alternative. There are no CVP or SWP water contractors in the Trinity River Region.

#### *Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under Alternative 1 as compared to the No Action Alternative as described in Chapter 15, Recreational Resources.

#### *Regional Changes to Salmon Fishing*

Trinity River flows would be similar under Alternative 1 as compared to the No Action Alternative. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

### *Central Valley Region*

#### *Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be greater under Alternative 1 as compared to the No Action Alternative. It is anticipated that groundwater use would decrease in response to increased CVP and SWP water supplies in 2030; and sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be increased by less than 1 percent ($1.6 million/year in the Sacramento Valley and $0.5 million/year in the San Joaquin Valley) primarily due to a decrease in groundwater pumping of approximately 7 percent. The agricultural production value under dry and critical dry conditions also would be increased by less than 1 percent ($11.3 million/year in the Sacramento Valley and $20.3 million/year in the San Joaquin Valley) primarily due to a decrease in groundwater pumping.

The overall increase in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.72 and 19.73, respectively.

**Table 19.72 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 1 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 87 | 21 | 0 | 108 | 11.3 | 1.3 | 0 | 12.7 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction | 0 | 1 | 0 | 1 | 0 | 0.1 | 0 | 0.2 |
| Manufacturing | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 |
| Transportation, Warehousing & Utilities | 0 | 1 | 0 | 2 | 0 | 0.4 | 0.1 | 0.5 |
| Wholesale Trade | 0 | 1 | 1 | 2 | 0 | 0.2 | 0.1 | 0.3 |
| Retail Trade | 0 | 0 | 4 | 4 | 0 | 0 | 0.3 | 0.3 |
| Information | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 |
| Financial Activities | 0 | 7 | 2 | 9 | 0 | 1.6 | 0.8 | 2.5 |
| Services | 0 | 3 | 12 | 15 | 0 | 0.3 | 1 | 1.3 |
| Government | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 |
| **Total** | **87** | **36** | **19** | **142** | **11.3** | **4.2** | **2.5** | **18.1** |

Note: In 2012 dollars.

**Table 19.73 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 1 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 139 | 53 | 0 | 192 | 20.3 | 2.3 | 0.1 | 22.7 |
| Mining & Logging | 0 | 1 | 0 | 1 | 0 | 0.3 | 0 | 0.3 |
| Construction | 0 | 2 | 0 | 2 | 0 | 0.2 | 0 | 0.2 |
| Manufacturing | 0 | 1 | 0 | 2 | 0 | 1.8 | 0.3 | 2.1 |
| Transportation, Warehousing & Utilities | 0 | 3 | 1 | 4 | 0 | 0.8 | 0.2 | 1 |
| Wholesale Trade | 0 | 2 | 1 | 3 | 0 | 0.4 | 0.2 | 0.5 |
| Retail Trade | 0 | 0 | 7 | 8 | 0 | 0 | 0.6 | 0.6 |
| Information | 0 | 0 | 0 | 1 | 0 | 0.1 | 0.1 | 0.2 |
| Financial Activities | 0 | 12 | 3 | 15 | 0 | 2.7 | 1.5 | 4.1 |
| Services | 0 | 5 | 21 | 26 | 0 | 0.5 | 1.7 | 2.2 |
| Government | 0 | 1 | 0 | 1 | 0 | 0.2 | 0.1 | 0.3 |
| **Total** | **139** | **79** | **35** | **254** | **20.3** | **9.2** | **4.9** | **34.4** |

Note: In 2012 dollars.

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley. The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would increase under Alternative 1 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis are described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.74 and 19.75 for the Sacramento and San Joaquin Valley, respectively. The average annual water supply operating expenses would decrease by 0.11 and 0.39 percent in the Sacramento Valley and the San Joaquin Valley, respectively; and therefore, the results would be similar under Alternative 1 and the No Action Alternative.

**Table 19.74 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under Alternative 1 as compared to the No Action Alternative**

| Differences in Total | Alternative 1 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 463 | 447 | 16 |
| Delivery Cost ($1,000) | $8,317 | $8,031 | $287 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $207 | $213 | -$6 |
| Transfer Costs ($1,000) | $517 | $739 | -$222 |
| Shortage Costs ($1,000) | $68 | $69 | -$1 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,916 | -$3,858 | -$58 |
| Excess Water Savings ($1,000) | -$2,563 | -$2,275 | -$288 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,630** | **$2,919** | **-$288** |

Note: In 2012 dollars

**Table 19.75 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under Alternative 1 as compared to the No Action Alternative**

| Differences in Total | Alternative 1 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 237 | 214 | 23 |
| Delivery Cost ($1,000) | $3,854 | $3,460 | $394 |
| Assumed New Supply Deliveries (TAF) | 0 | 2 | -2 |
| Annualized New Supply Costs ($1,000) | $15 | $429 | -$414 |
| Water Storage Costs ($1,000) | $820 | $942 | -$122 |
| Lost Water Sales Revenues ($1,000) | $322 | $361 | -$39 |
| Transfer Costs ($1,000) | $2,623 | $2,673 | -$50 |
| Shortage Costs ($1,000) | $102 | $115 | -$13 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$16,011 | -$15,377 | -$634 |
| Excess Water Savings ($1,000) | -$1,318 | -$1,029 | -$289 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$9,593** | **-$8,427** | **-$1,166** |

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.76 and 19.77, respectively.

**Table 19.76 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 1 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 1.7 | 1.6 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 0.3 | -0.1 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -29.0 | 2.5 | -26.5 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -3.1 | 22.2 | 19.1 |
| Transportation, Warehousing & Utilities | -1 | 0 | 0 | -1 | -286.4 | -2.8 | 18.0 | -271.2 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -1.0 | 27.1 | 26.1 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | -0.9 | 46.6 | 45.6 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -3.4 | 20.6 | 17.2 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -13.0 | 147.7 | 134.6 |
| Services | 0 | 0 | 2 | -1 | 0.0 | -30.8 | 154.7 | 123.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.2 | 3.8 | 3.7 |
| **Total** | **-1** | **-1** | **3** | **-1** | **-286.4** | **-84.8** | **445.2** | **74.0** |

Note: In 2012 dollars

**Table 19.77 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 1 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 6.7 | 6.7 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.4 | 6.4 | 6.8 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 13.3 | 5.6 | 18.9 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 1.4 | 46.4 | 47.8 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 140.8 | 1.4 | 44.7 | 186.9 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.4 | 39.0 | 39.3 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | 0.4 | 97.4 | 97.8 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 1.0 | 27.0 | 28.0 |
| Financial Activities | 0 | 0 | 1 | 1 | 0.0 | 4.3 | 263.7 | 268.0 |
| Services | 0 | 0 | 3 | 3 | 0.0 | 11.7 | 292.3 | 303.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 12.9 | 13.0 |
| **Total** | **1** | **0** | **6** | **7** | **140.8** | **34.3** | **842.0** | **1,017.2** |

Note: In 2012 dollars

#### *Regional Changes to Recreational Opportunities*

Recreational opportunities would increase at San Luis Reservoir by 6 percent under Alternative 1 as compared to the No Action Alternative, as described in Chapter 15, Recreation Resources. Therefore, it is anticipated that recreational economic factors would be increased under Alternative 1 as compared to the No Action Alternative.

#### *Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on socioeconomic factors could be adverse in the seller's service area.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

### *San Francisco Bay Area Region*

#### *Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the San Francisco Bay Area Region would not result in changes in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be an increase in irrigated acreage in dry and critical dry years under Alternative 1 as compared to the No Action Alternative.

#### *Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would increase under Alternative 1 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would decrease by 1.75 percent, as presented in Table 19.78; and therefore, the results would be similar under Alternative 1 and the No Action Alternative.

**Table 19.78 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under Alternative 1 as compared to the No Action Alternative**

| Differences in Total | Alternative 1 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 445 | 396 | 48 |
| Delivery Cost ($1,000) | $12,515 | $11,044 | $1,471 |
| Assumed New Supply Deliveries (TAF) | 16 | 18 | -2 |
| Annualized New Supply Costs ($1,000) | $234 | $599 | -$365 |
| Water Storage Costs ($1,000) | $1,963 | $1,577 | $386 |
| Lost Water Sales Revenues ($1,000) | $1,595 | $4,286 | -$2,691 |
| Transfer Costs ($1,000) | $1,154 | $5,722 | -$4,568 |
| Shortage Costs ($1,000) | $523 | $1,410 | -$887 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$792 | -$493 | -$298 |
| Excess Water Savings ($1,000) | -$549 | -$225 | -$324 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$16,643** | **$23,919** | **-$7,276** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.79.

**Table 19.79 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under Alternative 1 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 7.9 | 7.8 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -1.6 | 5.0 | 3.4 |
| Construction | 0 | -1 | 0 | -1 | 0.0 | -158.8 | 37.1 | -121.7 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -28.8 | 478.0 | 449.1 |
| Transportation, Warehousing & Utilities | -5 | 0 | 1 | -4 | -1,492.4 | -11.2 | 183.5 | -1,320.1 |
| Wholesale Trade | 0 | 0 | 1 | 1 | 0.0 | -5.0 | 350.6 | 345.7 |
| Retail Trade | 0 | 0 | 6 | 6 | 0.0 | -4.2 | 567.2 | 563.0 |
| Information | 0 | 0 | 1 | 1 | 0.0 | -16.8 | 306.6 | 289.8 |
| Financial Activities | 0 | 0 | 5 | 4 | 0.0 | -55.8 | 1,740.5 | 1,684.7 |
| Services | 0 | -1 | 20 | 19 | 0.0 | -133.7 | 2,162.8 | 2,029.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.7 | 55.1 | 54.4 |
| **Total** | **-5** | **-3** | **35** | **27** | **-1,492.4** | **-416.7** | **5,894.3** | **3,985.2** |

Note: In 2012 dollars

#### *Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 11 to 21 percent); and would result in increased recreational economic factors under Alternative 1 as compared to the No Action Alternative.

#### *Regional Changes to Salmon Fishing*

Changes in commercial and sport ocean salmon fishing primarily would be related to the presence of fall-run Chinook Salmon from Central Valley hatcheries. It is assumed that the production of hatchery fish would be similar under Alternative 1 and the No Action Alternative. However, survival of the fall-run Chinook Salmon hatchery fish to the Pacific Ocean could be related to changes in CVP and SWP operations. As described in Chapter 9, Fish and Aquatic Resources, there would be little change in through-Delta survival by emigrating natural juvenile fall-run Chinook Salmon under Alternative 1 and the No Action Alternative. It is assumed that the survival of the hatchery juvenile fall-run Chinook Salmon would be similar to the survival of the natural juvenile fall-run Chinook Salmon. Therefore, the availability of fish for commercial and sport ocean salmon fishing and the associated economic conditions for the fishing industry would be similar under Alternative 1 and the No Action Alternative.

### *Central Coast Region*

#### *Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Central Coast Region would not result in increases in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be increased irrigated acreage in dry and critical dry years under Alternative 1 as compared to the No Action Alternative.

#### *Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be higher under Alternative 1 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase 0.7 percent, as presented in Table 19.80; and therefore, the results would be similar under Alternative 1 and the No Action Alternative.

**Table 19.80 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under Alternative 1 as compared to the No Action Alternative**

| Differences in Total | Alternative 1 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 54 | 44 | 10 |
| Delivery Cost ($1,000) | $8,174 | $6,663 | $1,510 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,643 | -$8,068 | -$575 |
| Excess Water Savings ($1,000) | -$4,176 | -$2,970 | -$1,206 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,645** | **-$4,374** | **-$271** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.81.

**Table 19.81 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under Alternative 1 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.6 | 4.0 | 3.4 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -6.4 | 9.3 | 2.9 |
| Construction | 0 | -2 | 0 | -2 | 0.0 | -201.9 | 9.7 | -192.2 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -26.8 | 51.8 | 25.0 |
| Transportation, Warehousing & Utilities | -6 | 0 | 0 | -6 | -1,510.8 | -17.0 | 56.2 | -1,471.6 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -4.8 | 58.6 | 53.8 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | -6.1 | 118.5 | 112.4 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -12.0 | 39.0 | 27.0 |
| Financial Activities | 0 | 0 | 1 | 1 | 0.0 | -68.9 | 352.0 | 283.2 |
| Services | 0 | -2 | 5 | 3 | 0.0 | -167.1 | 447.4 | 280.3 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.9 | 13.2 | 12.3 |
| **Total** | **-6** | **-4** | **8** | **-2** | **-1,510.8** | **-512.7** | **1,159.9** | **-863.6** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 11 to 21 percent); and would result in increased recreational economic factors under Alternative 1 as compared to the No Action Alternative.

*Southern California Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Southern California Region would not result in increases in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be increased irrigated acreage in dry and critical dry years under Alternative 1 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be higher under Alternative 1 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would decrease 2.14 percent, as presented in Table 19.82; and therefore, the results would be similar under Alternative 1 and the No Action Alternative.

**Table 19.82 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under Alternative 1 as compared to the No Action Alternative**

| Differences in Total | Alternative 1 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 2,394 | 1,932 | 461 |
| Delivery Cost ($1,000) | $296,795 | $239,692 | $57,103 |
| Assumed New Supply Deliveries (TAF) | 11 | 47 | -35 |
| Annualized New Supply Costs ($1,000) | $4,032 | $12,688 | -$8,656 |
| Water Storage Costs ($1,000) | $2,824 | $7,598 | -$4,774 |
| Lost Water Sales Revenues ($1,000) | $1,119 | $14,614 | -$13,495 |
| Transfer Costs ($1,000) | $3,705 | $11,484 | -$7,779 |
| Shortage Costs ($1,000) | $353 | $17,319 | -$16,966 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$91,507 | -$57,474 | -$34,033 |
| Excess Water Savings ($1,000) | -$10,573 | -$4,629 | -$5,944 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$206,749** | **$241,291** | **-$34,542** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.83.

**Table 19.83 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California Region under Alternative 1 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | -2 | -1 | 0.0 | 12.5 | -272.7 | -260.2 |
| Mining & Logging | 0 | 1 | -1 | -1 | 0.0 | 164.2 | -369.0 | -204.8 |
| Construction | 0 | 43 | -3 | 40 | 0.0 | 5,205.5 | -395.5 | 4,810.0 |
| Manufacturing | 0 | 2 | -10 | -8 | 0.0 | 1,452.6 | -6,814.5 | -5,361.9 |
| Transportation, Warehousing & Utilities | 175 | 2 | -12 | 166 | 43,673.4 | 592.0 | -2,602.9 | 41,662.5 |
| Wholesale Trade | 0 | 1 | -20 | -19 | 0.0 | 275.3 | -4,339.0 | -4,063.8 |
| Retail Trade | 0 | 2 | -58 | -56 | 0.0 | 170.6 | -5,106.3 | -4,935.7 |
| Information | 0 | 1 | -6 | -5 | 0.0 | 637.5 | -2,962.1 | -2,324.6 |
| Financial Activities | 0 | 9 | -52 | -43 | 0.0 | 2,528.7 | -17,797.9 | -15,269.1 |
| Services | 0 | 46 | -212 | -166 | 0.0 | 5,542.2 | -20,430.6 | -14,888.4 |
| Government | 0 | 0 | -3 | -3 | 0.0 | 29.8 | -587.3 | -557.5 |
| **Total** | **175** | **108** | **-378** | **-95** | **43,673.4** | **16,611.0** | **-61,677.8** | **-1,393.5** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 11 to 21 percent); and would result in increased recreational economic factors under Alternative 1 as compared to the No Action Alternative.

##### 19.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison.

#### *19.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, therefore, Alternative 2 is only compared to the Second Basis of Comparison.

##### 19.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to socioeconomic factors under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 12.4.3.1, No Action Alternative.

#### *19.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations and reductions in Striped Bass fishing opportunities. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 19.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under Alternative 3 as compared to the No Action Alternative. There are no CVP or SWP water contractors in the Trinity River Region.

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under Alternative 3 as compared to the No Action Alternative as described in Chapter 15, Recreational Resources.

*Regional Changes to Salmon Fishing*

Trinity River flows would be similar under Alternative 3 as compared to the No Action Alternative. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

*Central Valley Region*

*Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be greater under Alternative 3 as compared to the No Action Alternative. It is anticipated that groundwater use would decrease in response to increased CVP and SWP water supplies in 2030; and sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be increased by less than 1 percent ($1.2 million/year in the Sacramento Valley and $0.3 million/year in the San Joaquin Valley) primarily due to a decrease in groundwater pumping of approximately 4 percent. The agricultural production value under dry and critical dry conditions also would be increased by less than 1 percent ($9.2 million/year in the Sacramento Valley and $11.4 million/year in the San Joaquin Valley), primarily due to a decrease in groundwater pumping.

The overall increase in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.84 and 19.85, respectively.

**Table 19.84 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 3 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 69 | 18 | 0 | 86 | 9.2 | 1.1 | 0.0 | 10.3 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | 1 | 0 | 1 | 0.0 | 0.1 | 0.0 | 0.1 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 0.0 | 0.1 |
| Transportation, Warehousing & Utilities | 0 | 1 | 0 | 1 | 0.0 | 0.3 | 0.1 | 0.4 |
| Wholesale Trade | 0 | 1 | 0 | 1 | 0.0 | 0.2 | 0.1 | 0.3 |
| Retail Trade | 0 | 0 | 3 | 3 | 0.0 | 0.0 | 0.3 | 0.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| Financial Activities | 0 | 5 | 2 | 7 | 0.0 | 1.3 | 0.7 | 2.0 |
| Services | 0 | 3 | 10 | 13 | 0.0 | 0.2 | 0.9 | 1.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 0.0 | 0.1 |
| **Total** | **69** | **29** | **17** | **115** | **9.2** | **3.4** | **2.2** | **14.8** |

Note: In 2012 dollars

**Table 19.85 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 3 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 103 | 26 | 0 | 130 | 11.4 | 1.2 | 0.0 | 12.7 |
| Mining & Logging | 0 | 1 | 0 | 1 | 0.0 | 0.2 | 0.0 | 0.2 |
| Construction | 0 | 1 | 0 | 1 | 0.0 | 0.1 | 0.0 | 0.1 |
| Manufacturing | 0 | 1 | 0 | 1 | 0.0 | 1.2 | 0.1 | 1.3 |
| Transportation, Warehousing & Utilities | 0 | 2 | 0 | 2 | 0.0 | 0.5 | 0.1 | 0.6 |
| Wholesale Trade | 0 | 1 | 0 | 1 | 0.0 | 0.2 | 0.1 | 0.3 |
| Retail Trade | 0 | 0 | 3 | 3 | 0.0 | 0.0 | 0.3 | 0.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| Financial Activities | 0 | 8 | 1 | 10 | 0.0 | 1.8 | 0.6 | 2.5 |
| Services | 0 | 3 | 9 | 12 | 0.0 | 0.3 | 0.7 | 1.0 |
| Government | 0 | 0 | 0 | 1 | 0.0 | 0.1 | 0.0 | 0.1 |
| **Total** | 103 | 44 | 15 | 161 | 11.4 | 5.7 | 2.1 | 19.1 |

Note: In 2012 dollars

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley. The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would increase under Alternative 3 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.86 and 19.87 for the Sacramento and San Joaquin Valley, respectively. Average annual water supply operating expenses would decrease by 0.07 and 0.5 percent in the Sacramento Valley and the San Joaquin Valley, respectively; and therefore, the results would be similar under Alternative 3 and the No Action Alternative.

**Table 19.86 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under Alternative 3 as compared to the No Action Alternative**

| Differences in Total | Alternative 3 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 461 | 447 | 13 |
| Delivery Cost ($1,000) | $8,285 | $8,031 | $255 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $243 | $213 | $30 |
| Transfer Costs ($1,000) | $601 | $739 | -$138 |
| Shortage Costs ($1,000) | $77 | $69 | $8 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,938 | -$3,858 | -$81 |
| Excess Water Savings ($1,000) | -$2,517 | -$2,275 | -$241 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,750** | **$2,919** | **-$169** |

Note: In 2012 dollars

**Table 19.87 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under Alternative 3 as compared to the No Action Alternative**

| Differences in Total | Alternative 3 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 241 | 214 | 27 |
| Delivery Cost ($1,000) | $3,896 | $3,460 | $436 |
| Assumed New Supply Deliveries (TAF) | 0 | 2 | -2 |
| Annualized New Supply Costs ($1,000) | $13 | $429 | -$417 |
| Water Storage Costs ($1,000) | $465 | $942 | -$477 |
| Lost Water Sales Revenues ($1,000) | $284 | $361 | -$78 |
| Transfer Costs ($1,000) | $2,104 | $2,673 | -$568 |
| Shortage Costs ($1,000) | $89 | $115 | -$26 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$15,660 | -$15,377 | -$283 |
| Excess Water Savings ($1,000) | -$1,378 | -$1,029 | -$349 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$10,187** | **-$8,427** | **-$1,761** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.88 and 19.89, respectively.

**Table 19.88 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 3 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | -1.2 | -1.1 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.4 | -0.2 | 0.2 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 25.8 | -1.8 | 23.9 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 2.8 | -16.2 | -13.5 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 254.4 | 2.5 | -13.1 | 243.7 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.9 | -20.0 | -19.1 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | 0.8 | -33.8 | -33.0 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 3.0 | -15.1 | -12.1 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | 11.6 | -107.7 | -96.1 |
| Services | 0 | 0 | -1 | -1 | 0.0 | 27.4 | -112.8 | -85.4 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.1 | -2.8 | -2.7 |
| **Total** | **1** | **1** | **-2** | **0** | **254.4** | **75.3** | **-324.8** | **4.9** |

Note: In 2012 dollars

**Table 19.89 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 3 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.2 | -8.9 | -9.1 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -1.2 | -8.5 | -9.7 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -43.3 | -7.4 | -50.7 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -4.4 | -62.0 | -66.3 |
| Transportation, Warehousing & Utilities | -2 | 0 | 0 | -2 | -457.3 | -4.4 | -59.6 | -521.3 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -1.2 | -51.6 | -52.8 |
| Retail Trade | 0 | 0 | -2 | -2 | 0.0 | -1.3 | -130.7 | -132.0 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -3.2 | -36.0 | -39.2 |
| Financial Activities | 0 | 0 | -1 | -1 | 0.0 | -14.1 | -352.2 | -366.3 |
| Services | 0 | 0 | -5 | -5 | 0.0 | -38.0 | -391.1 | -429.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.3 | -17.2 | -17.5 |
| **Total** | **-2** | **-1** | **-8** | **-11** | **-457.3** | **-111.6** | **-1,125.2** | **-1,694.1** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar at San Luis Reservoir under Alternative 3 as compared to the No Action Alternative, as described in Chapter 15, Recreation Resources. Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 3 is implemented.

However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 3 as compared to the Second Basis of Comparison due to actions to reduce predation. Therefore, it is anticipated that recreational economic factors would be reduced under Alternative 3 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on socioeconomic factors could be adverse in the seller's service area.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the San Francisco Bay Area Region would not result in changes in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be an increase in irrigated acreage in dry and critical dry years under Alternative 3 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would increase under Alternative 3 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would decrease by 1.23 percent, as presented in Table 19.90; and therefore, the results would be similar under Alternative 3 and the No Action Alternative.

**Table 19.90 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under Alternative 3 as compared to the No Action Alternative**

| Differences in Total | Alternative 3 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 431 | 396 | 34 |
| Delivery Cost ($1,000) | $12,096 | $11,044 | $1,052 |
| Assumed New Supply Deliveries (TAF) | 18 | 18 | 0 |
| Annualized New Supply Costs ($1,000) | $575 | $599 | -$24 |
| Water Storage Costs ($1,000) | $2,303 | $1,577 | $726 |
| Lost Water Sales Revenues ($1,000) | $2,381 | $4,286 | -$1,905 |
| Transfer Costs ($1,000) | $1,826 | $5,722 | -$3,896 |
| Shortage Costs ($1,000) | $743 | $1,410 | -$667 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$726 | -$493 | -$232 |
| Excess Water Savings ($1,000) | -$393 | -$225 | -$167 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$18,806** | **$23,919** | **-$5,113** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.91.

**Table 19.91 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under Alternative 3 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | -6.0 | -5.9 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 1.9 | -3.8 | -1.9 |
| Construction | 0 | 1 | 0 | 1 | 0.0 | 186.7 | -28.2 | 158.6 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 33.9 | -363.5 | -329.6 |
| Transportation, Warehousing & Utilities | 6 | 0 | -1 | 5 | 1,754.5 | 13.2 | -139.1 | 1,628.6 |
| Wholesale Trade | 0 | 0 | -1 | -1 | 0.0 | 5.8 | -268.7 | -262.9 |
| Retail Trade | 0 | 0 | -5 | -5 | 0.0 | 4.9 | -428.6 | -423.7 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 19.8 | -233.1 | -213.4 |
| Financial Activities | 0 | 0 | -3 | -3 | 0.0 | 65.6 | -1,320.3 | -1,254.7 |
| Services | 0 | 1 | -15 | -14 | 0.0 | 157.2 | -1,639.6 | -1,482.4 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.8 | -41.8 | -41.0 |
| **Total** | **6** | **3** | **-26** | **-17** | **1,754.5** | **489.9** | **-4,472.7** | **-2,228.3** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 9 to 17 percent);

and would result in increased recreational economic factors under Alternative 3 as compared to the No Action Alternative.

*Regional Changes to Salmon Fishing*

Commercial and sport ocean salmon fishing would be reduced under Alternative 3 and the No Action Alternative due to increased commercial and sport ocean salmon harvests limits.

*Central Coast Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Central Coast Region would not result in increases in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be increased irrigated acreage in dry and critical dry years under Alternative 3 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be higher under Alternative 3 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would decrease by $125,000, or 0.33 percent, as presented in Table 19.92; and therefore, the results would be similar under Alternative 3 and the No Action Alternative.

**Table 19.92 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under Alternative 3 as compared to the No Action Alternative**

| Differences in Total | Alternative 3 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 51 | 44 | 8 |
| Delivery Cost ($1,000) | $7,814 | $6,663 | $1,151 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,333 | -$8,068 | -$265 |
| Excess Water Savings ($1,000) | -$3,980 | -$2,970 | -$1,010 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,499** | **-$4,374** | **-$125** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.93.

**Table 19.93 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under Alternative 3 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.4 | -2.8 | -2.4 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 4.9 | -6.5 | -1.7 |
| Construction | 0 | 1 | 0 | 1 | 0.0 | 153.8 | -6.8 | 147.0 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 20.4 | -36.5 | -16.0 |
| Transportation, Warehousing & Utilities | 5 | 0 | 0 | 5 | 1,150.6 | 13.0 | -39.5 | 1,124.0 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 3.7 | -41.4 | -37.8 |
| Retail Trade | 0 | 0 | -1 | -1 | 0.0 | 4.7 | -83.0 | -78.4 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 9.1 | -27.4 | -18.3 |
| Financial Activities | 0 | 0 | -1 | 0 | 0.0 | 52.5 | -247.3 | -194.8 |
| Services | 0 | 1 | -3 | -2 | 0.0 | 127.3 | -314.2 | -186.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.7 | -9.3 | -8.6 |
| **Total** | **5** | **3** | **-6** | **2** | **1,150.6** | **390.4** | **-814.8** | **726.2** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 9 to 17 percent); and would result in increased recreational economic factors under Alternative 3 as compared to the No Action Alternative.

*Southern California Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Southern California Region would not result in increases in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be increased irrigated acreage in dry and critical dry years under Alternative 3 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be higher under Alternative 3 as compared to the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies would be $4.94 million, or 0.31 percent, as presented in Table 19.94; and therefore, the results would be similar under Alternative 3 and the No Action Alternative.

**Table 19.94 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under Alternative 3 as compared to the No Action Alternative**

| Differences in Total | Alternative 3 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 2,241 | 1,932 | 308 |
| Delivery Cost ($1,000) | $278,085 | $239,692 | $38,393 |
| Assumed New Supply Deliveries (TAF) | 40 | 47 | -7 |
| Annualized New Supply Costs ($1,000) | $10,584 | $12,688 | -$2,104 |
| Water Storage Costs ($1,000) | $8,154 | $7,598 | $556 |
| Lost Water Sales Revenues ($1,000) | $11,409 | $14,614 | -$3,205 |
| Transfer Costs ($1,000) | $6,181 | $11,484 | -$5,303 |
| Shortage Costs ($1,000) | $12,632 | $17,319 | -$4,687 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$81,693 | -$57,474 | -$24,218 |
| Excess Water Savings ($1,000) | -$9,005 | -$4,629 | -$4,376 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$236,347** | **$241,291** | **-$4,944** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.95.

**Table 19.95 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California under Alternative 3 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | -1 | -1 | 0.0 | 10.5 | -146.4 | -135.8 |
| Mining & Logging | 0 | 1 | -1 | 0 | 0.0 | 138.6 | -199.8 | -61.2 |
| Construction | 0 | 37 | -2 | 35 | 0.0 | 4,391.6 | -211.9 | 4,179.8 |
| Manufacturing | 0 | 2 | -6 | -3 | 0.0 | 1,225.5 | -3,662.5 | -2,437.0 |
| Transportation, Warehousing & Utilities | 148 | 2 | -6 | 143 | 36,845.0 | 499.5 | -1,389.7 | 35,954.8 |
| Wholesale Trade | 0 | 1 | -11 | -10 | 0.0 | 232.2 | -2,405.6 | -2,173.3 |
| Retail Trade | 0 | 2 | -31 | -29 | 0.0 | 143.9 | -2,688.1 | -2,544.2 |
| Information | 0 | 1 | -3 | -2 | 0.0 | 537.8 | -1,595.7 | -1,057.9 |
| Financial Activities | 0 | 7 | -28 | -20 | 0.0 | 2,133.4 | -9,496.1 | -7,362.8 |
| Services | 0 | 39 | -113 | -74 | 0.0 | 4,675.7 | -10,892.2 | -6,216.5 |
| Government | 0 | 0 | -2 | -1 | 0.0 | 25.1 | -314.7 | -289.6 |
| **Total** | 148 | 91 | -202 | 37 | 36,845.0 | **14,013.9** | **-33,002.7** | **17,856.2** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir elevations in reservoirs that store CVP and SWP water (up to 9 to 17 percent); and would result in increased recreational economic factors under Alternative 3 as compared to the No Action Alternative.

#### 19.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under Alternative 3 and the Second Basis of Comparison. There are no CVP or SWP water contractors in the Trinity River Region.

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under Alternative 3 as compared to the Second Basis of Comparison as described in Chapter 15, Recreational Resources.

*Regional Changes to Salmon Fishing*

Trinity River flows would be similar under Alternative 3 as compared to the Second Basis of Comparison. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

*Central Valley Region*

*Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 3 than under the Second Basis of Comparison. It is anticipated that groundwater use would increase in response to reduced CVP and SWP water supplies in 2030 because sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be reduced by less than 1 percent ($0.3 million/year in the Sacramento Valley and $0.3 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping of approximately 2 percent. The agricultural production value under dry and critical dry conditions also would be reduced by less than 1 percent ($2.1 million/year in the Sacramento Valley and $8.9 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping.

The overall reduction in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.96 and 19.97, respectively.

**Table 19.96 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 3 as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -18 | -4 | 0 | -22 | -2.1 | -0.2 | 0.0 | -2.3 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | -0.1 |
| Retail Trade | 0 | 0 | 0 | -1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Activities | 0 | -2 | 0 | -2 | 0.0 | -0.4 | -0.1 | -0.5 |
| Services | 0 | -1 | -1 | -2 | 0.0 | -0.1 | -0.1 | -0.2 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **-18** | **-7** | **-2** | **-27** | **-2.1** | **-0.9** | **-0.3** | **-3.3** |

Note: In 2012 dollars

**Table 19.97 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 3 as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -36 | -26 | 0 | -63 | -8.9 | -1.1 | 0.0 | -10.0 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| Construction | 0 | -1 | 0 | -1 | 0.0 | -0.1 | 0.0 | -0.1 |
| Manufacturing | 0 | 0 | 0 | -1 | 0.0 | -0.7 | -0.2 | -0.8 |
| Transportation, Warehousing & Utilities | 0 | -1 | -1 | -2 | 0.0 | -0.3 | -0.1 | -0.5 |
| Wholesale Trade | 0 | -1 | -1 | -1 | 0.0 | -0.1 | -0.1 | -0.2 |
| Retail Trade | 0 | 0 | -4 | -4 | 0.0 | 0.0 | -0.4 | -0.4 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | -0.1 | -0.1 |
| Financial Activities | 0 | -4 | -2 | -5 | 0.0 | -0.8 | -0.9 | -1.7 |
| Services | 0 | -2 | -12 | -14 | 0.0 | -0.2 | -1.0 | -1.2 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| **Total** | **-36** | **-36** | **-20** | **-92** | **-8.9** | **-3.5** | **-2.8** | **-15.3** |

Note: In 2012 dollars

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley. The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be similar in the Sacramento Valley and greater in the San Joaquin Valley under Alternative 3 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.98 and 19.99 for the Sacramento and San Joaquin Valley, respectively. Average annual water supply operating costs would increase in the Sacramento Valley by 0.05 percent, decrease in the San Joaquin Valley by 0.2 percent; and therefore, the results would be similar under Alternative 3 and the Second Basis of Comparison.

**Table 19.98 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under Alternative 3 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 3 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 461 | 463 | -2 |
| Delivery Cost ($1,000) | $8,285 | $8,317 | -$32 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $243 | $207 | $35 |
| Transfer Costs ($1,000) | $601 | $517 | $84 |
| Shortage Costs ($1,000) | $77 | $68 | $9 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,938 | -$3,916 | -$23 |
| Excess Water Savings ($1,000) | -$2,517 | -$2,563 | $46 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,750** | **$2,630** | **$119** |

Note: In 2012 dollars

**Table 19.99 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under Alternative 3 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 3 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 241 | 237 | 4 |
| Delivery Cost ($1,000) | $3,896 | $3,854 | $42 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $13 | $15 | -$3 |
| Water Storage Costs ($1,000) | $465 | $820 | -$355 |
| Lost Water Sales Revenues ($1,000) | $284 | $322 | -$39 |
| Transfer Costs ($1,000) | $2,104 | $2,623 | -$518 |
| Shortage Costs ($1,000) | $89 | $102 | -$13 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$15,660 | -$16,011 | $351 |
| Excess Water Savings ($1,000) | -$1,378 | -$1,318 | -$59 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$10,187** | **-$9,593** | **-$595** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.100 and 19.101, respectively.

**Table 19.100 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 3 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.5 | 0.5 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -3.5 | 0.7 | -2.8 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 6.4 | 6.0 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | 0 | -34.6 | -0.3 | 5.2 | -29.7 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 7.7 | 7.6 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 13.6 | 13.5 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 6.0 | 5.5 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -1.6 | 42.9 | 41.3 |
| Services | 0 | 0 | 0 | 0 | 0.0 | -3.7 | 45.0 | 41.2 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 1.1 | 1.1 |
| **Total** | **0** | **0** | **1** | **1** | **-34.6** | **-10.2** | **129.2** | **84.4** |

Note: In 2012 dollars

**Table 19.101 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 3 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | -2.3 | -2.4 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.8 | -2.1 | -3.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -29.9 | -1.9 | -31.8 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -3.0 | -15.5 | -18.6 |
| Transportation, Warehousing & Utilities | -1 | 0 | 0 | -1 | -315.8 | -3.0 | -14.9 | -333.7 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -0.8 | -12.7 | -13.5 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | -0.9 | -33.4 | -34.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -2.2 | -9.0 | -11.2 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -9.7 | -88.6 | -98.4 |
| Services | 0 | 0 | -1 | -1 | 0.0 | -26.2 | -99.0 | -125.2 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.2 | -4.3 | -4.5 |
| **Total** | **-1** | **-1** | **-2** | **-4** | **-315.8** | **-77.0** | **-283.5** | **-676.3** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar at San Luis Reservoir under Alternative 3 as compared to the Second Basis of Comparison, as described in Chapter 15, Recreation Resources. Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 3 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 3 as compared to the Second Basis of Comparison due to actions to reduce predation. Therefore, it is anticipated that recreational economic factors would be reduced under Alternative 3 as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on socioeconomic factors could be adverse in the seller's service area.

Under Alternative 3 and Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the San Francisco Bay Area Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 3 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 3 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by $2.16 million, or 0.52 percent, as presented in Table 19.102; and therefore, the results would be similar under Alternative 3 and the Second Basis of Comparison.

**Table 19.102 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 3 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 431 | 445 | -14 |
| Delivery Cost ($1,000) | $12,096 | $12,515 | -$419 |
| Assumed New Supply Deliveries (TAF) | 18 | 16 | 2 |
| Annualized New Supply Costs ($1,000) | $575 | $234 | $342 |
| Water Storage Costs ($1,000) | $2,303 | $1,963 | $340 |
| Lost Water Sales Revenues ($1,000) | $2,381 | $1,595 | $786 |
| Transfer Costs ($1,000) | $1,826 | $1,154 | $672 |
| Shortage Costs ($1,000) | $743 | $523 | $221 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$726 | -$792 | $66 |
| Excess Water Savings ($1,000) | -$393 | -$549 | $156 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$18,806** | **$16,643** | **$2,163** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.103.

**Table 19.103 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 1.9 | 1.9 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.3 | 1.2 | 1.5 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 28.0 | 9.0 | 36.9 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 5.1 | 114.4 | 119.5 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 262.6 | 2.0 | 44.3 | 308.9 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.9 | 81.9 | 82.8 |
| Retail Trade | 0 | 0 | 2 | 2 | 0.0 | 0.7 | 138.5 | 139.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 3.0 | 73.5 | 76.4 |
| Financial Activities | 0 | 0 | 1 | 1 | 0.0 | 9.8 | 420.2 | 430.0 |
| Services | 0 | 0 | 5 | 5 | 0.0 | 23.5 | 523.1 | 546.7 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 13.3 | 13.4 |
| **Total** | **1** | **0** | **8** | **10** | **262.6** | **73.3** | **1,421.3** | **1,757.2** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 3 as compared to the Second Basis of Comparison.

*Regional Changes to Salmon Fishing*

Commercial and sport ocean salmon fishing would be reduced under Alternative 3 and the Second Basis of Comparison due to increased commercial and sport ocean salmon harvests limits.

*Central Coast Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Central Coast Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 3 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 3 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by $146,000, or 0.38 percent, as presented in Table 19.104; and therefore, the results would be similar under Alternative 3 and the Second Basis of Comparison.

**Table 19.104 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 3 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 51 | 54 | -2 |
| Delivery Cost ($1,000) | $7,814 | $8,174 | -$360 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,333 | -$8,643 | $310 |
| Excess Water Savings ($1,000) | -$3,980 | -$4,176 | $196 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,499** | **-$4,645** | **$146** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.105.

**Table 19.105 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 1.2 | 1.0 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -1.5 | 2.8 | 1.2 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -48.1 | 2.9 | -45.2 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -6.4 | 15.4 | 9.0 |
| Transportation, Warehousing & Utilities | -2 | 0 | 0 | -2 | -359.9 | -4.1 | 16.7 | -347.2 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -1.2 | 17.2 | 16.1 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | -1.5 | 35.5 | 34.1 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -2.9 | 11.6 | 8.8 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -16.4 | 104.9 | 88.5 |
| Services | 0 | 0 | 1 | 1 | 0.0 | -39.8 | 133.4 | 93.6 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.2 | 3.9 | 3.7 |
| **Total** | **-2** | **-1** | **2** | **0** | **-359.9** | **-122.1** | **345.5** | **-136.5** |

Note: In 2012 dollars

### *Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 3 as compared to the Second Basis of Comparison.

*Southern California Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Southern California Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 3 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 3 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies would increase by 1.83 percent, as presented in Table 19.106; and therefore, the results would be similar under Alternative 3 and the Second Basis of Comparison.

**Table 19.106 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 3 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 2,241 | 2,394 | -153 |
| Delivery Cost ($1,000) | $278,085 | $296,795 | -$18,710 |
| Assumed New Supply Deliveries (TAF) | 40 | 11 | 28 |
| Annualized New Supply Costs ($1,000) | $10,584 | $4,032 | $6,552 |
| Water Storage Costs ($1,000) | $8,154 | $2,824 | $5,330 |
| Lost Water Sales Revenues ($1,000) | $11,409 | $1,119 | $10,289 |
| Transfer Costs ($1,000) | $6,181 | $3,705 | $2,476 |
| Shortage Costs ($1,000) | $12,632 | $353 | $12,279 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$81,693 | -$91,507 | $9,814 |
| Excess Water Savings ($1,000) | -$9,005 | -$10,573 | $1,568 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$236,347** | **$206,749** | **$29,598** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.107.

**Table 19.107 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California Region under Alternative 3 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 1 | 1 | 0.0 | -2.0 | 126.3 | 124.4 |
| Mining & Logging | 0 | 0 | 1 | 0 | 0.0 | -25.7 | 169.2 | 143.5 |
| Construction | 0 | -7 | 1 | -5 | 0.0 | -813.9 | 183.7 | -630.2 |
| Manufacturing | 0 | 0 | 5 | 4 | 0.0 | -227.1 | 3,152.0 | 2,924.9 |
| Transportation, Warehousing & Utilities | -27 | 0 | 5 | -22 | -6,828.3 | -92.6 | 1,213.1 | -5,707.8 |
| Wholesale Trade | 0 | 0 | 9 | 9 | 0.0 | -43.0 | 1,933.5 | 1,890.4 |
| Retail Trade | 0 | 0 | 27 | 27 | 0.0 | -26.7 | 2,418.2 | 2,391.5 |
| Information | 0 | 0 | 3 | 3 | 0.0 | -99.7 | 1,366.4 | 1,266.7 |
| Financial Activities | 0 | -1 | 24 | 23 | 0.0 | -395.4 | 8,301.7 | 7,906.3 |
| Services | 0 | -7 | 99 | 92 | 0.0 | -866.5 | 9,538.4 | 8,671.9 |
| Government | 0 | 0 | 1 | 1 | 0.0 | -4.7 | 272.6 | 268.0 |
| **Total** | **-27** | **-17** | **177** | **132** | **-6,828.3** | **-2,597.1** | **28,675.1** | **19,249.7** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 3 as compared to the Second Basis of Comparison.

### *19.4.3.5 Alternative 4*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1, as described in Chapter 3, Description of Alternatives. In addition, Alternative 4 includes Striped Bass predation control which would reduce recreational opportunities. The non-recreational socioeconomic factors under Alternative 4 would be identical to the conditions under the Second Basis of Comparison. Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 19.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in non-recreational socioeconomic factors under Alternative 4 as compared to the No Action Alternative would be the similar to impacts described in Section 12.4.3.2.1, Alternative 1 Compared to the No Action

Alternative. Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 4 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 4 as compared to the No Action Alternative due to actions to reduce predation. Commercial and sport ocean salmon fishing opportunities would be reduced under Alternative 4 as compared to the No Action Alternative due to increased harvest limitations.

#### 19.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, socioeconomic factors under Alternative 4 are the same as non-recreational socioeconomic factors under the Second Basis of Comparison. Recreational opportunities related to Striped Bass fishing would initially be increased when Alternative 4 is implemented. However, by 2030, Striped Bass fishing opportunities would be reduced under Alternative 4 as compared to the Second Basis of Comparison due to actions to reduce predation. Commercial and sport ocean salmon fishing opportunities would be reduced under Alternative 4 as compared to the Second Basis of Comparison due to increased harvest limitations.

### *19.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 19.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the No Action Alternative.

*Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under Alternative 5 as compared to the No Action Alternative. There are no CVP or SWP water contractors in the Trinity River Region.

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under Alternative 5 as compared to the No Action Alternative as described in Chapter 15, Recreational Resources.

*Regional Changes to Salmon Fishing*

Trinity River flows would be similar under Alternative 5 as compared to the No Action Alternative. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

*Central Valley Region*

*Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be similar under Alternative 5 and the No Action Alternative. It is anticipated that groundwater use would be similar and sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be the same under Alternative 5 as the No Action Alternative. The agricultural production value under dry and critical dry conditions also would be reduced by less than 1 percent ($0.8 million/year increase in the Sacramento Valley and $2.7 million/year decrease in the San Joaquin Valley), although groundwater pumping is not anticipated to change.

The overall decrease in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.108 and 19.109, respectively.

**Table 19.108 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 5 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 3 | 2 | 0 | 4 | 0.8 | 0.1 | 0.0 | 0.9 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 0.1 | 0.2 |
| Services | 0 | 0 | 1 | 2 | 0.0 | 0.0 | 0.1 | 0.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **3** | **2** | **2** | **7** | **0.8** | **0.2** | **0.3** | **1.3** |

Note: In 2012 dollars

**Table 19.109 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 5 as compared to the No Action Alternative in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -5 | -9 | 0 | -14 | -2.7 | -0.4 | 0.0 | -3.0 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -0.2 | -0.1 | -0.2 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | -1 | 0.0 | -0.1 | 0.0 | -0.1 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | -0.1 |
| Retail Trade | 0 | 0 | -2 | -2 | 0.0 | 0.0 | -0.1 | -0.1 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Financial Activities | 0 | -1 | -1 | -1 | 0.0 | -0.2 | -0.3 | -0.5 |
| Services | 0 | -1 | -4 | -5 | 0.0 | -0.1 | -0.4 | -0.4 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **-5** | **-11** | **-7** | **-24** | **-2.7** | **-0.9** | **-1.0** | **-4.6** |

Note: In 2012 dollars

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley. The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be similar in the Sacramento Valley and lower in the San Joaquin Valley under Alternative 5 and the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.110 and 19.111 for the Sacramento and San Joaquin Valley, respectively. Average annual water supply operating expenses would be similar (within 0.05 percent change) for the Sacramento Valley, and increase by 0.07 percent in the San Joaquin Valley; and therefore, the results would be similar under Alternative 5 and the No Action Alternative.

**Table 19.110 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under Alternative 5 as compared to the No Action Alternative**

| Differences in Total | Alternative 5 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 447 | 447 | -1 |
| Delivery Cost ($1,000) | $8,022 | $8,031 | -$8 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $204 | $213 | -$9 |
| Transfer Costs ($1,000) | $752 | $739 | $12 |
| Shortage Costs ($1,000) | $68 | $69 | -$2 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,856 | -$3,858 | $1 |
| Excess Water Savings ($1,000) | -$2,266 | -$2,275 | $10 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,924** | **$2,919** | **$5** |

Note: In 2012 dollars

**Table 19.111 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under Alternative 5 as compared to the No Action Alternative**

| Differences in Total | Alternative 5 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 211 | 214 | -3 |
| Delivery Cost ($1,000) | $3,411 | $3,460 | -$49 |
| Assumed New Supply Deliveries (TAF) | 2 | 2 | 1 |
| Annualized New Supply Costs ($1,000) | $601 | $429 | $171 |
| Water Storage Costs ($1,000) | $966 | $942 | $24 |
| Lost Water Sales Revenues ($1,000) | $361 | $361 | $0 |
| Transfer Costs ($1,000) | $2,661 | $2,673 | -$12 |
| Shortage Costs ($1,000) | $115 | $115 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$15,329 | -$15,377 | $49 |
| Excess Water Savings ($1,000) | -$996 | -$1,029 | $33 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$8,211** | **-$8,427** | **$215** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.112 and 19.113, respectively.

**Table 19.112 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 5 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -0.8 | 0.1 | -0.7 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.6 | 0.5 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | 0 | -7.8 | -0.1 | 0.5 | -7.4 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.7 | 0.7 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 1.2 | 1.1 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.5 | 0.4 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 3.7 | 3.4 |
| Services | 0 | 0 | 0 | 0 | 0.0 | -0.8 | 3.9 | 3.0 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| **Total** | **0** | **0** | **0** | **0** | **-7.8** | **-2.3** | **11.2** | **1.1** |

Note: In 2012 dollars

**Table 19.113 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 5 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 0.7 | 0.8 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.4 | 0.7 | 1.0 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 13.9 | 0.6 | 14.5 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 1.4 | 4.8 | 6.2 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 146.6 | 1.4 | 4.6 | 152.6 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.4 | 3.9 | 4.3 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | 0.4 | 10.6 | 11.0 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 1.0 | 2.8 | 3.8 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | 4.5 | 27.7 | 32.3 |
| Services | 0 | 0 | 0 | 0 | 0.0 | 12.2 | 31.1 | 43.3 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 1.3 | 1.5 |
| **Total** | **1** | **0** | **1** | **1** | **146.6** | **35.8** | **88.8** | **271.2** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Recreational opportunities at San Luis Reservoir would be similar under Alternative 5 as compared to the No Action Alternative, as described in Chapter 15, Recreation Resources. Therefore, it is anticipated that recreational economic factors would be similar under Alternative 5 as compared to the No Action Alternative.

*Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on socioeconomic factors could be adverse in the seller's service area.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, CVP and SWP water supplies within the San Francisco Bay Area Region would be similar under Alternative 5 and the No Action Alternative, and would not result in changes in irrigated acreage or land use changes due to the use of other water supplies.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be lower under Alternative 5 and the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would be increase by 0.1 percent, as presented in Table 19.114; and therefore, the results would be similar under Alternative 5 and the No Action Alternative.

**Table 19.114 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under Alternative 5 as compared to the No Action Alternative**

| Differences in Total | Alternative 5 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 394 | 396 | -3 |
| Delivery Cost ($1,000) | $10,962 | $11,044 | -$82 |
| Assumed New Supply Deliveries (TAF) | 18 | 18 | 0 |
| Annualized New Supply Costs ($1,000) | $599 | $599 | $0 |
| Water Storage Costs ($1,000) | $1,495 | $1,577 | -$81 |
| Lost Water Sales Revenues ($1,000) | $4,360 | $4,286 | $74 |
| Transfer Costs ($1,000) | $6,156 | $5,722 | $434 |
| Shortage Costs ($1,000) | $1,450 | $1,410 | $40 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$470 | -$493 | $24 |
| Excess Water Savings ($1,000) | -$225 | -$225 | $0 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$24,328** | **$23,919** | **$409** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.115.

**Table 19.115 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under Alternative 5 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.5 | 0.5 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.2 | 0.3 | 0.1 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -17.4 | 2.4 | -15.0 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -3.2 | 30.9 | 27.8 |
| Transportation, Warehousing & Utilities | -1 | 0 | 0 | -1 | -163.1 | -1.2 | 11.8 | -152.5 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -0.5 | 22.9 | 22.4 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | -0.5 | 36.4 | 35.9 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -1.8 | 19.8 | 18.0 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -6.1 | 112.3 | 106.2 |
| Services | 0 | 0 | 1 | 1 | 0.0 | -14.6 | 139.4 | 124.8 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 3.6 | 3.5 |
| **Total** | **-1** | **0** | **2** | **1** | **-163.1** | **-45.5** | **380.3** | **171.7** |

Note: In 2012 dollars

#### *Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 5 as compared o the No Action Alternative.

#### *Regional Changes to Salmon Fishing*

Changes in commercial and sport ocean salmon fishing primarily would be related to the presence of fall-run Chinook Salmon from Central Valley hatcheries. It is assumed that the production of hatchery fish would be similar under Alternative 15 and the No Action Alternative. However, survival of the fall-run Chinook Salmon hatchery fish to the Pacific Ocean could be related to changes in CVP and SWP operations. As described in Chapter 9, Fish and Aquatic Resources, there would be little change in through-Delta survival by emigrating natural juvenile fall-run Chinook Salmon under Alternative 5 and the No Action Alternative. It is assumed that the survival of the hatchery juvenile fall-run Chinook Salmon would be similar to the survival of the natural juvenile fall-run Chinook Salmon. Therefore, the availability of fish for commercial and sport ocean salmon fishing and the associated economic conditions for the fishing industry would be similar under Alternative 5 and the No Action Alternative.

### *Central Coast Region*

#### *Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Central Coast Region would be lower under Alternative 5 and the No Action Alternative, and would not result in changes in irrigated acreage or land use changes due to the use of other water supplies.

#### *Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be similar under Alternative 5 and the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by 0.06 percent, as presented in Table 19.116; and therefore, the results would be similar under Alternative 5 and the No Action Alternative.

**Table 19.116 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under Alternative 5 as compared to the No Action Alternative**

| Differences in Total | Alternative 5 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 43 | 44 | -1 |
| Delivery Cost ($1,000) | $6,567 | $6,663 | -$97 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,018 | -$8,068 | $50 |
| Excess Water Savings ($1,000) | -$2,899 | -$2,970 | $70 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,350** | **-$4,374** | **$23** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.117.

**Table 19.117 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under Alternative 5 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.3 | 0.2 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 0.6 | 0.2 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -13.0 | 0.7 | -12.3 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -1.7 | 3.5 | 1.8 |
| Transportation, Warehousing & Utilities | 0 | 0 | 0 | 0 | -97.1 | -1.1 | 3.9 | -94.3 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -0.3 | 4.0 | 3.7 |
| Retail Trade | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 8.1 | 7.8 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -0.8 | 2.7 | 1.9 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -4.4 | 24.1 | 19.7 |
| Services | 0 | 0 | 0 | 0 | 0.0 | -10.7 | 30.7 | 19.9 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.9 | 0.8 |
| **Total** | **0** | **0** | **1** | **0** | **-97.1** | **-32.9** | **79.5** | **-50.5** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 5 as compared to the No Action Alternative.

*Southern California Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, increases in CVP and SWP water supplies within the Southern California Region would be similar under Alternative 5 and the No Action Alternative, and would not result in changes in irrigated acreage or land use changes due to the use of other water supplies.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be lower under Alternative 5 and the No Action Alternative. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would be increase by 0.37 percent, as presented in Table 19.118; and therefore, the results would be similar under Alternative 5 and the No Action Alternative.

**Table 19.118 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under Alternative 5 as compared to the No Action Alternative**

| Differences in Total | Alternative 5 | No Action Alternative | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 1,912 | 1,932 | -20 |
| Delivery Cost ($1,000) | $237,118 | $239,692 | -$2,575 |
| Assumed New Supply Deliveries (TAF) | 81 | 47 | 34 |
| Annualized New Supply Costs ($1,000) | $24,191 | $12,688 | $11,503 |
| Water Storage Costs ($1,000) | $7,474 | $7,598 | -$124 |
| Lost Water Sales Revenues ($1,000) | $14,206 | $14,614 | -$408 |
| Transfer Costs ($1,000) | $10,505 | $11,484 | -$979 |
| Shortage Costs ($1,000) | $16,662 | $17,319 | -$657 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$58,323 | -$57,474 | -$849 |
| Excess Water Savings ($1,000) | -$4,588 | -$4,629 | $41 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$247,243** | **$241,291** | **$5,952** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes t9o employment and regional economic output, as summarized in Table 19.119.

**Table 19.119 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California under Alternative 5 as compared to the No Action Alternative**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 2.5 | 3.3 | 5.9 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 33.1 | 3.3 | 36.4 |
| Construction | 0 | 9 | 0 | 9 | 0.0 | 1,049.4 | 5.1 | 1,054.5 |
| Manufacturing | 0 | 0 | 0 | 1 | 0.0 | 292.8 | 80.2 | 373.0 |
| Transportation, Warehousing & Utilities | 35 | 0 | 0 | 36 | 8,804.2 | 119.3 | 37.0 | 8,960.5 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 55.5 | -0.2 | 55.3 |
| Retail Trade | 0 | 0 | 1 | 2 | 0.0 | 34.4 | 99.3 | 133.7 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 128.5 | 32.2 | 160.8 |
| Financial Activities | 0 | 2 | 1 | 2 | 0.0 | 509.8 | 257.7 | 767.4 |
| Services | 0 | 9 | 3 | 13 | 0.0 | 1,117.3 | 301.8 | 1,419.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 6.0 | 7.6 | 13.6 |
| **Total** | **35** | **22** | **6** | **63** | **8,804.2** | **3,348.6** | **827.3** | **12,980.1** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir elevations in reservoirs that store CVP and SWP water and similar recreational economic factors under Alternative 5 as compared to the No Action Alternative.

#### 19.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

*Regional Changes to Irrigated Agriculture*

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

The CVP would continue to release water in Trinity River for downstream beneficial uses, including water supplies under Alternative 5 and the Second Basis of Comparison. There are no CVP or SWP water contractors in the Trinity River Region.

*Regional Changes to Recreational Opportunities*

Recreational opportunities would be similar in the Trinity River Region under Alternative 5 as compared to the Second Basis of Comparison as described in Chapter 15, Recreational Resources.

#### *Regional Changes to Salmon Fishing*

Trinity River flows would be similar under Alternative 5 as compared to the Second Basis of Comparison. This could result in similar salmon harvest conditions by the Yurok and Hoopa Valley tribes.

### *Central Valley Region*

#### *Regional Changes to Irrigated Agriculture*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 5 than under the Second Basis of Comparison. It is anticipated that groundwater use would increase in response to reduced CVP and SWP water supplies in 2030 because sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 12, Agricultural Resources.

The agricultural production value under long-term average conditions would be reduced by less than 1 percent ($1.5 million/year in the Sacramento Valley and $0.7 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping of approximately 6 percent. The agricultural production value under dry and critical dry conditions also would be reduced by less than 1 percent ($10.5 million/year in the Sacramento Valley and $22.9 million/year in the San Joaquin Valley) primarily due to an increase in groundwater pumping.

The overall reduction in agricultural production values are less than 0.05 percent under long-term conditions; and, changes in employment and regional economic output would be minimal. Therefore, the analysis of employment and regional economic output is focused on dry and critical dry years.

The direct changes in agricultural production would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.120 and 19.121, respectively.

**Table 19.120 Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 5 as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -84 | -20 | 0 | -104 | -10.5 | -1.2 | 0.0 | -11.8 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 0 | -1 | 0 | -1 | 0.0 | -0.1 | 0.0 | -0.1 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| Transportation, Warehousing & Utilities | 0 | -1 | 0 | -2 | 0.0 | -0.3 | -0.1 | -0.5 |
| Wholesale Trade | 0 | -1 | 0 | -1 | 0.0 | -0.2 | -0.1 | -0.3 |
| Retail Trade | 0 | 0 | -3 | -4 | 0.0 | 0.0 | -0.3 | -0.3 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 0.0 | -0.1 | -0.1 |
| Financial Activities | 0 | -7 | -2 | -8 | 0.0 | -1.6 | -0.7 | -2.3 |
| Services | 0 | -3 | -10 | -13 | 0.0 | -0.3 | -0.9 | -1.1 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 0.0 | -0.1 |
| **Total** | **-84** | **-34** | **-17** | **-135** | **-10.5** | **-4.0** | **-2.2** | **-16.8** |

Note: In 2012 dollars

**Table 19.121 Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 5 as Compared to the Second Basis of Comparison in Dry and Critical Dry Years**

| Economic Sectors | Employment | | | | Economic Output ($ millions) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | -145 | -61 | 0 | -206 | -22.9 | -2.7 | -0.1 | -25.7 |
| Mining & Logging | 0 | -1 | 0 | -1 | 0.0 | -0.3 | 0.0 | -0.4 |
| Construction | 0 | -2 | 0 | -2 | 0.0 | -0.2 | 0.0 | -0.2 |
| Manufacturing | 0 | -1 | -1 | -2 | 0.0 | -2.0 | -0.4 | -2.4 |
| Transportation, Warehousing & Utilities | 0 | -3 | -1 | -4 | 0.0 | -0.9 | -0.3 | -1.2 |
| Wholesale Trade | 0 | -2 | -1 | -3 | 0.0 | -0.4 | -0.2 | -0.6 |
| Retail Trade | 0 | 0 | -9 | -9 | 0.0 | 0.0 | -0.7 | -0.8 |
| Information | 0 | 0 | 0 | -1 | 0.0 | -0.1 | -0.2 | -0.2 |
| Financial Activities | 0 | -13 | -4 | -16 | 0.0 | -2.8 | -1.8 | -4.6 |
| Services | 0 | -6 | -25 | -31 | 0.0 | -0.6 | -2.1 | -2.7 |
| Government | 0 | -1 | 0 | -1 | 0.0 | -0.2 | -0.1 | -0.3 |
| **Total** | **-145** | **-90** | **-42** | **-277** | **-22.9** | **-10.2** | **-5.9** | **-39.0** |

Note: In 2012 dollars

As described in Chapter 11, Geology and Soils Resources, increased groundwater pumping under the long-term average conditions may result in an additional increment of subsidence in those areas within the Central Valley.  The additional amount of subsidence and the economic costs associated with it have not been quantified in this EIS. However, total subsidence-related costs have been shown to be substantial, as reported by Borchers et al. (2014) who estimated that the cost of subsidence in San Joaquin Valley between 1955 and 1972 was more than $1.3 billion (in 2013 dollars). These estimates are based on the impacts to major infrastructure in the region including the San Joaquin River, Delta Mendota Canal, Friant-Kern Canal and San Luis Canal in addition to privately owned infrastructure. The incremental subsidence-related costs, expressed on an annual basis, could be an unknown fraction of that cumulative cost.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 5 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies are presented in Tables 19.122 and 19.123 for the Sacramento and San Joaquin Valley, respectively. Average annual water supply operating expenses would increase by 0.11 and 0.47 percent in the Sacramento Valley and the San Joaquin Valley, respectively; and therefore, the results would be similar under Alternative 5 and the Second Basis of Comparison.

**Table 19.122 Changes in Municipal and Industrial Water Supply Costs for the Sacramento Valley under Alternative 5 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 5 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 447 | 463 | -16 |
| Delivery Cost ($1,000) | $8,022 | $8,317 | -$295 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $204 | $207 | -$3 |
| Transfer Costs ($1,000) | $752 | $517 | $235 |
| Shortage Costs ($1,000) | $68 | $68 | -$1 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$3,856 | -$3,916 | $60 |
| Excess Water Savings ($1,000) | -$2,266 | -$2,563 | $298 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$2,924** | **$2,630** | **$293** |

Note: In 2012 dollars

**Table 19.123 Changes in Municipal and Industrial Water Supply Costs for the San Joaquin Valley under Alternative 5 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 5 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 211 | 237 | -26 |
| Delivery Cost ($1,000) | $3,411 | $3,854 | -$443 |
| Assumed New Supply Deliveries (TAF) | 2 | 0 | 2 |
| Annualized New Supply Costs ($1,000) | $601 | $15 | $585 |
| Water Storage Costs ($1,000) | $966 | $820 | $146 |
| Lost Water Sales Revenues ($1,000) | $361 | $322 | $39 |
| Transfer Costs ($1,000) | $2,661 | $2,623 | $38 |
| Shortage Costs ($1,000) | $115 | $102 | $13 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$15,329 | -$16,011 | $683 |
| Excess Water Savings ($1,000) | -$996 | -$1,318 | $322 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$8,211** | **-$9,593** | **$1,381** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output in the Sacramento and San Joaquin valleys, as summarized in Tables 19.124 and 19.125, respectively.

**Table 19.124 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Sacramento Valley under Alternative 5 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 1.7 | 1.6 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -0.4 | 0.3 | -0.1 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | -29.9 | 2.6 | -27.3 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -3.2 | 22.7 | 19.5 |
| Transportation, Warehousing & Utilities | -1 | 0 | 0 | -1 | -295.2 | -2.9 | 18.4 | -279.6 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -1.0 | 27.8 | 26.8 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | -0.9 | 47.7 | 46.8 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -3.5 | 21.1 | 17.6 |
| Financial Activities | 0 | 0 | 0 | 0 | 0.0 | -13.4 | 151.3 | 137.9 |
| Services | 0 | 0 | 2 | 1 | 0.0 | -31.8 | 158.5 | 126.8 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.2 | 3.9 | 3.8 |
| **Total** | **-1** | **-1** | **3** | **1** | **-295.2** | **-87.3** | **456.1** | **73.6** |

Note: In 2012 dollars

**Table 19.125 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Joaquin Valley under Alternative 5 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | 0.1 | 7.4 | 7.5 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | 0.8 | 7.1 | 7.8 |
| Construction | 0 | 0 | 0 | 0 | 0.0 | 27.2 | 6.1 | 33.4 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | 2.8 | 51.3 | 54.1 |
| Transportation, Warehousing & Utilities | 1 | 0 | 0 | 1 | 287.4 | 2.8 | 49.4 | 339.5 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | 0.7 | 42.9 | 43.6 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | 0.8 | 107.9 | 108.7 |
| Information | 0 | 0 | 0 | 0 | 0.0 | 2.0 | 29.8 | 31.8 |
| Financial Activities | 0 | 0 | 1 | 1 | 0.0 | 8.9 | 291.4 | 300.3 |
| Services | 0 | 0 | 4 | 4 | 0.0 | 23.9 | 323.4 | 347.2 |
| Government | 0 | 0 | 0 | 0 | 0.0 | 0.2 | 14.2 | 14.5 |
| **Total** | **1** | **1** | **6** | **8** | **287.4** | **70.1** | **930.8** | **1,288.4** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Recreational opportunities would decrease by 6 to 9 percent under Alternative 5 as compared to the Second Basis of Comparison, depending upon water year type, , as described in Chapter 15, Recreation Resources. Therefore, it is anticipated that recreational economic factors would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to socioeconomic factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on socioeconomic factors could be adverse in the seller's service area.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be decreased under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the San Francisco Bay Area Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 5 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 5 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis.

The average annual water supply costs over the 81-year hydrologic period for M&I water supplies would increase by 1.85 percent, as presented in Table 19.126; and therefore, the results would be similar under Alternative 5 and the Second Basis of Comparison.

**Table 19.126 Changes in Municipal and Industrial Water Supply Costs for the San Francisco Bay Area Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 5 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 394 | 445 | -51 |
| Delivery Cost ($1,000) | $10,962 | $12,515 | -$1,553 |
| Assumed New Supply Deliveries (TAF) | 18 | 16 | 2 |
| Annualized New Supply Costs ($1,000) | $599 | $234 | $365 |
| Water Storage Costs ($1,000) | $1,495 | $1,963 | -$467 |
| Lost Water Sales Revenues ($1,000) | $4,360 | $1,595 | $2,765 |
| Transfer Costs ($1,000) | $6,156 | $1,154 | $5,002 |
| Shortage Costs ($1,000) | $1,450 | $523 | $927 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$470 | -$792 | $322 |
| Excess Water Savings ($1,000) | -$225 | -$549 | $324 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$24,328** | **$16,643** | **$7,686** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.127.

**Table 19.127 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the San Francisco Bay Area Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.1 | 8.4 | 8.3 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -1.7 | 5.3 | 3.5 |
| Construction | 0 | -1 | 0 | -1 | 0.0 | -176.1 | 39.5 | -136.6 |
| Manufacturing | 0 | 0 | 1 | 0 | 0.0 | -32.0 | 509.0 | 477.0 |
| Transportation, Warehousing & Utilities | -6 | 0 | 1 | -5 | -1,654.5 | -12.4 | 195.3 | -1,471.6 |
| Wholesale Trade | 0 | 0 | 2 | 1 | 0.0 | -5.5 | 373.6 | 368.1 |
| Retail Trade | 0 | 0 | 7 | 7 | 0.0 | -4.7 | 603.7 | 599.0 |
| Information | 0 | 0 | 1 | 1 | 0.0 | -18.6 | 326.5 | 307.9 |
| Financial Activities | 0 | 0 | 5 | 5 | 0.0 | -61.9 | 1,853.1 | 1,791.2 |
| Services | 0 | -1 | 22 | 20 | 0.0 | -148.2 | 2,302.6 | 2,154.4 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -0.7 | 58.7 | 57.9 |
| **Total** | **-6** | **-3** | **37** | **29** | **-1,654.5** | **-462.0** | **6,275.6** | **4,159.1** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs that store CVP and SWP water (up to 10 to 18 percent); and would result in decreased recreational economic factors under Alternative 5 as compared to the Second Basis of Comparison.

*Regional Changes to Salmon Fishing*

Changes in commercial and sport ocean salmon fishing primarily would be related to the presence of fall-run Chinook Salmon from Central Valley hatcheries. It is assumed that the production of hatchery fish would be similar under Alternative 5 and the Second Basis of Comparison. However, survival of the fall-run Chinook Salmon hatchery fish to the Pacific Ocean could be related to changes in CVP and SWP operations. As described in Chapter 9, Fish and Aquatic Resources, there would be little change in through-Delta survival by emigrating natural juvenile fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison. It is assumed that the survival of the hatchery juvenile fall-run Chinook Salmon would be similar to the survival of the natural juvenile fall-run Chinook Salmon. Therefore, the availability of fish for commercial and sport ocean salmon fishing and the associated economic conditions for the fishing industry would be similar under Alternative 5 and the Second Basis of Comparison.

*Central Coast Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Central Coast Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 5 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 5 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by 0.77 percent, as presented in Table 19.128; and therefore, the results would be similar under Alternative 5 and the Second Basis of Comparison.

**Table 19.128 Changes in Municipal and Industrial Water Supply Costs for the Central Coast Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 5 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 43 | 54 | -11 |
| Delivery Cost ($1,000) | $6,567 | $8,174 | -$1,607 |
| Assumed New Supply Deliveries (TAF) | 0 | 0 | 0 |
| Annualized New Supply Costs ($1,000) | $0 | $0 | $0 |
| Water Storage Costs ($1,000) | $0 | $0 | $0 |
| Lost Water Sales Revenues ($1,000) | $0 | $0 | $0 |
| Transfer Costs ($1,000) | $0 | $0 | $0 |
| Shortage Costs ($1,000) | $0 | $0 | $0 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$8,018 | -$8,643 | $625 |
| Excess Water Savings ($1,000) | -$2,899 | -$4,176 | $1,277 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **-$4,350** | **-$4,645** | **$295** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.129.

**Table 19.129 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Central Coast Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 0 | 0 | 0.0 | -0.6 | 4.3 | 3.7 |
| Mining & Logging | 0 | 0 | 0 | 0 | 0.0 | -6.8 | 9.9 | 3.1 |
| Construction | 0 | -2 | 0 | -2 | 0.0 | -214.8 | 10.4 | -204.4 |
| Manufacturing | 0 | 0 | 0 | 0 | 0.0 | -28.6 | 55.4 | 26.8 |
| Transportation, Warehousing & Utilities | -7 | 0 | 0 | -7 | -1,606.9 | -18.1 | 60.1 | -1,565.0 |
| Wholesale Trade | 0 | 0 | 0 | 0 | 0.0 | -5.1 | 62.7 | 57.5 |
| Retail Trade | 0 | 0 | 1 | 1 | 0.0 | -6.5 | 126.7 | 120.2 |
| Information | 0 | 0 | 0 | 0 | 0.0 | -12.8 | 41.7 | 29.0 |
| Financial Activities | 0 | 0 | 1 | 1 | 0.0 | -73.3 | 376.2 | 303.0 |
| Services | 0 | -2 | 5 | 3 | 0.0 | -177.8 | 478.2 | 300.4 |
| Government | 0 | 0 | 0 | 0 | 0.0 | -1.0 | 14.1 | 13.1 |
| **Total** | **-7** | **-4** | **9** | **-2** | **-1,606.9** | **-545.3** | **1,239.6** | **-912.6** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs that store CVP and SWP water (up to 10 to 18 percent); and would result in decreased recreational economic factors under Alternative 5 as compared to the Second Basis of Comparison.

*Southern California Region*

*Regional Changes to Irrigated Agriculture*

It is anticipated that as in the Central Valley Region, reductions in CVP and SWP water supplies within the Southern California Region would not result in reductions in long-term irrigated acreage or land use changes due to the use of other water supplies. However, there could be a reduction in irrigated acreage in dry and critical dry years under Alternative 5 as compared to the Second Basis of Comparison.

*Regional Changes to Municipal and Industrial Water Supplies*

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water supplies would be less under Alternative 5 than under the Second Basis of Comparison. The analysis assumed CVP and SWP water deliveries, as described in Chapter 5, and determined the need for new water supplies, changes in water storage and groundwater pumping, water transfers, water shortage costs, and excess water savings. The factors and basis of the analysis is described in detail in Appendix 19A, CWEST Model. The analysis assumes that no new annual transfer supplies would be implemented until shortages were greater than 5 percent. The costs of these shortages are included in the analysis. It is assumed that some communities that do not have alternative water supplies would utilize water transfers.

The average annual water supply operating expenses over the 81-year hydrologic period for M&I water supplies would increase by 2.5 percent, as presented in Table 19.130; and therefore, the results would be similar under Alternative 5 and the Second Basis of Comparison.

**Table 19.130 Changes in Municipal and Industrial Water Supply Costs for the Southern California Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Differences in Total | Alternative 5 | Second Basis of Comparison | Changes |
|---|---|---|---|
| Average Annual CVP/SWP Deliveries (TAF) | 1,912 | 2,394 | -482 |
| Delivery Cost ($1,000) | $237,118 | $296,795 | -$59,677 |
| Assumed New Supply Deliveries (TAF) | 81 | 11 | 70 |
| Annualized New Supply Costs ($1,000) | $24,191 | $4,032 | $20,159 |
| Water Storage Costs ($1,000) | $7,474 | $2,824 | $4,649 |
| Lost Water Sales Revenues ($1,000) | $14,206 | $1,119 | $13,087 |
| Transfer Costs ($1,000) | $10,505 | $3,705 | $6,800 |
| Shortage Costs ($1,000) | $16,662 | $353 | $16,309 |
| Groundwater Pumping Savings (due to reductions in Groundwater Pumping) ($1,000) | -$58,323 | -$91,507 | $33,183 |
| Excess Water Savings ($1,000) | -$4,588 | -$10,573 | $5,985 |
| **Average Annual Changes in Water Supply Costs ($1,000)** | **$247,243** | **$206,749** | **$40,495** |

Note: In 2012 dollars

The changes in M&I water supply costs would result in changes to employment and regional economic output, as summarized in Table 19.131.

**Table 19.131 Changes in Municipal and Industrial Water Supply Related Employment and Regional Economic Output for the Southern California Region under Alternative 5 as Compared to the Second Basis of Comparison**

| Economic Sectors | Employment | | | | Economic Output ($ thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Induced | Total | Direct | Indirect | Induced | Total |
| Agriculture | 0 | 0 | 2 | 1 | 0.0 | -10.0 | 276.1 | 266.1 |
| Mining & Logging | 0 | 0 | 1 | 1 | 0.0 | -131.1 | 372.3 | 241.2 |
| Construction | 0 | -35 | 3 | -32 | 0.0 | -4,156.1 | 400.7 | -3,755.4 |
| Manufacturing | 0 | -2 | 10 | 9 | 0.0 | -1,159.8 | 6,894.7 | 5,734.9 |
| Transportation, Warehousing & Utilities | -140 | -2 | 12 | -130 | -34,869.2 | -472.7 | 2,639.9 | -32,702.0 |
| Wholesale Trade | 0 | -1 | 20 | 19 | 0.0 | -219.8 | 4,338.8 | 4,119.1 |
| Retail Trade | 0 | -2 | 59 | 58 | 0.0 | -136.2 | 5,205.5 | 5,069.3 |
| Information | 0 | -1 | 7 | 6 | 0.0 | -509.0 | 2,994.4 | 2,485.4 |
| Financial Activities | 0 | -7 | 52 | 45 | 0.0 | -2,019.0 | 18,055.5 | 16,036.5 |
| Services | 0 | -37 | 215 | 178 | 0.0 | -4,424.9 | 20,732.4 | 16,307.5 |
| Government | 0 | 0 | 3 | 3 | 0.0 | -23.8 | 594.9 | 571.1 |
| **Total** | **-140** | **-86** | **384** | **158** | **-34,869.2** | **-13,262.4** | **62,505.2** | **14,373.6** |

Note: In 2012 dollars

*Regional Changes to Recreational Opportunities*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir elevations in reservoirs that store CVP and SWP water (up to 10 to 18 percent); and would result in decreased recreational economic factors under Alternative 5 as compared to the Second Basis of Comparison.

#### *19.4.3.7 Summary of Environmental Consequences*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 19.132 and 19.133.

**Table 19.132 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would increase or be similar related to use of reservoirs that store CVP and SWP water. | None needed |
| Alternative 2 | No effects on socioeconomic factors. | None needed |
| Alternative 3 | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would increase or be similar related to use of reservoirs that store CVP and SWP water.<br>Reduced recreational economic factors related to Striped Bass fishing.<br>Reduced commercial and sport ocean salmon fishing due to increased harvest limitations. | None identified at this time to reduce economic effects of reduced Striped Bass fishing and ocean salmon. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative for non-recreational economic factors.<br>Reduced recreational economic factors related to Striped Bass fishing.<br>Reduced commercial and sport ocean salmon fishing due to increased harvest limitations. | None identified at this time to reduce economic effects of reduced Striped Bass fishing or ocean salmon fishing. |
| Alternative 5 | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would be similar related to use of reservoirs that store CVP and SWP water. | None needed |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

**Table 19.133 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would decrease at San Luis Reservoir and at of reservoirs that store CVP and SWP water in the San Francisco Bay Area and Central Coast regions. | Not considered for this comparison. |
| Alternative 1 | No effects on socioeconomic factors. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would be similar related to use of reservoirs that store CVP and SWP water.<br>Reduced recreational economic factors related to Striped Bass fishing.<br>Reduced commercial and sport ocean salmon fishing due to increased harvest limitations.<br>Recreational economic factors would be similar. | Not considered for this comparison. |
| Alternative 4 | No effects on non-recreational socioeconomic factors.<br>Reduced recreational economic factors related to Striped Bass fishing.<br>Reduced commercial and sport ocean salmon fishing due to increased harvest limitations. | Not considered for this comparison. |
| Alternative 5 | Agricultural and M&I water-related employment would be similar.<br>M&I water supply operating expenses would be similar.<br>Recreational economic factors would decrease at San Luis Reservoir and at of reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions.<br>Reduced recreational economic factors related to Striped Bass fishing.<br>Reduced commercial and sport ocean salmon fishing due to increased harvest limitations. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the No Action Alternative are considered to be “similar.”

#### *19.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in adverse changes in socioeconomic factors related to the average annual agricultural production or M&I water supply operating expenses as compared to the No Action Alternative. However, implementation of Alternatives 3 and 4 would result in adverse changes in recreational Striped Bass and sport ocean salmon fishing opportunities.

##### 19.4.3.8.1 Recreational Fishing Opportunities

Under Alternatives 3 and 4, fishing opportunities for Striped Bass and commercial and sport ocean salmon fishing would be reduced as compared to the No Action Alternative. Mitigation measures are not identified at this time to reduce the impact to the Striped Bass and ocean salmon fishing opportunities.

#### *19.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Socioeconomics are summarized in Table 19.134.

**Table 19.134 Summary of Cumulative Effects on Socioeconomics of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in all Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the Biological Opinions, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the Biological Opinions, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>• Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>• General plans for 2030.<br>• Trinity River Restoration Program.<br>• Central Valley Project Improvement Act programs<br>• Folsom Dam Water Control Manual Update<br>• FERC Relicensing for the Middle Fork of the American River Project<br>• San Joaquin River Restoration Program<br>• Contra Loma Recreation Resource Management Plan<br>• San Luis Reservoir State Recreation Area Resource Management Plan/General Plan | <u>These effects would be the same in all alternatives.</u><br>Climate change and sea level rise and development under the general plans are anticipated to reduce carryover storage in reservoirs in a manner that would reduce CVP and SWP water supply availability and recreational opportunities at some reservoirs that store CVP and SWP water, and could reduce the opportunities for ocean salmon fishing.<br>Other actions, including restoration projects, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to improve recreational opportunities and salmon populations that could improve ocean salmon fishing. |
| Future Actions considered as Cumulative Effects Actions in all Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>• Bay-Delta Water Quality Control Plan Update<br>• FERC Relicensing Projects<br>• Bay Delta Conservation Plan (including the California WaterFix alternative)<br>• Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations | <u>These effects would be the same in all alternatives.</u><br>Some of the future reasonably foreseeable actions to improve water quality and FERC Relicensing projects could improve recreational opportunities and salmon populations that could improve ocean salmon fishing.<br>Other actions, such as expanded or new reservoirs would improve water supply availability and recreational opportunities. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | • El Dorado Water and Power Authority Supplemental Water Rights Project<br>• Semitropic Water Storage District Delta Wetlands<br>• North Bay Aqueduct Alternative Intake<br>• Irrigated Lands Regulatory Program | |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative would result in changes stream flows. Changes in stream flows would in turn in changes in water supply availability, recreational opportunities, and salmon populations. Changes in salmon populations would affect ocean salmon fishing as compared to historical conditions prior to the BOs. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar agricultural and M&I water supply economics, and similar or improved reservoir recreational opportunities compared to the No Action Alternative with these added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions for recreational opportunities would be the same as for the No Action Alternative with these added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased ocean salmon fishing harvest limitations | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar agricultural and M&I water supply economics, and similar or improved reservoir recreational opportunities as for the No Action Alternative with tjese added actions.<br>Recreational opportunities related to Striped Bass fishing would initially be increased; however by 2030 recreational fishing related to Striped Bass would be reduced.<br>Opportunities related to commercial and sport ocean salmon fishing would be reduced. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 4 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Increased bag limits for Striped Bass and Pikeminnow<br>Increased ocean salmon fishing harvest limitations | Implementation of Alternative with these reasonably foreseeable actions would result in similar agricultural and M&I water supply economics, and similar or improved reservoir recreational opportunities as for the No Action Alternative with these added actions.<br>Recreational opportunities related to Striped Bass fishing would initially be increased; however by 2030 recreational fishing related to Striped Bass would be reduced.<br>Opportunities related to commercial and sport ocean salmon fishing would be reduced. |
| Alternative 5 with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar agricultural and M&I water supply economics, and similar reservoir recreational opportunities as for the No Action Alternative with these added actions. |

## 19.5 References


Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan, Final, 2013 Update*.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html

BEA (U.S. Bureau of Economic Analysis). 2014a. R*egional Economic Accounts – Local Area Personal Income and Employment - Total full-time and Part-time Employment by Industry*. Site accessed October 13, 2014. http://www.bea.gov/regional/index.htm.

BEA (U.S. Bureau of Economic Analysis). 2014b. *Regional Economic Accounts - BEARFACTS. Trinity County*. Site accessed June 24, 2014. http://www.bea.gov/regional/bearfacts/action.cfm.

BEA (U.S. Bureau of Economic Analysis). 2014c. *Regional Economic Accounts - BEARFACTS. Humboldt County*. Site accessed February 27, 2014. http://www.bea.gov/regional/bearfacts/action.cfm.

BEA (U.S. Bureau of Economic Analysis). 2014d. *Regional Economic Accounts - BEARFACTS. Del Norte County*. Site accessed May 12, 2014. http://www.bea.gov/regional/bearfacts/action.cfm.

BEA (U.S. Bureau of Economic Analysis). 2014e. *Regional Economic Accounts – Local Areas Personal Income and Employment – Personal Income and Earnings by Industry*. Site accessed October 13, 2014. http://www.bea.gov/regional/index.htm.

BIA (U.S. Department of the Interior, Bureau of Indian Affairs). 2003. *2001 Indian Population and Labor Force Report*. November 6.

BIA (U.S. Department of the Interior, Bureau of Indian Affairs). 2006. *2003 Indian Population and Labor Force Report*. February 17.

BIA (U.S. Department of the Interior, Bureau of Indian Affairs). 2008. *2005 Indian Population and Labor Force Report*. September 17.

BIA (U.S. Department of the Interior, Bureau of Indian Affairs). 2014. *2013 Indian Population and Labor Force Report*. January 16.

BLS (U.S. Bureau of Labor Statistics). 2014. *Local Area Unemployment Statistics*. Site accessed January 28, 2014. http://www.bls.gov/lau/

BOE (State of California, Board of Equalization). 2000. *Taxable Sales in California (Sales & Use Tax) During 2000, Fortieth Annual Report*.

BOE (State of California, Board of Equalization). 2008. *Taxable Sales in California (Sales & Use Tax) During 2008, Forty-Eighth Annual Report*.

BOE (State of California, Board of Equalization). 2012. *Taxable Sales in California (Sales & Use Tax) During 2012, Fifty-Second Annual Report*.

BOE (State of California, Board of Equalization). 2014. *California City and County Sales and Use Tax Rates*. Site accessed June 20, 2014. http://www.boe.ca.gov/cgi-bin/rates.cgi.

BOP (Federal Bureau of Prisons). 2014. Locations of Federal Prisons in California. Site accessed November 9, 2014. http://www.bop.gov/locations/list.jsp

Borchers, James W., Vicki K. Grabert, Michael Carpenter, Barbara Dalgish, and Debra Cannon. 2014. *Land Subsidence from Groundwater Use in California*. April.

Butte County. 2000. *2000 Butte County Agricultural Crop Report*.

Butte County. 2001. *2001 Butte County Agricultural Crop Report*.

Butte County. 2002. *Butte County Agricultural Commissioner's Office 2002 Agricultural Crop Report*.

Butte County. 2003. *Butte County Agricultural Commissioner's Office 2003 Agricultural Crop Report*.

Butte County. 2004. *2004 Butte County Agricultural Crop Report*.

Butte County. 2005. *2005 Butte County Agricultural Crop Report*.

Butte County. 2006. *2006 Butte County Agricultural Crop Report*.

Butte County. 2007. *Butte County 2007 Agricultural Crop Report*.

Butte County. 2008. *2008 Butte County Agricultural Crop Report*.

Butte County. 2009. *Butte County 2009 Agricultural Crop Report*.

Butte County. 2010. *2010 Butte County Agricultural Crop Report*.

Butte County. 2011. *2011 Butte County Agricultural Crop Report*.

Butte County. 2012. *Butte County Agricultural Crop Report 2012*.

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://bvh2o.com/James.html

California State Controller. 2012. *Fiscal Year 2011-2012 Property Tax Collections Statistical Report*. October 1.

California State Controller. 2013. *Special District's Annual Report. 62nd edition.* November 22.

California State Controller. 2014. *Cities Annual Report. 102nd edition.* April 23.

California State Controller. 2014a. *Counties Annual Report. 102nd edition.* January 28.

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

CDCR (California Department of Corrections). 2014a. *Central California Women's Facility (CCWF)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/CCWF-Institution_Stats.html

CDCR (California Department of Corrections). 2014b. *Valley State Prison (VSP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/VSP-Institution_Stats.html

CDCR (California Department of Corrections). 2014c. *Pleasant Valley State Prison (PVSP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/PVSP-Institution_Stats.html

CDCR (California Department of Corrections). 2014d. *Avenal State Prison (ASP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/ASP-Institution_Stats.html

CDCR (California Department of Corrections). 2014e. *California State Prison, Corcoran (CSP-COR)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/COR-Institution_Stats.html

CDCR (California Department of Corrections). 2014f. *Wasco State Prison-Reception Center (WSP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/WSP-Institution_Stats.html

CDCR (California Department of Corrections). 2014g. *North Kern State Prison (NKSP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/NKSP-Institution_Stats.html

CDCR (California Department of Corrections). 2014h. *Kern Valley State Prison (KVSP)*. Site accessed June 7, 2014. http://www.cdcr.ca.gov/Facilities_Locator/KVSP-Institution_Stats.html

CDFA (California Department of Food and Agriculture). 2014. *County Statistical Data, California Agricultural Statistics Review 2013-2014*.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://www.lbwater.org/overview-long-beach-seawater-desalination-project

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

City of Los Angeles. 2013. *Tujunga Spreading Grounds Enhancement Project, Final Environmental Impact Report*. April.

City of Oceanside. 2012. *Oceanside Harbor Desalination Testing Project*.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2009a. *Mission Valley Basin*. September 11.

City of San Diego. 2009b. *San Pasqual Basin*. September 11.

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp

Colusa County. 2000. *Colusa County Department of Agriculture 2000 Crop Report*.

Colusa County. 2001. *Colusa County Department of Agriculture 2001 Crop Report*.

Colusa County. 2002. *Colusa County Department of Agriculture 2002 Crop Report*.

Colusa County. 2003. *Colusa County Department of Agriculture 2003 Crop Report*.

Colusa County. 2004. *Colusa County Department of Agriculture 2004 Crop Report*.

Colusa County. 2005. *Colusa County Department of Agriculture 2005 Crop Report*.

Colusa County. 2006. *Colusa County Department of Agriculture 2006 Crop Report*.

Colusa County. 2007. *Colusa County Department of Agriculture 2007 Crop Report*.

Colusa County. 2008. *Colusa County Department of Agriculture 2008 Crop Report*.

Colusa County. 2009. *Colusa County Department of Agriculture 2009 Crop Report*.

Colusa County. 2010. *Colusa County Department of Agriculture 2010 Crop Report*.

Colusa County. 2011. *Colusa County Department of Agriculture 2011 Crop Report*.

Colusa County. 2012. *Colusa County Department of Agriculture Annual Crop Report 2012*.

Contra Costa County. 2000. *2000 Crop Report*.

Contra Costa County. 2001. *2001 Crop Report*.

Contra Costa County. 2002. *2002 Crop Report*.

Contra Costa County. 2003. *2003 Crop Report*.

Contra Costa County. 2004. *2004 Crop Report*.

Contra Costa County. 2005. *2005 Crop Report*.

Contra Costa County. 2006. *2006 Crop Report*.

Contra Costa County. 2007. *2007 Crop Report*.

Contra Costa County. 2008. *2008 Crop Report*.

Contra Costa County. 2009. *2009 Annual Crop and Livestock Report*.

Contra Costa County. 2010. *2010 Crop Report*.

Contra Costa County. 2011. *2011 Annual Crop and Livestock Report*.

Contra Costa County. 2012. *2012 Crop Report*.

CRS (Congressional Research Service). 2013. *Commercial Fishery Disaster Assistance*. By Harold F. Upton. Report 7-5700, RL 34209. January 10.

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html

DFW (California Department of Fish and Wildlife). 2014. 2014-2015 Fees and Descriptions. Site accessed October 13, 2014. https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions.

Del Norte County. 2003. *Del Norte County General Plan*. January 28.

DOF (California Department of Finance). 2013a. *State of California, Department of Finance, E-4 Population Estimates for Cities, Counties, and the State, 2001-2010, with 2000 & 2010 Census Counts*. Sacramento, California. Site accessed January 29, 2013. http://www.dof.ca.gov/research/demographic/reports/estimates/e-4/2001-10/view.php.

DOF (California Department of Finance). 2013b. *State of California, Department of Finance, Interim Projections for California and Its Counties 2010-2050. Sacramento, California, May 2012*. Site accessed January 8, 2013. http://www.dof.ca.gov/research/demographic/reports/projections/interim/view.php.

DOF (California Department of Finance). 2013c. *State of California, Department of Finance, E-8 Historical Population and Housing Estimates for Cities, Counties, and the State, 2000-2010. Sacramento, California*, Site accessed January 29, 2013. http://www.dof.ca.gov/research/demographic/reports/estimates/e-8/2000-10/.

DOF (California Department of Finance). 2014. *State of California, Department of Finance, E-5 Population and Housing Estimates for Cities, Counties, and the State, 2011-2013, with 2010 Census Benchmark. Sacramento,* *California*. Site accessed October 13, 2014. http://www.dof.ca.gov/research/demographic/reports/estimates/e-5/2011-20/view.php.

DOI (Department of the Interior). 1993. *Fishing Rights of the Yurok and Hoopa Valley Tribes, M-36979*.

DWR (California Department of Water Resources). 2011. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

DWR (California Department of Water Resources). 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

EBMUD (East Bay Municipal Utility District). 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

EMWD (Eastern Municipal Water District). 2014a. *Administrative Draft, Mitigated Negative Declaration, Temecula Valley Regional Water Reclamation Facility, 23 MGD Expansion*. January.

EMWD (Eastern Municipal Water District). 2014b. *San Jacinto Regional Water Reclamation Facility*. March.

EMWD (Eastern Municipal Water District). 2014c. *Indirect Potable Reuse Program*. January 8.

EMWD (Eastern Municipal Water District). 2014d. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

EDD (California Employment Development Department). 2013. *Local Area Profile - Trinity County Profile*. Site accessed February 14, 2013.

EDD (California Employment Development Department). 2014a. *Humboldt County Profile*. Site accessed October 13, 2014. http://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/localAreaProfileQSResults.asp?selectedarea=Humboldt+County&selectedindex=12&menuChoice=localareapro&state=true&geogArea=0604000023&countyName=

EDD (California Employment Development Department). 2014b. *Del Norte County Profile*. Site accessed October 13, 2014. http://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/localAreaProfileQSResults.asp?selectedarea=Del+Norte+County&selectedindex=8&menuChoice=localareapro&state=true&geogArea=0604000015&countyName=

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Glenn County. 2000. *2000 Annual Crop and Livestock Report*.

Glenn County. 2001. *2001 Annual Crop and Livestock Report*.

Glenn County. 2002. *2002 Annual Crop & Livestock Report*.

Glenn County. 2003. *2003 Annual Crop & Livestock Report*.

Glenn County. 2004. *Glenn County 2004 Annual Crop & Livestock Report*.

Glenn County. 2005. *Glenn County 2005 Annual Crop & Livestock Report*.

Glenn County. 2006. *Glenn County 2006 Annual Crop & Livestock Report*.

Glenn County. 2007. *Glenn County 2007 Annual Crop & Livestock Report*.

Glenn County. 2008. *Glenn County 2008 Annual Crop & Livestock Report*.

Glenn County. 2009. *Glenn County 2009 Annual Crop & Livestock Report*.

Glenn County. 2010. *Glenn County 2010 Annual Crop & Livestock Report*.

Glenn County. 2011. *Glenn County 2011 Annual Crop & Livestock Report*.

Glenn County. 2012. *Glenn County 2012 Annual Crop & Livestock Report*.

Hackett, Steven, and Hansen, M. 2008. Cost and Revenue Characteristics of the Salmon Fisheries in California and Oregon. Department of Economics, Humboldt State University. Arcata, California. October 3.

Howitt et al. (R. Howitt, D. MacEwan, C. Garnarche, J.M Azuara, P. Marchand, and D. Brown). 2012. *Yolo Bypass Flood Date and Flow Volume Agricultural Impact Analysis, Prepared for Yolo County*. May 15.

Humboldt County. 2012. *Humboldt 21st Century General Plan Update, Draft Environmental Impact Report*. April 2.

Humboldt County. 2014. *Humboldt County Information*. Site accessed May 16, 2014. http://co.humboldt.ca.us/portal/about.asp.

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP)*.

Los Angeles County (County of Los Angeles). 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

NEA (Northwest Economic Associates). 1997. *The Role and Value of Agriculture in the San Joaquin River Exchange Contractors' Service Area*. Prepared for the San Joaquin River Exchange Contractors Water Authority, Los Banos, CA. April 1.

NMFS (National Marine Fisheries Service). 2014a. *Annual Commercial Landings Statistics*. Crab, Dungeness 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014b. *Annual Commercial Landings Statistics*. Squid, California Market 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014c. *Annual Commercial Landings Statistics*. Lobster, California Spiny 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014d. *Annual Commercial Landings Statistics*. Salmon, Chinook 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014e. *Annual Commercial Landings Statistics*. Sablefish 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014f. *Annual Commercial Landings Statistics*. Oyster Pacific 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014g. *Annual Commercial Landings Statistics*. Sea Urchin 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014h. *Annual Commercial Landings Statistics*. Shrimp, Spot 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014i. *Annual Commercial Landings Statistics*. Sardine, Pacific 2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014j. *Annual Commercial Landings Statistics*. Oyster, Kumamoto 2012. Site accessed October 13, 2013.

https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014k. *Annual Commercial Landings Statistics*. Salmon, Chinook 2001-2012. Site accessed October 13, 2013. https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NMFS (National Marine Fisheries Service). 2014l. *Fisheries Economics of the United States*, 2012.

NOAA (National Oceanic and Atmospheric Administration). 2007. *Community Profiles for West Coast and North Pacific Fisheries, Washington, Oregon, California, and other U.S. States, NOAA Technical Memorandum NMFS-NWFSC-85)*. November.

NOAA (National Oceanic and Atmospheric Administration). 2014. *FishWatch: Chinook Salmon*. Site accessed October 13, 2014. . http://www.fishwatch.gov/seafood_profiles/species/salmon/species_pages/chinook_salmon.htm.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

ODFW (Oregon Department of Fish and Wildlife). 2014. Commercial Fisheries. Site accessed October 13, 2014. http://www.dfw.state.or.us/fish/commercial.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

Pacific Fisheries Information Network (PacFIN). 2014. W-O-C - All Species by County data sets. Pacific States Marine Fisheries Commission, Portland, Oregon. Site accessed May 19, 2014. http://pacfin.psmfc.org/pacfin_pub/woc.php.

PFMC (Pacific Fishery Management Council). 2001. *Review of 2000 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2002. *Review of 2001 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2003. *Review of 2002 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2004. *Review of 2003 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2005. *Review of 2004 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2006. *Review of 2005 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2007. *Review of 2006 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2008. *Review of 2007 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2009. *Review of 2008 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2010. *Review of 2009 Ocean Salmon Fisheries*. February.

PFMC (Pacific Fishery Management Council). 2011. *Review of 2010 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*. February.

PFMC (Pacific Fishery Management Council). 2012. *Review of 2011 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*. February.

PFMC (Pacific Fishery Management Council). 2013. *Review of 2012 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*.

PFMC (Pacific Fishery Management Council. 2014a. *Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as Revised Through Amendment 18*. September.

PFMC (Pacific Fishery Management Council). 2014b. *Review of 2013 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*. February.

PFMC and NMFS (Pacific Fishery Management Council and National Marine Fisheries Service). 2011. *Final Environmental Assessment and Initial Regulatory Impact Review for Pacific Coast Salmon Plan Amendment 16: Classifying Stocks, Revising Status Determination Criteria, Establishing Annual Catch Limits, and Accountability Measures, and De minimus Fishing Provisions*. December 2011.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

RCWD (Rancho California Water District). 2012. *Agricultural Water Management Plan*. December 13.

Reclamation (Bureau of Reclamation). 2011. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

Reclamation (Bureau of Reclamation). 2012. *Economics and Tribal Summary Technical Report – For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. July.

Reclamation (Bureau of Reclamation). 2013a. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

Reclamation (Bureau of Reclamation). 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2014a. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014b. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation (Bureau of Reclamation). 2014d. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation (Bureau of Reclamation). 2014e. *Spring Creek Debris Dam and Powerplant*. Site accessed September 19, 2014. http://www.usbr.gov/mp/headlines/2014/June/Photo_of_the_Week6-16-14.pdf.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Sacramento County. 2000. *2000 Crop & Livestock Report*.

Sacramento County. 2001. *2001 Crop & Livestock Report*.

Sacramento County. 2002. *2002 Crop & Livestock Report*.

Sacramento County. 2003. *2003 Crop & Livestock Report*.

Sacramento County. 2004. *2004 Crop & Livestock Report*.

Sacramento County. 2005. *2005 Crop & Livestock Report*.

Sacramento County. 2006. *2006 Crop & Livestock Report*.

Sacramento County. 2007. *2007 Crop & Livestock Report*.

Sacramento County. 2008. *2008 Crop & Livestock Report*.

Sacramento County. 2009. *2009 Crop & Livestock Report*.

Sacramento County. 2010. *2010 Crop & Livestock Report*.

Sacramento County. 2011. *2011 Crop & Livestock Report*.

Sacramento County. 2012. *2012 Crop & Livestock Report*.

San Joaquin County. 2000. *2000 Agricultural Report*.

San Joaquin County. 2001. *2001 Agricultural Report*.

San Joaquin County. 2002. *2002 Agricultural Report*.

San Joaquin County. 2003. *2003 Agricultural Report*.

San Joaquin County. 2004. *2004 Agricultural Report*.

San Joaquin County. 2005. *2005 Agricultural Report*.

San Joaquin County. 2006. *2006 Agricultural Report*.

San Joaquin County. 2007. *2007 Agricultural Report*.

San Joaquin County. 2008. *2008 Agricultural Report*.

San Joaquin County. 2009. *2009 Agricultural Report*.

San Joaquin County. 2010. *2010 Agricultural Report*.

San Joaquin County. 2011. *2011 Agricultural Report*.

San Joaquin County. 2012. *2012 Agricultural Report*.

San Luis Obispo County (County of San Luis Obispo). 2000. *2000 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2001. *2001 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2002. *2002 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2003. *2003 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2004. *2004 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2005. *2005 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2006. *2006 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2007. *2007 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2008. *2008 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2009. *2009 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2010. *2010 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2011. *2011 Annual Report*.

San Luis Obispo County (County of San Luis Obispo). 2012. *2012 Annual Report*.

Santa Barbara County (County of Santa Barbara). 2000. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2001. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2002. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2003. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2004. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2005. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2006. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2007. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2008. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2009. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2010. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2011. *Agricultural Production Report*.

Santa Barbara County (County of Santa Barbara). 2012. *Agricultural Production Report*.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

SDCWA (San Diego County Water Authority). 2015. *Seawater Desalination*. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

Shasta County (County of Shasta). 2000. *County of Shasta 2000 Crop and Livestock Report*.

Shasta County (County of Shasta). 2001. *County of Shasta 2001 Crop and Livestock Report*.

Shasta County (County of Shasta). 2002. *Shasta County 2002 Crop and Livestock Report*.

Shasta County (County of Shasta). 2003. *Shasta County 2003 Crop and Livestock Report*.

Shasta County (County of Shasta). 2004. *Shasta County 2004 Crop and Livestock Report*.

Shasta County (County of Shasta). 2005. *Shasta County 2005 Crop and Livestock Report*.

Shasta County (County of Shasta). 2006. *Shasta County 2006 Crop and Livestock Report*.

Shasta County (County of Shasta). 2007. *Shasta County 2007 Crop and Livestock Report*.

Shasta County (County of Shasta). 2008. *Shasta County 2008 Crop and Livestock Report*.

Shasta County (County of Shasta). 2009. *Shasta County 2009 Crop and Livestock Report*.

Shasta County (County of Shasta). 2010. *Shasta County 2010 Crop and Livestock Report*.

Shasta County (County of Shasta). 2011. *Shasta County 2011 Crop and Livestock Report*.

Shasta County (County of Shasta). 2012. *Shasta County 2012 Crop and Livestock Report*.

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011a. *Draft Program Environmental Impact Statement/Environmental Impact Report*. April.

SJRRP (San Joaquin River Restoration Program). 2011b. *Friant-Kern Canal Capacity Restoration, Draft*. June.

SJRRP (San Joaquin River Restoration Program). 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://www.restoresjr.net/water-management-goal/madera-canal-capacity-restoration-project/

Solano County. 2000. *Agricultural Crop & Livestock Report*.

Solano County. 2001. *2001 Crop & Livestock Report*.

Solano County. 2002. *2002 Crop & Livestock Report*.

Solano County. 2003. *Crop and Livestock Report 2003*.

Solano County. 2004. *Crop and Livestock Report 2004*.

Solano County. 2005. *2005 Crop and Livestock Report*.

Solano County. 2006. *2006 Crop & Livestock Report*.

Solano County. 2007. *2007 Crop & Livestock Report*.

Solano County. 2008. *2008 Crop and Livestock Report*.

Solano County. 2009. *2009 Crop and Livestock Report*.

Solano County. 2010. *2010 Crop and Livestock Report*.

Solano County. 2011. *Crop and Livestock Report 2011*.

Solano County. 2012. *Crop and Livestock Report 2012*.

Sutter County. 2000. *Sutter County Crop Report 2000*.

Sutter County. 2001. *Sutter County 2001 Crop Report*.

Sutter County. 2002. *Sutter County 2002 Crop Report*.

Sutter County. 2003. *Sutter County 2003 Crop Report*.

Sutter County. 2004. *Sutter County 2004 Crop Report*.

Sutter County. 2005. *2005 Sutter County Crop, Livestock and Annual Department Report*.

Sutter County. 2006. *2006 Sutter County Crop, Livestock and Annual Department Report*.

Sutter County. 2007. *2007 Sutter County Crop, Livestock and Annual Department Report*.

Sutter County. 2008. *2008 Sutter County Crop, Livestock and Annual Department Report*.

Sutter County. 2009. *Sutter County 2009 Crop Report*.

Sutter County. 2010. *Sutter County 2010 Crop Report*.

Sutter County. 2011. *Sutter County 2011 Crop Report*.

Sutter County. 2012. *Sutter County 2012 Crop Report*.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

UCAIC (University of California Agricultural Issues Center). 2009. *The Measure of California Agriculture*. August.

USDA (U.S. Department of Agriculture). 2007. *2007 Census of Agriculture, County Profile, Stanislaus County, California*.

USDA (U.S. Department of Agriculture). 2012. *2012 Census of Agriculture, County Profile, Stanislaus County, California*.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

WBMWD (West Basin Municipal Water District). 2011. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

WBMWD (West Basin Municipal Water District). 2015a. *Water Recycling Satellite Facilities*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/recycled-water/satellite-facilities

WBMWD (West Basin Municipal Water District). 2015b. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview

This page left blank intentionally.

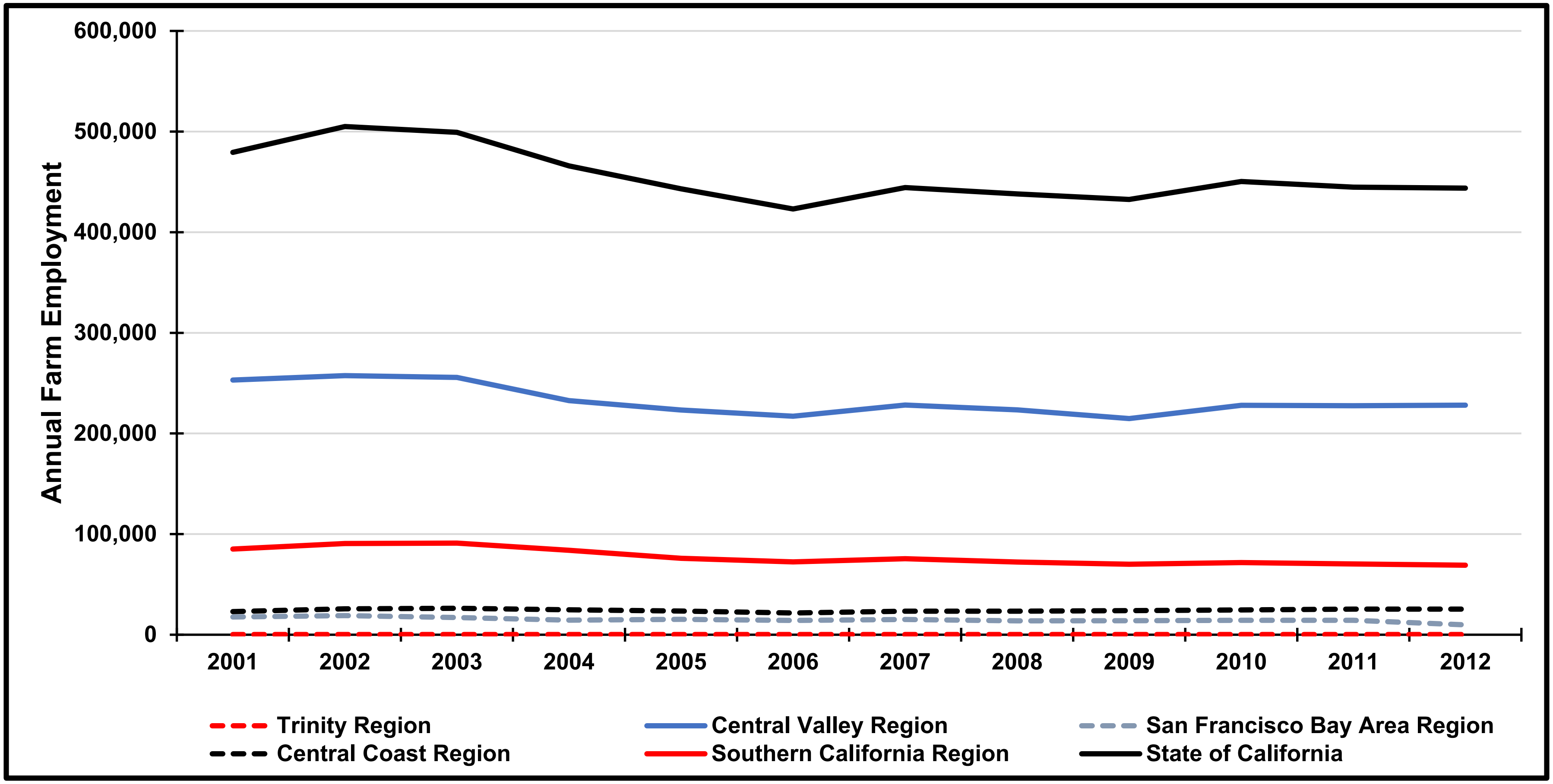



**Figure 19.1 Farm Employment in Counties within the Study Area**

Source: BEA 2014a

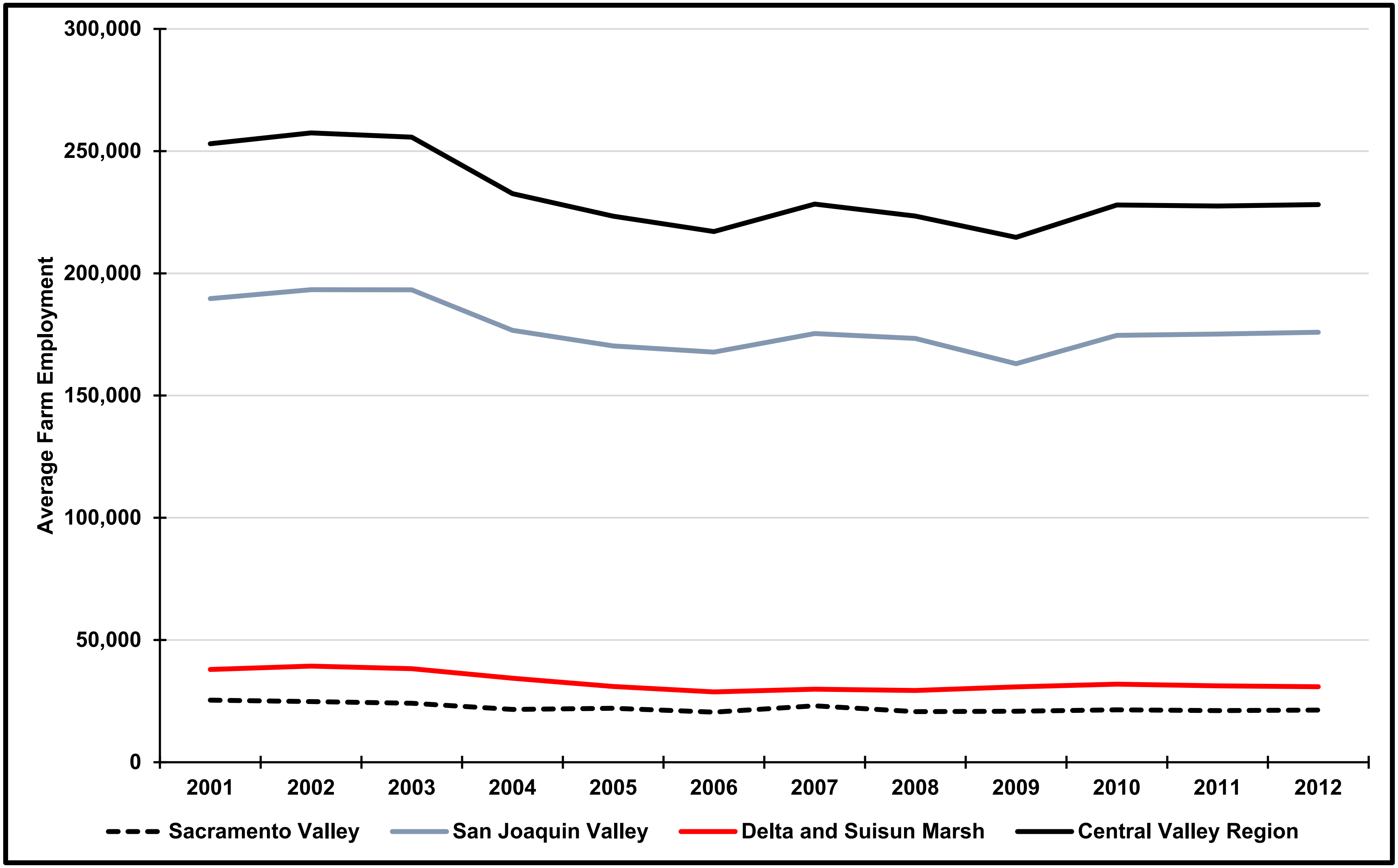



**Figure 19.2 Farm Employment in Counties within the Central Valley Region**

Source: BEA 2014a

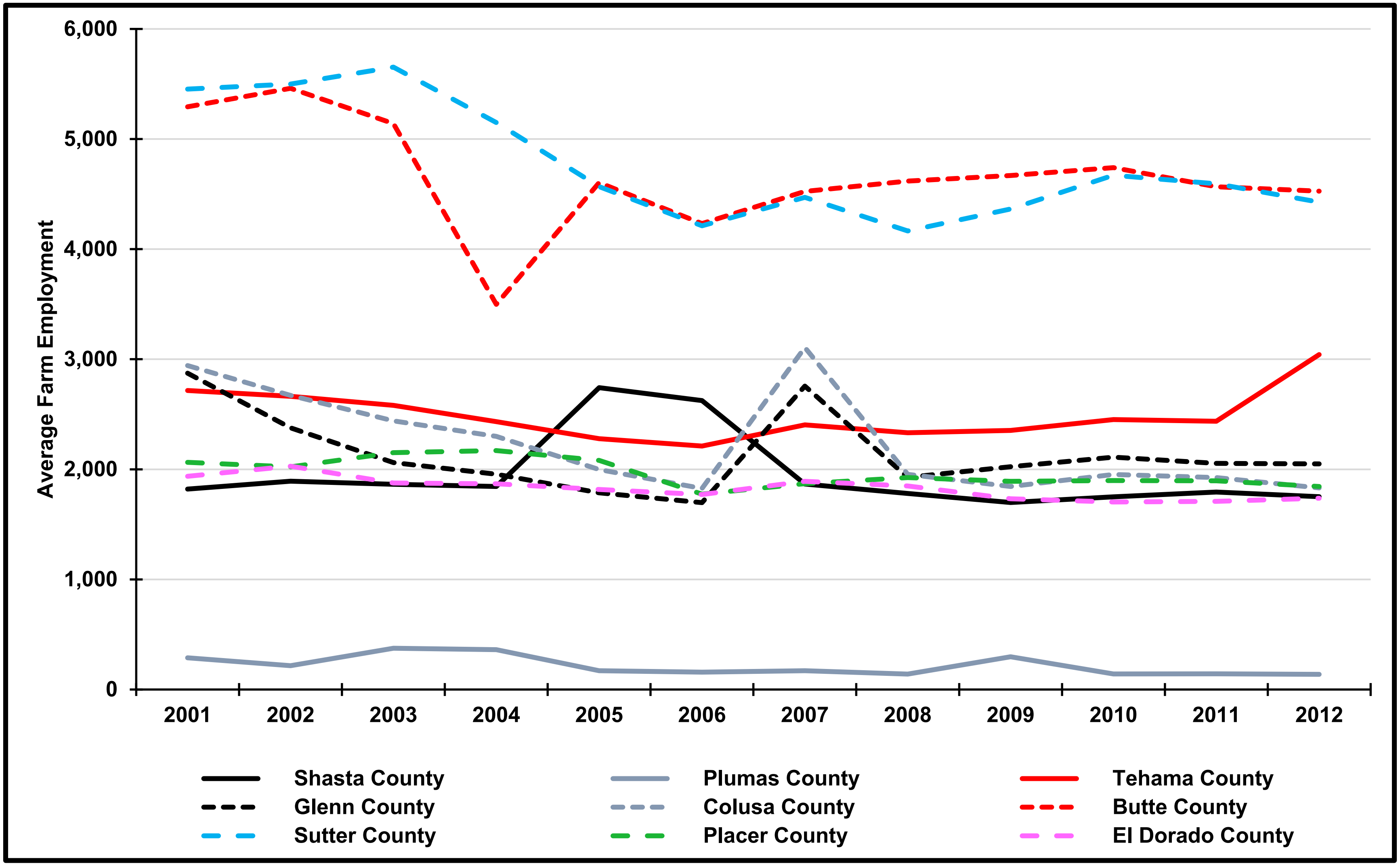



**Figure 19.3 Farm Employment in Counties within the Sacramento Valley Portion of the Central Valley Region**

Source: BEA 2014a

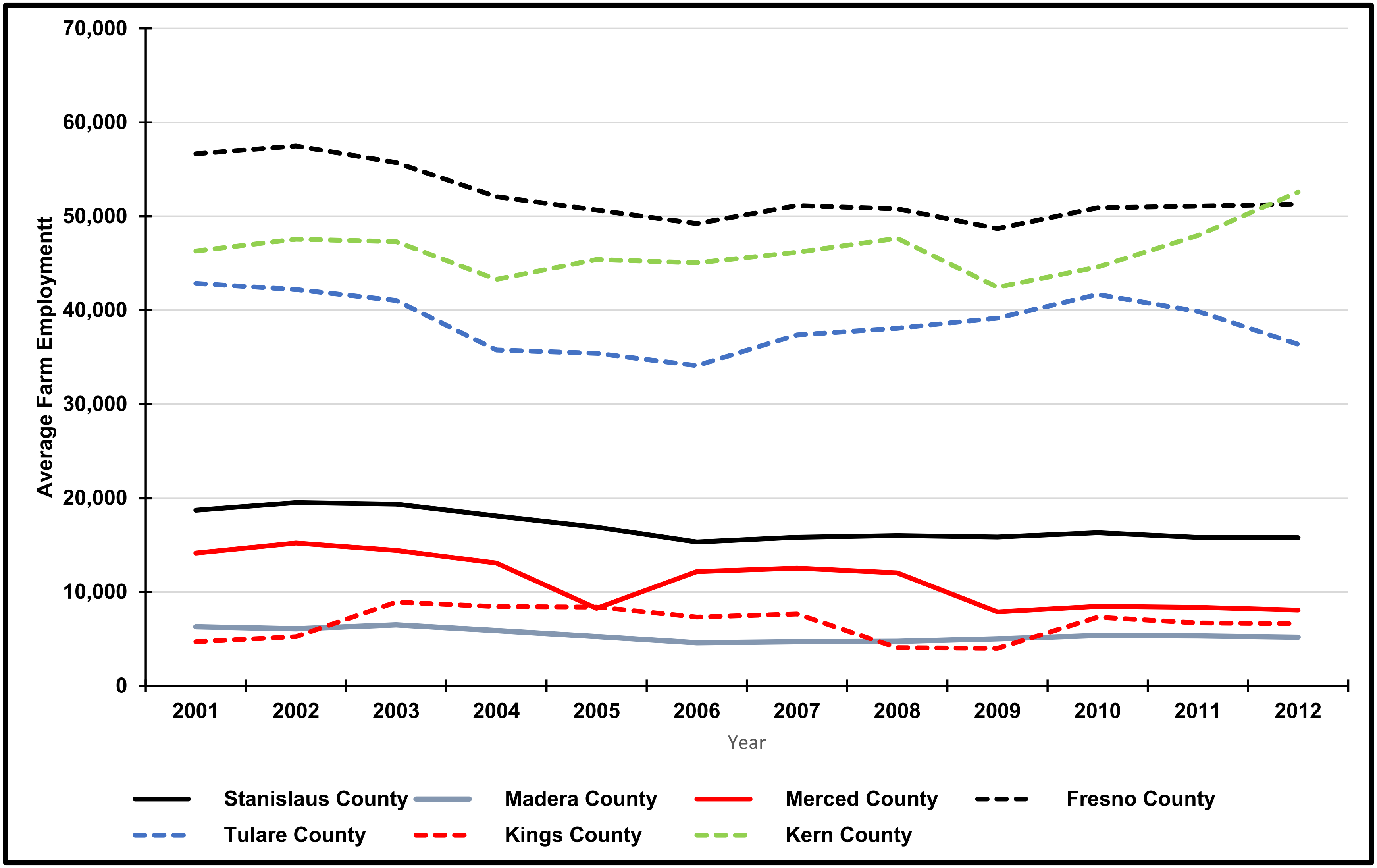



**Figure 19.4 Farm Employment in Counties within the San Joaquin Valley Portion of the Central Valley Region**

Source: BEA 2014a

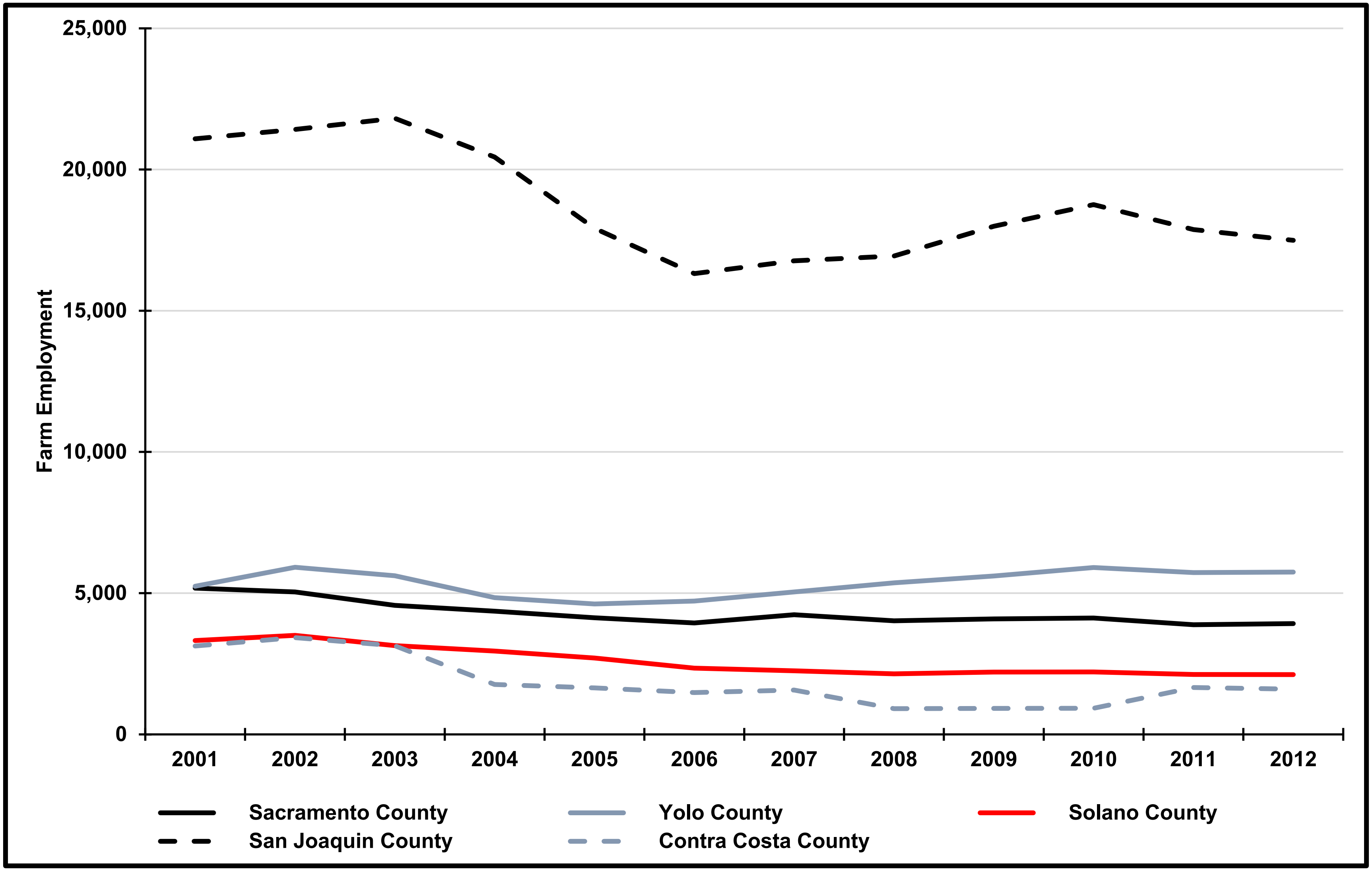



**Figure 19.5 Farm Employment in Counties within the Delta and Suisun Marsh Portion of the Central Valley Region**

Source: BEA 2014a

This page left blank intentionally.

Chapter 20

# Indian Trust Assets

## 20.1 Introduction

This chapter describes Indian Trust Assets (ITAs) in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect ITAs through potential changes to the operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 20.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect ITAs in the areas along the rivers and reservoirs directly impacted by changes in the operation of CVP or SWP reservoirs and in the vicinity of lands served by CVP and SWP water supplies. Actions located on public agency lands, or implemented, funded, or approved by Federal and state agencies, would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

The Federal Indian Trust Asset policies, summarized below and in Chapter 4, have been used to identify potential areas of change to ITAs that could occur due to changes in long-term operation of the CVP and/or SWP facilities.

The ITAs are legal interests in property held in trust by the U.S. for federally-recognized Indian tribes or individual Indians. An Indian trust has three components: (1) the trustee, (2) the beneficiary, and (3) the trust asset. ITAs can include land, minerals, federally-reserved hunting and fishing rights, federally-reserved water rights, and in-stream flows associated with trust land. Beneficiaries of the Indian trust relationship are federally-recognized Indian tribes with trust land; the U.S. is the trustee. By definition, ITAs cannot be sold, leased, or otherwise encumbered without approval of the U.S. The characterization and application of the U.S. trust relationship have been defined by case law that interprets Congressional acts, executive orders, and historic treaty provisions.

The federal government, through treaty, statute or regulation, may take on specific, enforceable fiduciary obligations that give rise to a trust responsibility to federally recognized tribes and individual Indians possessing trust assets. Courts have recognized an enforceable federal fiduciary duty with respect to federal supervision of Indian money or natural resources, held in trust by the federal government, where specific treaties, statutes or regulations create such a fiduciary duty.

Consistent with President William J. Clinton's 1994 memorandum, "Government-to-Government Relations with Native American Tribal Governments," Bureau of Reclamation (Reclamation) assesses the effect of its programs on tribal trust resources and federally-recognized tribal governments. Reclamation is tasked to actively engage federally-recognized tribal governments and consult with such tribes on government-to-government level when its actions affect ITAs (Federal Register, Vol. 59, No. 85, May 4, 1994, pages 22951-22952). The U.S. Department of the Interior (DOI) Departmental Manual Part 512.2 ascribes the responsibility for ensuring protection of ITAs to the heads of bureaus and offices. DOI is required to carry out activities in a manner that protects ITAs and avoids adverse effects whenever possible.

## 20.3 Affected Environment

The U.S. Government's trust responsibility for Indian resources requires Reclamation and other agencies to take measures to protect and maintain trust resources. These responsibilities include taking reasonable actions to preserve and restore tribal resources.

In compliance with 36 Code of Federal Register 800.4(a) (4), Reclamation sent letters to the federally-recognized Indian tribes in the study area, including most of the tribes listed in Table 20.1, to request their input regarding the identification of any properties to which they might attach religious and cultural significance to within the area of potential effect.

**Table 20.1 Federally Recognized Tribes in the Vicinity of the Study Area**

| Federally Recognized Tribe | EIS Geographical Region | County | In the Vicinity of this Community |
|---|---|---|---|
| Hoopa Valley Tribal Council | Trinity River | Trinity and Humboldt | Hoopa |
| Resighini Rancheria Tribe | Trinity River | Del Norte | Klamath |
| Yurok Tribe of the Yurok Reservation | Trinity River | Trinity, Humboldt, and Del Norte | Klamath |
| Pit River Tribe | Central Valley | Shasta | Burney |
| Redding Rancheria Tribe | Central Valley | Shasta | Redding |
| Paskenta Band of Nomlaki Indians of California | Central Valley | Tehama and Glenn | Corning and Orland |
| Grindstone Indian Rancheria of Wintun-Wailaki Indians of California | Central Valley | Glenn | Elk Creek |

| Federally Recognized Tribe | EIS Geographical Region | County | In the Vicinity of this Community |
|---|---|---|---|
| Cachil Dehe Band of Wintun Indians of the Colusa Indian Community of the Colusa Rancheria | Central Valley | Colusa | Colusa |
| Cortina Indian Rancheria of Wintun Indians of California | Central Valley | Colusa | Williams |
| Tyme Maidu of Berry Creek Rancheria | Central Valley | Butte | Oroville |
| Konkow Maidu of Mooretown Rancheria | Central Valley | Butte | Oroville |
| Enterprise Rancheria of Maidu Indians of California | Central Valley | Butte | Oroville |
| Mechoopda Indian Tribe of Chico Rancheria | Central Valley | Butte | Chico |
| Miwok Maidu United Auburn Indian Community of the Auburn Rancheria | Central Valley | Placer | Placer |
| United Auburn Indian Community of the Auburn Rancheria of California | Central Valley | Placer | Rocklin |
| Shingle Springs Band of Miwok Indians, including Shingle Springs Rancheria | Central Valley | El Dorado and Nevada County | Shingle Springs |
| Buena Vista Rancheria of Me-Wuk | Central Valley | Sacramento | Sacramento |
| Wilton Miwok Indians of the Wilton Rancheria | Central Valley | Sacramento | Elk Grove |
| Yocha Dehe Wintun Nation | Central Valley | Yolo | Brooks |
| Northfork Rancheria of Mono Indians of California | Central Valley | Madera | North Fork |
| Picayune Rancheria of Chukchansi Indians of California | Central Valley | Madera | Coarsegold |
| California Valley Miwok Tribe | Central Valley | San Joaquin | Stockton |
| Big Sandy Rancheria of Mono Indians of California | Central Valley | Fresno | Auberry |

| Federally Recognized Tribe | EIS Geographical Region | County | In the Vicinity of this Community |
|---|---|---|---|
| Table Mountain Rancheria | Central Valley | Fresno | Friant |
| Santa Rosa Indian Community of Santa Rosa Rancheria | Central Valley | Kings | Lemoore |
| Tule River Indian Tribe of the Tule River Reservation of the Yokut Indians | Central Valley | Tulare | Porterville |
| Santa Ynez Band of Chumash Mission Indians of Santa Ynez Reservation | Central Coast | Santa Barbara | Santa Ynez |
| Cahuilla Band of Mission Indians of the Cahuilla Reservation | Southern California | San Diego | Anza |
| Campo Band of Diegueno Mission Indians of the Campo Indian Reservation | Southern California | San Diego | Campo |
| Capitan Grande Band of Diegueno Mission Indians of California (Barona Reservation and Viejas Reservation) | Southern California | San Diego | Alpine |
| Ewiiaapaayp Band of Kumeyaay Indians | Southern California | San Diego | Alpine |
| Iipay Nation of Santa Ysabel | Southern California | San Diego | Santa Ysabel |
| Inaja Band of Diegueno Mission Indians of the Inaja and Cosmit Reservation | Southern California | San Diego | Escondido |
| Jamul Indian Village of California | Southern California | San Diego | Jamul |
| La Jolla Band of Luiseño Indians | Southern California | San Diego | Pauma Valley |
| La Posta Band of Diegueno Mission Indians of the La Posta Indian Reservation | Southern California | San Diego | Boulevard |
| Los Coyotes Band of Cahuilla and Cupeno Indians | Southern California | San Diego | Warner Springs |

| Federally Recognized Tribe | EIS Geographical Region | County | In the Vicinity of this Community |
|---|---|---|---|
| Manzanita Band of Diegueno Mission Indians of the Manzanita Reservation | Southern California | San Diego | Boulevard |
| Mesa Grande Band of Diegueno Mission Indians of the Mesa Grande Reservation | Southern California | San Diego | Santa Ysabel |
| Pala Band of Luiseño Mission Indians of the Pala Reservation | Southern California | San Diego | Pala |
| Pauma Band of Luiseño Mission Indians of the Pauma & Yuima Reservation | Southern California | San Diego | Pauma Valley |
| Rincon Band of Luiseño Mission Indians of the Rincon Reservation | Southern California | San Diego | Valley Center |
| San Pasqual Band of Diegueno Mission Indians of California | Southern California | San Diego | Valley Center |
| Sycuan Band of the Kumeyaay Nation | Southern California | San Diego | El Cajon |
| Agua Caliente Band of Cahuilla Indians of the Agua Caliente Indian Reservation | Southern California | Riverside | Palm Springs |
| Augustine Band of Cahuilla Indians | Southern California | Riverside | Coachella |
| Cabazon Band of Mission Indians | Southern California | Riverside | Indio |
| Morongo Band of Mission Indians | Southern California | Riverside | Banning |
| Pechanga Band of Luiseño Mission Indians of the Pechanga Reservation | Southern California | Riverside | Temecula |
| Ramona Band of Cahuilla | Southern California | Riverside | Anza |
| Santa Rosa Band of Cahuilla Indians | Southern California | Riverside | Mountain Center |
| Soboba Band of Luiseño Indians | Southern California | Riverside | San Jacinto |

| Federally Recognized Tribe | EIS Geographical Region | County | In the Vicinity of this Community |
|---|---|---|---|
| Torres-Martinez Desert Cahuilla Indians | Southern California | Riverside | Thermal |
| Twenty-Nine Palms Band of Mission Indians of California | Southern California | Riverside and San Bernardino | Coachella |
| Chemehuevi Indian Tribe of the Chemehuevi Reservation | Southern California | San Bernardino | Needles |
| San Manuel Band of Mission Indians | Southern California | San Bernardino | Highland |
| Big Lagoon Rancheria | Not within study area | Humboldt | Arcata |
| Blue Lake Rancheria | Not within study area | Humboldt | Blue Lake |
| Karuk Tribe | Not within study area | Siskiyou | Happy Camp |
| Greenville Rancheria of Maidu Indians | Not within study area | Plumas and Tehama | Greenville |
| Susanville Indian Rancheria | Not within study area | Lassen | Susanville |
| Lytton Rancheria | Not within study area | Sonoma | Santa Rosa |
| Chicken Ranch Rancheria of Me-Wuk Indians of California | Not within study area | Tuolumne | Jamestown |
| Cold Springs Rancheria of Mono Indians | Not within study area | Fresno | Tollhouse |
| Colorado River Indian Tribes of the Colorado River Indian Reservation | Not within study area | Riverside | Parker, Arizona |

## 20.4 Impact Analysis

This section describes the potential mechanisms for change to ITAs, quantitative and qualitative analytical methods, effects of the analyses, potential mitigation measures, and cumulative effects.

### 20.4.1 Potential Mechanisms for Change and Analytical Tools

As described in Chapter 4, Approach to Environmental Analysis, the environmental consequences assessment considers changes in conditions related to changes in CVP and SWP operation under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operation under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could change water elevations within the CVP and SWP reservoirs, flow patterns in the rivers downstream of CVP and SWP reservoirs, and CVP and SWP water deliveries. Impacts to existing ITAs would be considered adverse if the action:

- Interfered with the exercise of a federally reserved water right, or degrade water quality where there is a federally reserved water right
- Interfered with the use, value, occupancy, character or enjoyment of an ITA
- Failed to protect ITAs from loss, damage, waste, depletion, or other negative effects

#### *20.4.1.1 Changes in CVP and SWP Reservoir Elevation*

There are no ITAs within any of the reservoir inundation areas (DWR 2005; Reclamation 2010, 2012, 2013a, 2014a; Reclamation et al. 2011; USACE et al. 2012). Therefore, the changes in reservoir elevations would not affect ITAs and are not analyzed in this EIS.

#### *20.4.1.2 Changes in Rivers Downstream of CVP and SWP Reservoirs*

There are no ITAs within the rivers downstream of CVP and SWP reservoirs (DWR 2005; Reclamation 2010, 2012, 2013a, 2014a; Reclamation et al. 2011; USACE et al. 2012). Therefore, changes in river flow patterns would not directly affect any ITAs. However, changes in river flow patterns in the Trinity River could indirectly affect several ITAs, including the Hoopa Valley Tribe, Resighini Rancheria Tribe, and Yurok Tribe of the Yurok Reservation. Changes in the river flow patterns could affect use of the Trinity River for boats, access to adjacent lands, and fish in the Trinity River that are important to the tribes.

As described in Chapter 5, Surface Water Resources and Water Supplies, implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison, and the No Action Alternative as compared to the Second Basis of Comparison could affect change river flow patterns in the Trinity River.

#### *20.4.1.3 Changes due to CVP and SWP Water Deliveries*

There are no ITAs that directly receive CVP or SWP water. As described in Chapter 19, Socioeconomics, municipalities that use CVP or SWP water supplies, including agencies that serve ITAs, would continue to meet water demands in 2030 if CVP and SWP water supplies are reduced through the increased use of non-CVP and SWP water supplies. Therefore, changes in CVP and SWP water deliveries would not affect water supplies to ITAs and are not analyzed in this EIS.

#### *20.4.1.4 Effects Related to Cross Delta Water Transfers*

Cross Delta water transfers involving the CVP and SWP facilities or water supplies would be required to be implemented in accordance with all existing regulations and requirements, including not causing adverse impacts to other water users in accordance with the requirements of Reclamation, California Department of Water Resources (DWR), and the State Water Resources Control Board (SWRCB).

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014d). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

The transfers could change flow patterns in rivers downstream of CVP and SWP reservoirs. Surface water elevations in CVP and SWP reservoirs due to transfer programs under the alternatives and Second Basis of Comparison could be affected for a short-time during a water year; however, because the transferred water would have been released for the seller's use, the end of September storage elevations would be similar with or without the transfer.

### 20.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison (e.g., climate change, sea-level rise, general plan development, and implementation of reasonable and foreseeable projects). Due to these changes, especially climate change and sea-level rise, it is anticipated that reservoir elevations at the end of September would be lower and flows patterns in the rivers downstream of the reservoirs would be different than under recent condition, as described in Chapter 5, Surface Water Resources and Water Supplies.

### 20.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative, and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison. The evaluation of alternatives is focused on the Trinity River Region because, as discussed above, potential changes that could affect ITAs are located along the Trinity River.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operation for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of four alternative analyses:

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison

#### *20.4.3.1 No Action Alternative*

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

##### 20.4.3.1.1 Potential Changes in Trinity River downstream of Lewiston Dam

As described in Chapter 5, Surface Water Resources and Water Supplies, the following changes would occur on the Trinity River under the No Action Alternative as compared to the Second Basis of Comparison.

- Over long-term conditions (over the 82-year analysis period), flows would be similar (within 5 percent) from March through November, and reduced from December through February (up to 9.5 percent; 70 cubic feet per second [cfs]).
- In wet years, flows would be similar from April through November, and reduced from December through March (up to 11.2 percent; 160 cfs).
- In above normal years, flows would be similar from March through November, and reduced in January and February (up to 19.9 percent; 74 cfs).
- In below normal years, flows would be similar from March through January, and reduced in February (30.4 percent, 192 cfs).
- In dry and Critical dry years, flows would be similar all months.

The changes in river flows would occur in the winter months of wetter years when potential use of the rivers would be less for transportation and ceremonies (USFWS et al. 1999). As described in Chapter 9, Fish and Aquatic Resources, these changes in river flows would result in similar conditions for salmonids using Trinity River. Therefore, there would be no effect the ITAs.

##### 20.4.3.1.2 Effects Related to Cross Delta Water Transfers

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento Valley to San Joaquin Valley (Reclamation 2014d). Potential effects were identified as reduced surface water storage in upstream reservoirs; changes in flow patterns in rivers downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the sellers; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative as compared to the Second Basis of Comparison, and there would be no effect on the ITAs due to cross Delta water transfers.

### *20.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because conditions under Alternative 1 are identical to conditions under the Second Basis of Comparison, Alternative 1 is only compared to the No Action Alternative.

#### 20.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Potential Changes in Trinity River downstream of Lewiston Dam*

As described in Chapter 5, Surface Water Resources and Water Supplies, the following changes would occur on the Trinity River under Alternative 1 and the No Action Alternative.

- Over long-term conditions, flows would be similar from March through November, and increased from December through February (up to 10.5 percent, 86 cfs).
- In wet years, flows would be similar from April through November, and increased from December through March (up to 12.6 percent, 160 cfs).
- In above normal years, flows would be similar from March through November, and increased in January and February (up to 24.8 percent; 74 cfs).
- In below normal years, flows would be similar from March through January, and increased in February (30.4 percent, 192 cfs).
- In dry and critical dry years, flows would be similar all months.

The changes in river flows would increase flows in the Trinity River under Alternative 1 as compared to the No Action Alternative. As described in Chapter 9, Fish and Aquatic Resources, these changes in river flows would result in similar conditions for salmonids using Trinity River. Therefore, there would be no effect on the ITAs.

*Effects Related to Cross Delta Water Transfers*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as reduced surface water storage in upstream reservoirs; changes in flow patterns in rivers downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the seller; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 1 as compared to the No Action Alternative, and there would be no effect on the ITAs due to cross Delta water transfers.

#### 20.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *20.4.3.3 Alternative 2*

The ITA conditions under Alternative 2 would be identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 20.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to ITAs under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 20.4.3.1, No Action Alternative.

### *20.4.3.4 Alternative 3*

CVP and SWP operation under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operation.

Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative and Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 thousand acre feet (TAF)/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 20.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Potential Changes in Trinity River downstream of Lewiston Dam*

As described in Chapter 5, Surface Water Resources and Water Supplies, the following changes would occur on the Trinity River under Alternative 3 as compared to the No Action Alternative.

- Over long-term conditions, flows would be similar from March through November, and increased from December through February (up to 11.8 percent, 79 cfs).
- In wet years, flows would be similar from April through October, reduced in November (7.0 percent, 36 cfs), and increased from December through March (up to 15.0 percent, 193 cfs).
- In above normal years, flows would be similar from March through November, and increased in January and February (up to 24.8 percent; 74 cfs).
- In dry years, flows would be similar in all months.

However, as described in Chapter 9, Fish and Aquatic Resources, these changes in river flows would result in similar conditions for salmonids using Trinity River, and there would be no effect on the ITAs.

- In above normal years, flows would be similar from March through December, and increased in January and February (up to 22.5 percent; 67 cfs).
- In below normal years, flows would be similar from March through January, and increased in February (43.3 percent, 192 cfs).
- In dry years, flows would be similar all months.
- In Critical dry years, flows would be similar from December through October, and increased in November (20.0 percent, 50 cfs).

The changes in river flows would increase flows in the Trinity River under Alternative 3 as compared to the No Action Alternative. As described in Chapter 9, Fish and Aquatic Resources, these changes in river flows would result in similar conditions for salmonids using Trinity River. Therefore, there would be no effect on the ITAs.

*Effects Related to Cross Delta Water Transfers*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as: reduced surface water storage in upstream reservoirs; changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the sellers; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 3 as compared to the No Action Alternative, and there would be no effect on the ITAs due to cross Delta water transfers.

##### 20.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Potential Changes in Trinity River downstream of Lewiston Dam*

As described in Chapter 5, Surface Water Resources and Water Supplies, under Alternative 3 as compared to the Second Basis of Comparison, flows would be similar under long-term conditions and all water year types. As described in Chapter 9, Fish and Aquatic Resources, there would be similar conditions for salmonids using Trinity River. Therefore, there would be no effect on the ITAs.

*Effects Related to Cross Delta Water Transfers*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as: reduced surface water storage in upstream reservoirs; changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the sellers; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 3 as compared to the Second Basis of Comparison, and there would be no effect on the ITAs due to cross Delta water transfers.

#### *20.4.3.5 Alternative 4*

The ITA conditions under Alternative 4 would be identical to the ITA conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

#### 20.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in ITA conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 20.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

### *20.4.3.6 Alternative 5*

The CVP and SWP operation under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operation. Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

#### 20.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Potential Changes in Trinity River downstream of Lewiston Dam*

As described in Chapter 5, Surface Water Resources and Water Supplies, flows under Alternative 5 and the No Action Alternative would be similar under long-term conditions and all water year types. As described in Chapter 9, Fish and Aquatic Resources, there would be similar conditions for salmonids using Trinity River. Therefore, there would be no effect on the ITAs.

*Effects Related to Cross Delta Water Transfers*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as: reduced surface water storage in upstream reservoirs; changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the sellers; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 5 as compared to the No Action Alternative, and there would be no effect on the ITAs due to cross Delta water transfers.

#### 20.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Potential Changes in Trinity River downstream of Lewiston Dam*

As described in Chapter 5, Surface Water Resources and Water Supplies, the following changes would occur on the Trinity River flows under Alternative 5 and Second Basis of Comparison

- Over long-term conditions, flows would be similar from March through November and January, and reduced in December and February (up to 9.6 percent, 200 cfs).
- In wet years, flows would be similar from April through November, and reduced in December through March (up to 13.9 percent).
- In above normal years, flows would be similar from April through December, and reduced in January and February (up to 19.9 percent, 74 cfs).
- In below normal years, flows would be similar from March through January, and reduced in February (up to 21.5 percent, 135 cfs).
- In dry and critical dry years, flows would be similar in all months.

However, as described in Chapter 9, Fish and Aquatic Resources, these changes in river flows would result in similar conditions for salmonids using Trinity River; and there would be no effect the ITAs.

*Effects Related to Cross Delta Water Transfers*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 7, Groundwater Resources and Groundwater Quality, potential effects on surface water resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as reduced surface water storage in upstream reservoirs and changes in flow patterns in river downstream of the reservoirs if water was released from the reservoirs in patterns that were different than would have been used by the water seller's; and groundwater elevation reductions if groundwater substitution was used to provide the water for the transfers. All water transfers would be required to avoid adverse impacts on other water users and biological resources; and water transfer programs would include groundwater mitigation and monitoring plans (see Section 3.A.6.3, Transfers). Therefore, water transfer programs would need to be implemented in a manner that would avoid impacts associated with changes in Trinity Lake storage, Trinity River flow patterns, and groundwater elevation reductions in the Central Valley that could affect ITAs. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under Alternative 5 as compared to the Second Basis of Comparison, and there would be no effect on the ITAs due to cross Delta water transfers.

#### 20.4.3.7 Summary of Impact Analysis

The results of the impact analysis of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 20.2 and 20.3.

**Table 20.2 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects to ITAs | None needed |
| Alternative 2 | No effects to ITAs | None needed |
| Alternative 3 | No effects to ITAs | None needed |
| Alternative 4 | No effects to ITAs | None needed |
| Alternative 5 | No effects to ITAs | None needed |

**Table 20.3 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | No effects to ITAs | None needed |
| Alternative 1 | No effects to ITAs | None needed |
| Alternative 2 | No effects to ITAs | None needed |
| Alternative 3 | No effects to ITAs | None needed |
| Alternative 4 | No effects to ITAs | None needed |
| Alternative 5 | No effects to ITAs | None needed |

#### 20.4.3.8 Potential Mitigation Measures

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes under Alternatives 1 through 5 as compared to the No Action Alternative would result in similar or increased flows in the Trinity River, and implementation of cross Delta water transfers would not result in adverse impacts to ITAs. Therefore, there would be no adverse impacts to ITAs, and no mitigation measures are needed.

#### 20.4.3.9 Cumulative Effects Analysis

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative, and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 to Indian Trust Assets are summarized in Table 20.4. As described in this chapter, potential changes to Indian Trust Assets would be associated with changes in flows in the Trinity River.

**Table 20.4 Summary of Cumulative Effects on Indian Trust Assets with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs | <u>These effects would be the same under all alternatives.</u><br>Climate change and sea level rise are anticipated to reduce carryover storage in reservoirs, including Trinity Lake, and changes in stream flow patterns, including Trinity River, in a manner that would change beneficial use of the Trinity River, including salmon fishing.<br>Other ongoing actions, including Trinity River Restoration Program, would improve water quality and/or habitat along the Trinity River. |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake | <u>These effects would be the same under all alternatives.</u><br>Based upon environmental documents prepared for these programs, changes to the Trinity River flows are not anticipated due to implementation of these programs. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative with reasonably foreseeable actions would result in changes Trinity Lake carryover storage and Trinity River flows which would result in changes to beneficial use opportunities for Indian Trust Assets as compared to historical conditions prior to the BOs. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar conditions for Indian Trust Assets as for the No Action Alternative with the added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar conditions for Indian Trust Assets as for the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar conditions for Indian Trust Assets as for the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar conditions for Indian Trust Assets as for the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar conditions for Indian Trust Assets as for the No Action Alternative with the added actions. |

## 20.5 References

DWR (California Department of Water Resources). 2005. *Before the Federal Energy Regulatory Commission, Application for New License, Oroville Facilities FERC Project No. 2100, Volume III, Preliminary Draft Environmental Assessment*. January.

_____. 2013d. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Reclamation (Bureau of Reclamation). 2010. *New Melones Lake Area, Final Resource Management Plan and Environmental Impact Statement*. February.

_____. 2012. *San Luis Reservoir State Recreation Area, Final Resource Management Plan/General Plan and Final Environmental Impact Statement/Final Environment Impact Report*. August.

_____. 2013a. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

_____. 2013b. *Record of Decision, Water Transfer Program for the San Joaquin River Exchange Contractors Water Authority, 2014-2038*. July 30.

_____. 2014a. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

_____. 2014b. *Findings of No Significant Impact, 2014 Tehama-Colusa Canal Authority Water Transfers*. April 22.

_____. 2014c. *Findings of No Significant Impact, 2014 San Luis & Delta-Mendota Water Authority Water Transfers*. April 22.

_____. 2014d. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation et al. (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement/Environmental Impact Report*. March.

Reclamation et al. (Bureau of Reclamation, California Department of Fish and Game [now known as Department of Fish and Wildlife], and U.S. Fish and Wildlife Service). 2011. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan Final Environmental Impact Statement/Environmental Impact Report*.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

_____. 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

SWSD (Semitropic Water Storage District). 2011. *Delta Wetlands Project Place of Use, Final Environmental Impact Report*. August.

USACE et al. (U.S. Army Corps of Engineers, Bureau of Reclamation, Sacramento Area Flood Control Agency, and California Central Valley Flood Protection Board). 2012. *Folsom Dam Modification Project Approach Channel, Draft Supplemental Environmental Impact Statement/ Environmental Impact Report*. July.

USFWS et al. (U.S. Fish and Wildlife Service, Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County). 1999. *Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Report*. October.

**Chapter 21**

# Environmental Justice

## 21.1 Introduction

This chapter describes the presence of environmental justice populations in the study area and potential changes that could have disproportionately high and adverse human health or environmental effects on minority and/or low-income populations as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect conditions through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 21.2 Regulatory Environment and Compliance Requirements

This chapter was prepared in compliance with Presidential Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated February 11, 1994 and Title VI of the Civil Rights Act of 1964.

Potential actions that could be implemented under the alternatives evaluated in this EIS could have disproportionately high and adverse human health or environmental effects on minority and/or low-income populations. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 21.3 Affected Environment

This section describes changes that could result in disproportionately high and adverse human health or environmental effects on minority and/or low-income populations due to changes in CVP and SWP operations. The conditions described in this chapter are related to the distribution of minority populations and populations below poverty levels.

### 21.3.1 Area of Analysis

A summary of conditions are described in this section of the EIS for the following regions that could be affected by implementation of alternatives analyzed in this EIS, as described in Chapter 4, Approach to Environmental Analysis.

- Trinity River Region
- Central Valley Region

- San Francisco Bay Area Region
- Central Coast Region
- Southern California Region

### 21.3.2 Characterization of Conditions Considered in the Environmental Justice Analysis

Characterization of the conditions within the Study Area is based upon publically available data from government websites and other data sources. The data sources used include the 2010 U.S. Census Bureau data on minority populations and the 2010 American Community Survey (ACS) 5-year population estimates on populations below the poverty level.

#### *21.3.2.1 Determination of Minority Populations*

The U.S. Census Bureau provides a total population value for each county, which are also used by the State Department of Finance, as presented in Chapter 14, Socioeconomics. The U.S. Census Bureau also provides a definition of minority and low income populations. Minority populations are defined by the U.S. Census as racial and ethnic minorities. Racial minorities, as defined by the U.S. Census, include people who identified themselves in the census as belonging to one of the following categories:

- Single Race
  - Black/African American
  - American Indian and Alaskan Native
  - Asian
  - Native Hawaiian and Other Pacific Islander
  - Some Other Race
- Two or More Races (inclusive the races listed above and White).

Ethnic minorities, as defined by the U.S. Census, include individuals who identified themselves as being of Hispanic or Latino origin by responding to one of the following categories in the census:

- Mexican
- Mexican American
- Chicano
- Puerto Rican
- Cuban
- Other Spanish/Hispanic/Latino

Individuals who identified themselves of Hispanic or Latino origin maybe of one or more races according to the U.S. Census.

#### *21.3.2.2 Determination of Populations below the Poverty Level*

Populations below the Federal poverty level can be identified using several methodologies. The information presented in this chapter has been developed in ACS reports by the U.S. Census Bureau based upon 48 different sets of dollar value thresholds related to family size and ages. The poverty level is assigned at the family-level and affects every member of the family. The thresholds are consistent throughout the United States and do not consider geographic differentials. The thresholds are updated each year based on the Consumer Price Index. For the five-year ACS reporting period used in this chapter, separate thresholds are applied to each year in this continuous survey. Other federal agencies rely upon different poverty statistics including the Current Population Survey Annual Social and Economic Supplement and the U.S. Department of Health and Human Services poverty guidelines.

The population for whom poverty level is estimated by ACS is smaller value than the total population values presented in Chapter 14, Socioeconomics, for each county and the equivalent population values used for the distribution of the population by race and ethnicity. The population values to determine poverty rates do not include institutionalized individuals (e.g., military personnel that live in group quarters, students that live in college dormitories, and prison inmates. The U.S. Census Bureau designates geographical areas with poverty rates at and above 20 percent as “poverty areas.”

#### *21.3.2.3 Social Services*

The need for and delivery of social services within each county is another indication of social conditions, including Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh (previously referred to as “Food Stamps”) and supplemental social security income.

#### *21.3.2.4 Limited English Proficiency*

Another consideration related to environmental justice is the ability of the Federal government to provide access to federally conducted and assisted programs and activities to all people who, as a result of their national origin, are limited in their English proficiency (LEP). These individuals are not able to speak, read, write, or understand the English language at a level that permits them to interact effectively with Federal employees who provide Federal services. Therefore, these individuals are often excluded from Federal programs, do not receive all available Federal services, and/or experience delays when interacting with Federal programs. The Executive Order 13166 became effective on August 11, 2000 to ensure meaningful participation by individuals who have limited English proficiency in federally conducted and federally assisted programs and activities. This information is compiled and reported by the U.S. Census Bureau.

### 21.3.3 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. Tribal lands along the Trinity or Lower Klamath River within the Trinity River Region include the

Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria.

#### 21.3.3.1 Minority Populations

As recorded in the 2010 Census, the Trinity River Region had a total population of 177,019 (U.S. Census 2014a). About 24.3 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.1 (U.S. Census 2014a, 2014b, 2014c, 2014d). There are fewer minorities in the Trinity River Region than in the entire State of California.

#### 21.3.3.2 Poverty Levels

Poverty levels presented in Table 21.2 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty is determined in the Trinity River Region, 167,987 individuals (or 18.2 percent) were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a “poverty areas.” Both Humboldt and Del Norte counties are defined as poverty areas.

Poverty rates based upon the 2000 census were reported as 40 percent for Indians on the Yurok Indian Reservation, 34 percent of the Indians on the Hoopa Valley Indian Reservation, and 54 percent of the Indians on and off Karuk Reservation trust lands (NMFS 2012a, 2012b, 2012c). The Yurok Tribe has reported an average poverty rate of 80 percent of the Indians on the Yurok Indian Reservation (Yurok Tribe 2014a). Average per capita income of residents on the Resighini Rancheria (not limited to Resighini Rancheria members) in 1999 was reported to be approximately 46 percent of the average per capita income in Del Norte County (NMFS 2012d).

#### 21.3.3.3 Social Services

Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh (previously referred to as “Food Stamps”) and supplemental social security income within counties in the Trinity River Region are summarized in Table 21.3.

Social services to tribal members are funded by the tribe and/or the federal government (DOI and DFG 2012). The Hoopa Valley Tribe provides food distribution and other social services, including Temporary Assistance for Needy Families (TANF) which receives some assistance from Humboldt County social services to provide cash assistance, utility billing assistance, childcare, educational assistance, job development, substance abuse assistance, and family assistance (Hoopa Tribe 2014 a, 2014b). The Yurok Tribe provides a wide range of services, including general assistance, food distribution, Indian Child welfare, low income energy assistance, Yurok Youth Program, emergency and temporary assistance, and Yurok Domestic Violence/Sexual Assault Project (Yurok Tribe 2014b).

#### *21.3.3.4 Limited English Proficiency*

The percent of the population that speaks English and other languages at home and the percent of the population that speak English “less than very well” based on the language they speak at home are presented in Tables 21.4 and 21.5.

### 21.3.4 Central Valley Region

The Central Valley Region includes the Sacramento Valley, San Joaquin Valley, and Delta and Suisun Marsh subregions.

#### *21.3.4.1 Sacramento Valley*

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, and El Dorado counties. Sacramento, Yolo, and Solano counties also are located within the Sacramento Valley; however, these counties are discussed below as part of the Delta and Suisun Marsh subsection. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties.

##### 21.3.4.1.1 Minority Populations

As recorded in the 2010 U.S. Census, the Sacramento Valley portion of the Central Valley Region had a total population of 1,325,380 in 2010. About 25.8 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.6. The table also shows the minority population distribution for the entire Central Valley Region and the State of California.

**Table 21.1 Minority Population Distribution in Trinity River Region in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Trinity County | 13,786 | 87.3% | 0.4% | 4.8% | 0.7% | 0.1% | 1.6% | 5.2% | 7.0% | 16.5% |
| Humboldt County | 134,623 | 81.7% | 1.1% | 5.7% | 2.2% | 0.3% | 3.7% | 5.3% | 9.8% | 22.8% |
| Del Norte County | 28,610 | 73.7% | 3.5% | 7.8% | 3.4% | 0.1% | 6.9% | 4.5% | 17.8% | 35.3% |
| Trinity River Region | 177,019 | 80.8% | 1.4% | 6.0% | 2.3% | 0.2% | 4.1% | 5.2% | 10.9% | 24.3% |
| **STATE OF CALIFORNIA** | **37,253,956** | **57.6%** | **6.2%** | **1.0%** | **13.0%** | **0.4%** | **17.0%** | **4.9%** | **40.1%** | **59.9%** |

Sources: U.S. Census 2014a, 2014b, 2014c, 2014d

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

**Table 21.2 Population below Poverty Level in Trinity River Region, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Trinity County | 13,225 | 1,993 | 15.1% |
| Humboldt County | 129,592 | 22,973 | 17.7% |
| Del Norte County | 25,170 | 5,526 | 22.0% |
| Trinity River Region | 167,987 | 30,492 | 18.2% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note: a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

**Table 21.3 Federal Funds Distributed for Social Programs in Trinity River Region in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Trinity County | $12.5 | $4.9 | $6.6 |
| Humboldt County | $167.8 | $36.0 | $65.6 |
| Del Norte County | $28.8 | $10.1 | $19.1 |
| Trinity River Region | $209.1 | $51.0 | $91.3 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.4 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Trinity River Region, 2006–2010**

| Areas | Only English | Spanish/ Spanish Creole | Portuguese/ Portuguese Creole | German | Tagalog | Hmong | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Trinity County | 93.9% | 3.8% | 0.0% | 0.3% | 0.1% | 0.0% | 4.2% |
| Humboldt County | 90.8% | 5.7% | 0.4% | 0.3% | 0.3% | 0.0% | 6.8% |
| Del Norte County | 83.3% | 11.6% | 0.1% | 0.5% | 0.5% | 1.6% | 14.2% |
| Trinity River Region | 89.8% | 6.5% | 0.4% | 0.3% | 0.3% | 0.3% | 7.8% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **0.2%** | **0.3%** | **2.2%** | **0.2%** | **31.4%** |

Source: U.S. Census 2014f

**Table 21.5 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Trinity River Region that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish/ Spanish Creole | Portuguese/ Portuguese Creole | German | Tagalog | Hmong |
|---|---|---|---|---|---|
| Trinity County | 1.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| Humboldt County | 2.3% | 0.2% | 0.1% | 0.1% | 0.0% |
| Del Norte County | 3.1% | 0.0% | 0.1% | 0.1% | 0.6% |
| Trinity River Region | 2.4% | 0.1% | 0.1% | 0.1% | 0.1% |
| **STATE OF CALIFORNIA** | **13.6%** | **0.1%** | **0.05%** | **0.7%** | **0.1%** |

Source: U.S. Census 2014f

**Table 21.6 Minority Population Distribution in the Central Valley Region–Sacramento Valley in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Shasta County | 177,223 | 86.7% | 0.9% | 2.8% | 2.5% | 0.2% | 2.5% | 4.4% | 8.4% | 17.6% |
| Plumas County | 20,007 | 89.0% | 1.0% | 2.7% | 0.7% | 0.1% | 3.0% | 3.6% | 8.0% | 15.0% |
| Tehama County | 63,463 | 81.5% | 0.6% | 2.6% | 1.0% | 0.1% | 9.9% | 4.3% | 21.9% | 28.1% |
| Glenn County | 28,122 | 71.1% | 0.8% | 2.2% | 2.6% | 0.1% | 19.6% | 3.6% | 37.5% | 44.1% |
| Colusa County | 21,419 | 64.7% | 0.9% | 2.0% | 1.3% | 0.3% | 27.3% | 3.6% | 55.1% | 60.2% |
| Butte County | 220,000 | 81.9% | 1.6% | 2.0% | 4.1% | 0.2% | 5.5% | 4.7% | 14.1% | 24.8% |
| Yuba County | 72,155 | 68.4% | 3.3% | 2.3% | 6.7% | 0.4% | 11.8% | 7.1% | 25.0% | 41.2% |
| Nevada County | 98,764 | 91.4% | 0.4% | 1.1% | 1.2% | 0.1% | 2.7% | 3.2% | 8.5% | 13.5% |
| Sutter County | 94,737 | 61.0% | 2.0% | 1.4% | 14.4% | 0.3% | 15.3% | 5.6% | 28.8% | 49.6% |
| Placer County | 348,432 | 83.5% | 1.4% | 0.9% | 5.9% | 0.2% | 3.8% | 4.3% | 12.8% | 23.9% |
| El Dorado County | 181,058 | 86.6% | 0.8% | 1.1% | 3.5% | 0.2% | 4.0% | 3.8% | 12.1% | 20.1% |
| Sacramento Valley Subtotal | 1,325,380 | 81.7% | 1.3% | 1.6% | 4.7% | 0.2% | 6.1% | 4.5% | 23.1% | 25.8% |
| Central Valley Region | 8,379,045 | 61.4% | 6.3% | 1.3% | 9.5% | 0.4% | 15.7% | 5.4% | 42.6% | 53.5% |
| **STATE OF CALIFORNIA** | **37,253,956** | **57.6%** | **6.2%** | **1.0%** | **13.0%** | **0.4%** | **17.0%** | **4.9%** | **37.6%** | **59.9%** |

Sources: U.S. Census 2014a, 2014g, 2014h, 2014i, 2014j, 2014k, 2014l, 2014m, 2014n, 2014o, 2014p, 2014q

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

#### 21.3.4.1.2 Poverty Levels

Poverty levels presented in Table 21.7 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty status is determined within the Sacramento Valley portion of the Central Valley Region, 1,288,594 individuals, 12.6 percent were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e).

The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a "poverty areas." There are no counties in this area defined as poverty areas; although, 20 percent of the populations in Tehama and Yuba counties are below the poverty level.

#### 21.3.4.1.3 Social Services

Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the Sacramento Valley portion of the Central Valley Region are summarized in Table 21.8.

#### 21.3.4.1.4 Limited English Proficiency

The percent of the population that speaks English and other languages at home and the percent of the population that speak English "less than very well" based on the language they speak at home are presented in Tables 21.9 and 21.10.

### *21.3.4.2 San Joaquin Valley*

The San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern counties. San Joaquin County also is located within the San Joaquin Valley; however, this county is discussed below as part of the Delta and Suisun Marsh subsection. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Calaveras, Mariposa, and Tuolumne counties.

#### 21.3.4.2.1 Minority Populations

As recorded in the 2010 U.S. Census, the San Joaquin Valley portion of the Central Valley Region had a total population of 3,286,353 in 2010. About 63.3 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.11. The table also shows the minority population distribution for the entire Central Valley Region and the State of California.

**Table 21.7 Population below Poverty Level in the Central Valley Region–Sacramento Valley, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Shasta County | 174,180 | 28,772 | 16.5% |
| Plumas County | 20,179 | 2,437 | 12.1% |
| Tehama County | 61,201 | 12,397 | 20.3% |
| Glenn County | 27,853 | 4,875 | 17.5% |
| Colusa County | 20,768 | 3,107 | 15.0% |
| Butte County | 213,501 | 39,290 | 18.4% |
| Yuba County | 68,848 | 13,760 | 20.0% |
| Nevada County | 97,209 | 8,740 | 9.0% |
| Sutter County | 92,477 | 13,194 | 14.3% |
| Placer County | 334,718 | 22,090 | 6.6% |
| El Dorado County | 177,660 | 14,003 | 7.9% |
| Sacramento Valley Subtotal | 1,288,594 | 162,665 | 12.6% |
| Central Valley Region | 8,025,054 | 1,268,984 | 15.8% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note: a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

**Table 21.8 Federal Funds Distributed for Social Programs in the Central Valley Region – Sacramento Valley in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Shasta County | $199.0 | $50.8 | $93.5 |
| Plumas County | $19.3 | $7.9 | $5.9 |
| Tehama County | $61.6 | $17.5 | $23.1 |
| Glenn County | $25.3 | $10.6 | $11.3 |
| Colusa County | $18.6 | $8.2 | $6.5 |
| Butte County | $263.4 | $44.7 | $104.9 |
| Yuba County | $125.0 | $21.8 | $45.2 |
| Nevada County | $53.8 | $15.4 | $16.1 |
| Sutter County | $76.4 | $20.1 | $28.8 |
| Placer County | $139.2 | $44.8 | $43.2 |
| El Dorado County | $62.5 | $32.4 | $29.0 |
| Sacramento Valley Subtotal | $1,044.1 | $274.2 | $407.5 |
| Central Valley Region | $8,759.9 | $4,308.9 | $3,179.8 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.9 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Central Valley Region – Sacramento Valley, 2006–2010**

| Areas | Only English | Spanish/ Spanish Creole | Tagalog | German | Chinese | Hmong | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Shasta County | 91.5% | 4.6% | 0.3% | 0.6% | 0.3% | 0.01% | 5.7% |
| Plumas County | 92.4% | 5.9% | 0.1% | 0.4% | 0.6% | 0.0% | 7.0% |
| Tehama County | 80.4% | 16.9% | 0.1% | 0.4% | 0.2% | 0.02% | 17.7% |
| Glenn County | 67.4% | 29.6% | 0.1% | 0.2% | 0.0% | 0.0% | 29.8% |
| Colusa County | 54.3% | 44.1% | 0.4% | 0.1% | 0.3% | 0.0% | 44.8% |
| Butte County | 85.4% | 9.3% | 0.3% | 0.3% | 0.5% | 1.3% | 11.7% |
| Yuba County | 74.4% | 17.8% | 0.8% | 0.4% | 0.3% | 3.1% | 22.3% |
| Nevada County | 93.4% | 4.1% | 0.1% | 0.8% | 0.1% | 0.0% | 5.1% |
| Sutter County | 65.5% | 20.5% | 0.5% | 0.4% | 0.5% | 0.1% | 21.9% |
| Placer County | 86.1% | 6.3% | 1.3% | 0.4% | 0.7% | 0.1% | 8.7% |
| El Dorado County | 88.2% | 7.3% | 0.4% | 0.6% | 0.5% | 0.02% | 9.0% |
| Sacramento Valley Subtotal | 84.4% | 9.7% | 0.6% | 0.5% | 0.5% | 0.4% | 11.6% |
| Central Valley Region | 66.2% | 23.1% | 1.7% | 0.3% | 1.2% | 0.8% | 27.1% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.2%** | **0.3%** | **2.9%** | **0.2%** | **34.1%** |

Source: U.S. Census 2014f

**Table 21.10 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Central Valley Region – Sacramento Valley that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish/ Spanish Creole | Tagalog | German | Chinese | Hmong |
|---|---|---|---|---|---|
| Shasta County | 1.4% | 0.1% | 0.05% | 0.1% | 0.01% |
| Plumas County | 1.8% | 0.0% | 0.00% | 0.6% | 0.0% |
| Tehama County | 8.0% | 0.1% | 0.04% | 0.1% | 0.0% |
| Glenn County | 13.3% | 0.0% | 0.1% | 0.0% | 0.0% |
| Colusa County | 24.7% | 0.0% | 0.02% | 0.3% | 0.0% |
| Butte County | 3.8% | 0.1% | 0.04% | 0.4% | 0.8% |
| Yuba County | 9.2% | 0.2% | 0.1% | 0.2% | 2.1% |
| Nevada County | 2.1% | 0.1% | 0.1% | 0.06% | 0.0% |
| Sutter County | 12.3% | 0.1% | 0.02% | 0.2% | 0.03% |
| Placer County | 2.7% | 0.4% | 0.05% | 0.3% | 0.07% |
| El Dorado County | 3.3% | 0.1% | 0.1% | 0.2% | 0.0% |
| Sacramento Valley Subtotal | 4.6% | 0.2% | 0.06% | 0.2% | 0.3% |
| Central Valley Region | 10.8% | 0.5% | 0.04% | 0.06% | 0.4% |
| **STATE OF CALIFORNIA** | **13.6%** | **0.7%** | **0.04%** | **1.6%** | **0.1%** |

Source: U.S. Census 2014f

**Table 21.11 Minority Population Distribution in the Central Valley Region – San Joaquin Valley in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Stanislaus County | 514,453 | 65.6% | 2.9% | 1.1% | 5.1% | 0.7% | 19.3% | 5.4% | 41.9% | 53.3% |
| Madera County | 150,865 | 62.6% | 3.7% | 2.7% | 1.9% | 0.1% | 24.8% | 4.2% | 53.7% | 62.0% |
| Merced County | 255,793 | 58.0% | 3.9% | 1.4% | 7.4% | 0.2% | 24.5% | 4.7% | 54.9% | 68.1% |
| Fresno County | 930,450 | 55.4% | 5.3% | 1.7% | 9.6% | 0.2% | 23.3% | 4.5% | 50.3% | 67.3% |
| Tulare County | 442,179 | 60.1% | 1.6% | 1.6% | 3.4% | 0.1% | 29.0% | 4.2% | 60.6% | 67.4% |
| Kings County | 152,982 | 54.3% | 7.2% | 1.7% | 3.7% | 0.2% | 28.1% | 4.9% | 50.9% | 64.8% |
| Kern County | 839,631 | 59.5% | 5.8% | 1.5% | 4.2% | 0.1% | 24.3% | 4.5% | 49.2% | 61.4% |
| San Joaquin Valley Subtotal | 3,286,353 | 59.1% | 4.5% | 1.6% | 5.9% | 0.2% | 24.1% | 4.6% | 50.6% | 63.3% |
| Central Valley Region | 8,379,045 | 61.4% | 6.3% | 1.3% | 9.5% | 0.4% | 15.7% | 5.4% | 42.6% | 53.5% |
| STATE OF CALIFORNIA | 37,253,956 | 57.6% | 6.2% | 1.0% | 13.0% | 0.4% | 17.0% | 4.9% | 37.6% | 59.9% |

Sources: U.S. Census 2014a, 2014r, 2014s, 2014t, 2014u, 2014v, 2014w, 2014x

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

#### 21.3.4.2.2 Poverty Levels

Poverty levels presented in Table 21.12 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty status is determined within the San Joaquin Valley portion of the Central Valley Region, 3,111,943 individuals, 20.8 percent, were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a “poverty areas.” Merced, Fresno, Tulare, and Kern counties are defined as poverty areas because more than 20 percent of the populations in these counties are below the poverty level.

#### 21.3.4.2.3 Social Services

Distribution of social services varies for each county. Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the San Joaquin Valley portion of the Central Valley Region are summarized in Table 21.13.

#### 21.3.4.2.4 Limited English Proficiency

The percent of the population that speaks English and other languages at home and the percent of the population that speak English “less than very well” based on the language they speak at home are presented in Tables 21.14 and 21.15.

#### 21.3.4.2.5 Effects of Recent Drought in Two San Joaquin Valley Communities

The San Joaquin Valley portion of the Central Valley Region includes about 8.8 percent of the state’s total population, 9.3 percent of the state’s population that identified themselves as a racial minority and/or of Hispanic or Latino origin, and about 13.1 percent of the state’s population below the poverty level. Merced, Fresno, and Tulare counties had the highest concentration of total minority populations and the highest concentration of individuals living below the poverty level. There are communities within these counties that have higher concentrations of minority populations and/or populations below the poverty level. These communities are mainly farming communities that have been impacted by loss in agricultural employment, as described in Chapter 12, Agricultural Resources, and Chapter 19, Socioeconomics. The impacts have increased recently during the current drought.

**Table 21.12 Population below Poverty Level in the Central Valley Region – San Joaquin Valley, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Stanislaus County | 502,108 | 82,480 | 16.4% |
| Madera County | 138,151 | 26,656 | 19.3% |
| Merced County | 246,260 | 53,738 | 21.8% |
| Fresno County | 890,694 | 200,288 | 22.5% |
| Tulare County | 423,902 | 97,012 | 22.9% |
| Kings County | 133,206 | 25,713 | 19.3% |
| Kern County | 777,622 | 159,967 | 20.6% |
| San Joaquin Valley Subtotal | 3,111,943 | 645,854 | 20.8% |
| Central Valley Region | 8,025,054 | 1,268,984 | 15.8% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note:

a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

**Table 21.13 Federal Funds Distributed for Social Programs in the Central Valley Region – San Joaquin Valley in 2010**

| | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| Areas | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Stanislaus County | $535.9 | $145.3 | $198.7 |
| Madera County | $144.3 | $33.6 | $45.6 |
| Merced County | $260.0 | $73.7 | $126.0 |
| Fresno County | $992.0 | $274.8 | $468.5 |
| Tulare County | $569.1 | $116.0 | $196.5 |
| Kings County | $129.2 | $37.8 | $49.3 |
| Kern County | $712.0 | $203.4 | $328.6 |
| San Joaquin Valley Subtotal | $3,342.5 | $884.6 | $1,413.2 |
| Central Valley Region | $8,759.9 | $4,308.9 | $3,179.8 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.14 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Central Valley Region – San Joaquin Valley, 2006–2010**

| Areas | Speaks Only English | Spanish and Spanish Creole | Tagalog | Chinese | Portuguese/ Portuguese Creole | Hmong | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Stanislaus County | 59.8% | 30.6% | 0.7% | 0.4% | 0.9% | 0.1% | 32.8% |
| Madera County | 58.0% | 38.6% | 0.3% | 0.1% | 0.2% | 0.3% | 39.5% |
| Merced County | 48.5% | 41.5% | 0.7% | 0.5% | 2.2% | 2.5% | 47.4% |
| Fresno County | 57.4% | 32.5% | 0.7% | 0.6% | 0.1% | 2.7% | 36.6% |
| Tulare County | 53.2% | 42.5% | 0.7% | 0.2% | 0.7% | 0.2% | 44.4% |
| Kings County | 57.4% | 37.9% | 1.6% | 0.4% | 1.0% | 0.0% | 40.9% |
| Kern County | 59.0% | 36.4% | 1.1% | 0.3% | 0.0% | 0.0% | 37.8% |
| San Joaquin Valley Subtotal | 57.0% | 35.8% | 0.8% | 0.4% | 0.5% | 1.0% | 38.5% |
| Central Valley Region | 66.2% | 23.1% | 1.7% | 1.2% | 0.3% | 0.8% | 27.1% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.2%** | **2.9%** | **0.2%** | **0.2%** | **34.0%** |

Source: U.S. Census 2014f

**Table 21.15 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Central Valley Region – San Joaquin Valley that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish and Spanish Creole | Tagalog | Chinese | Portuguese/ Portuguese Creole | Hmong |
|---|---|---|---|---|---|
| Stanislaus County | 13.1% | 0.2% | 0.3% | 0.4% | 0.0% |
| Madera County | 17.7% | 0.1% | 0.0% | 0.1% | 0.1% |
| Merced County | 19.4% | 0.2% | 0.2% | 0.9% | 1.2% |
| Fresno County | 14.7% | 0.2% | 0.3% | 0.0% | 1.3% |
| Tulare County | 21.4% | 0.3% | 0.1% | 0.3% | 0.1% |
| Kings County | 19.4% | 0.6% | 0.3% | 0.3% | 0.0% |
| Kern County | 16.4% | 0.4% | 0.2% | 0.0% | 0.0% |
| San Joaquin Valley Subtotal | 16.5% | 0.3% | 0.2% | 0.2% | 0.5% |
| Central Valley Region | 10.8% | 0.5% | 0.6% | 0.1% | 0.4% |
| **STATE OF CALIFORNIA** | **13.6%** | **0.7%** | **1.6%** | **0.1%** | **0.1%** |

Source: U.S. Census 2014f

Conditions in this geographic area have been the focus of recent newspaper articles describing conditions in these communities. According to AgAlert (2014), a weekly newspaper for California agriculture, increased levels of land fallowing on irrigated cropland in the San Joaquin Valley has resulted in significant economic losses in small farming communities. Higher than typical unemployment rates has resulted in increased food insecurity. As a result, food banks are facing increased demand. Another article in the Fresno Bee Newspaper (2014) described the food insecurity issue in the City of Mendota, a community in Fresno County.

Although there are emergency programs such as those administered through the U.S. Department of Agriculture (USDA), many of these programs are specific in their targets, require a long time to implement, or are of limited duration. For example, the 2014 Farm Bill includes $100 million in livestock disaster assistance; $15 million in assistance to farmers and ranchers to implement water conservation practices; and $60 million for food banks in the State of California (USDA 2014a). The USDA February 14, 2014 news release announcing these programs acknowledges that previous implementation of assistance programs were hampered by long processing times and emphasizes that the USDA is committed to reduce the response times by more than 80 percent. The USDA also is working with California Department of Education to expand the number of Summer Food Service Program meal sites. The U.S. Department of Homeland Security also provides assistance with food and related expenses through the Emergency Food and Shelter National Board Program (USDHS 2014); however this assistance is limited to one month. There also are many California-based programs, including the California Department of Social Services that provided in 2014 up to $25 million in food assistance for counties affected by employment losses due to the drought that has reduced agriculturally-related jobs (CDSS 2014). This program is specifically targeted for counties where the unemployment rate in 2013 was higher than the statewide average, including Fresno, Merced, and Tulare counties. This aid includes pre-packaged food boxes to be delivered to local food banks. Families and individuals that expected to experience long-term impacts due to the drought also were provided assistance to apply for the CalFresh Program to supplement funding for the food budget.

*Huron and Mendota*

The cities of Huron and Mendota are both located in Fresno County. Economic activities in both cities and surrounding communities are based on agriculture. Of the 25 major employers in Fresno County, only one, Stamoules Produce Company, is located in the City of Mendota (CEDD 2013). None of the 25 major employers in Fresno County are located in Huron. Another major employer in the City of Mendota is a medium security Federal prison for men (BOP 2014).

In 2010, the number of people that identified themselves as a racial minority and/or of Hispanic or Latino origin and the portion of the population below the poverty level in these two cities were significantly higher than the distribution of these populations in Fresno County and the State of California, as presented in Tables 21.16 and 21.17. Although the two communities became more racially diverse in 2010 than they were in the 2000 Census, both communities became poorer. While Huron and Mendota have experienced increases in poverty levels, the proportion of the population below the poverty level has been relatively stable in Fresno County.

**Table 21.16 Racial and Ethnic Minority Population in Huron and Mendota in 2010**

| Areas | Total Population | Racial Minority | Hispanic or Latino Origin | Below Poverty Level |
|---|---|---|---|---|
| Huron City | 6,754 | 65.9% | 96.6% | 54.5% |
| Mendota City | 11,014 | 47.1% | 96.6% | 44.6% |
| Fresno County | 930,450 | 44.6% | 50.3% | 22.5% |
| **State of California** | **37,253,956** | **42.4%** | **37.6%** | **13.7%** |

Source: U.S. Census Bureau, 2013a, 2013b, 2014e, 2014u

**Table 21.17 Racial and Ethnic Minority Population in Huron and Mendota in 2000**

| Areas | Total Population | Racial Minority | Hispanic or Latino Origin | Below Poverty Level |
|---|---|---|---|---|
| Huron City | 6,306 | 79.6% | 98.3% | 39.4% |
| Mendota City | 7,890 | 72.7% | 94.7% | 41.9% |
| Fresno County | 799,407 | 45.7% | 44.0% | 22.9% |
| **State of California** | **33,871,648** | **40.5%** | **32.4%** | **14.2%** |

Sources: U.S. Census Bureau, 2013c, 2013d, 2013e, 2013f

*Other Indicators of Economic Conditions*

Other indicators of economic struggles within these communities are the number of individuals who are on poverty alleviation programs, including CalFresh, the Federal Supplemental Nutrition Assistance Program administered by the State of California, California Work Opportunity and Responsibility to Kids (CalWORKs), and National School Lunch Program (NSLP).

Both CalFresh and CalWORKs are administered by the California Department of Social Services. The CalFresh Program issues monthly electronic benefits that can be used to buy most foods. The program's purpose is to help improve the health and well-being of qualified households and individuals. CalWORKs is a social welfare program that provides cash aid and services to eligible needy California families. Figure 21.1 shows the trend in the average annual population on public assistance (both the CalFresh Program and CalWORKs program) between 2006 and 2012, the years for which electronic data were available for the cities of Huron and Mendota. The populations in Huron and Mendota have higher levels of participations in the two public assistance programs compared to the levels in Fresno County and the state. Additionally, the rates of participation in the two communities have been growing at a faster rate than growth in these programs in Fresno County and the state. Eligibility in the CalFresh Program is based upon several factors, including a poverty threshold requirement and citizenship/immigration status. Eligibility for CalWORKs is determined on the basis of citizenship, age, income, resources, assets and other factors (CDSS 2013j).

The NSLP program includes students that are eligible for assistance under CalFresh and other federal assistance programs, such as the Temporary Assistance for Needy Families and the Food Distribution Program on Indian Reservations; and students who are eligible under the Other Source Categorically Eligible Programs. A student is eligible under the Other Source Categorically Eligible Programs if that student is: (1) homeless, runaway or migrant; (2) a foster child; or (3) enrolled in a Federally-funded Head Start Program or a comparable State-funded Head Start Program or pre-kindergarten programs, or in an Even Start Program (USDA 2014b). Students enrolled in the NSLP are eligible for either free or reduced price meals (FRPM). Figure 21.2 shows the proportion of students enrolled in the FRPM program in the two communities, Fresno County, and the state. Participation on FRPM in Fresno County is higher than in the entire state; and lower than within Huron and Mendota.

Relatively large participation in the social services programs is related to low employment in Huron and Mendota. Annual unemployment rates in Huron and Mendota between 2006 and 2012 have consistently remained higher than for Fresno County and the state, as presented in Figure 21.3. The pattern of unemployment has been similar to unemployment patterns in Fresno County, and increased following the economic recession that started in 2007. The increase in unemployment also occurred at a time when both agricultural cultivated acreage and farm employment in the area declined; and included five consecutive years with reduced water availability, as described in Chapter 12, Agricultural Resources, and Chapter 19, Socioeconomics.

#### *21.3.4.3 Delta and Suisun Marsh*

The Delta and Suisun Marsh portion of the Central Valley Region includes Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties.

##### 21.3.4.3.1 Minority Populations

As recorded in the 2010 U.S. Census, the Delta and Suisun Marsh portion of the Central Valley Region had a total population of 2,718,287 in 2010. About 54.8 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.18. The table also shows the minority population distribution for the entire Central Valley Region and the State of California.

##### 21.3.4.3.2 Poverty Levels

Poverty levels presented in Table 21.19 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis.

**Table 21.18 Minority Population Distribution in the Central Valley Region – Delta and Suisun Marsh in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Sacramento County | 1,418,788 | 57.5% | 10.4% | 1.0% | 14.3% | 1.0% | 9.3% | 6.6% | 21.6% | 51.6% |
| Yolo County | 200,849 | 63.2% | 2.6% | 1.1% | 13.0% | 0.5% | 13.9% | 5.8% | 30.3% | 50.1% |
| Solano County | 413,344 | 51.0% | 14.7% | 0.8% | 14.6% | 0.9% | 10.5% | 7.6% | 24.0% | 59.2% |
| San Joaquin County | 685,306 | 51.0% | 7.6% | 1.1% | 14.4% | 0.5% | 19.1% | 6.4% | 38.9% | 64.1% |
| Contra Costa County | 1,049,025 | 58.6% | 9.3% | 0.6% | 14.4% | 0.5% | 10.7% | 5.9% | 24.4% | 52.2% |
| Total Delta and Suisun Marsh Valley | 3,767,312 | 56.2% | 9.6% | 0.9% | 14.3% | 0.7% | 11.9% | 6.4% | 26.2% | 54.8% |
| Central Valley Region | 8,379,045 | 61.4% | 6.3% | 1.3% | 9.5% | 0.4% | 15.7% | 5.4% | 42.6% | 53.5% |
| STATE OF CALIFORNIA | 37,253,956 | 57.6% | 6.2% | 1.0% | 13.0% | 0.4% | 17.0% | 4.9% | 37.6% | 59.9% |

Sources: U.S. Census 2014a, 2014y, 2014z, 2014aa, 2014ab, 2014ac

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

**Table 21.19 Population below Poverty Level in the Central Valley Region – Delta and Suisun Marsh, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Sacramento County | 1,368,693 | 190,768 | 13.9% |
| Yolo County | 186,800 | 31,895 | 17.1% |
| Solano County | 397,576 | 41,158 | 10.4% |
| San Joaquin County | 657,594 | 105,502 | 16.0% |
| Contra Costa County | 1,013,854 | 91,142 | 9.0% |
| Total Delta and Suisun Marsh Valley | 3,624,517 | 460,465 | 12.7% |
| Central Valley Region | 8,025,054 | 1,268,984 | 15.8% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note:

a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

Of the total population for whom poverty status is determined within the Delta and Suisun Marsh portion of the Central Valley Region, 3,624,517 individuals, 12.7 percent were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a "poverty areas." None of the counties in this area are defined as poverty areas.

#### 21.3.4.3.3 Social Services

Distribution of social services varies for each county. Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the Delta and Suisun Marsh portion of the Central Valley Region are summarized in Table 21.20.

#### 21.3.4.3.4 Limited English Proficiency

The percent of the population that speaks English and other languages at home and the percent of the population that speak English "less than very well" based on the language they speak at home are presented in Tables 21.21 and 21.22.

### 21.3.5 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. Contra Costa County also is part of the San Francisco Bay Area Region. However, for this chapter, Contra Costa County is discussed under Section 14.3.4.3, Delta Suisun Marsh.

#### *21.3.5.1 Minority Populations*

As recorded in the 2010 U.S. Census, the San Francisco Bay Area Region had a total population of 3,483,666 in 2010. About 64.4 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.23. The table also shows the minority population distribution for the State of California.

#### *21.3.5.2 Poverty Levels*

Poverty levels presented in Table 21.24 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty status is determined within the San Francisco Bay Area Region, 3,344,994 individuals, 10.1 percent were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a "poverty areas." None of the counties in the San Francisco Bay Area Region are defined as poverty areas.

**Table 21.20 Federal Funds Distributed for Social Programs in the Central Valley Region – Delta and Suisun Marsh in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Sacramento County | $2,115.5 | $2,695.9 | $659.1 |
| Yolo County | $504.8 | $39.7 | $55.2 |
| Solano County | $264.2 | $71.7 | $118.6 |
| San Joaquin County | $739.1 | $153.5 | $287.4 |
| Contra Costa County | $749.7 | $189.3 | $238.8 |
| Total Delta and Suisun Marsh Valley | $4,373.3 | $3,150.1 | $1,359.1 |
| Central Valley Region | $8,759.9 | $4,308.9 | $3,179.8 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.21 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Central Valley Region – Delta and Suisun Marsh, 2006 – 2010**

| Areas | Speaks Only English | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Russian | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Sacramento County | 69.8% | 13.2% | 2.2% | 2.0% | 1.5% | 1.6% | 20.5% |
| Yolo County | 65.8% | 20.2% | 3.3% | 0.8% | 0.9% | 1.6% | 26.9% |
| Solano County | 70.6% | 15.9% | 0.8% | 6.8% | 0.6% | 0.1% | 24.1% |
| San Joaquin County | 0.0% | 25.1% | 1.0% | 2.8% | 1.0% | 0.0% | 29.9% |
| Contra Costa County | 67.6% | 17.3% | 2.9% | 2.8% | 0.6% | 0.6% | 24.2% |
| Total Delta and Suisun Marsh Valley | 56.5% | 17.2% | 2.1% | 2.8% | 1.0% | 0.9% | 24.0% |
| Central Valley Region | 66.2% | 23.1% | 1.2% | 1.7% | 0.6% | 0.5% | 27.1% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.9%** | **2.2%** | **1.4%** | **0.4%** | **35.4%** |

Source: U.S. Census 2014f

**Table 21.22 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Central Valley Region – Delta and Suisun Marsh that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Russian |
|---|---|---|---|---|---|
| Sacramento County | 6.0% | 1.3% | 0.7% | 0.9% | 0.9% |
| Yolo County | 9.5% | 1.5% | 0.2% | 0.3% | 1.0% |
| Solano County | 7.4% | 0.4% | 2.2% | 0.3% | 0.0% |
| San Joaquin County | 12.3% | 0.6% | 1.0% | 0.6% | 0.0% |
| Contra Costa County | 8.4% | 1.3% | 0.7% | 0.3% | 0.3% |
| Total Delta and Suisun Marsh Valley | 8.1% | 1.1% | 0.9% | 0.6% | 0.5% |
| Central Valley Region | 10.8% | 0.6% | 0.5% | 0.3% | 0.2% |
| **STATE OF CALIFORNIA** | **13.6%** | **1.6%** | **0.7%** | **0.9%** | **0.2%** |

Source: U.S. Census 2014f

**Table 21.23 Minority Population Distribution in the San Francisco Bay Area Region in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Alameda County | 1,510,271 | 43.0% | 12.6% | 0.6% | 26.1% | 0.8% | 10.8% | 6.0% | 22.5% | 65.9% |
| Santa Clara County | 1,781,642 | 47.0% | 2.6% | 0.7% | 32.0% | 0.4% | 12.4% | 4.9% | 26.9% | 64.8% |
| San Benito County | 55,269 | 63.7% | 0.9% | 1.6% | 2.6% | 0.2% | 26.2% | 4.9% | 56.4% | 61.7% |
| Napa County | 136,484 | 71.5% | 2.0% | 0.8% | 6.8% | 0.3% | 14.7% | 4.1% | 32.2% | 43.6% |
| San Francisco Bay Area Region | 3,483,666 | 46.5% | 6.9% | 0.7% | 28.0% | 0.6% | 12.0% | 5.4% | 25.7% | 64.4% |
| **STATE OF CALIFORNIA** | **37,253,956** | **57.6%** | **6.2%** | **1.0%** | **13.0%** | **0.4%** | **17.0%** | **4.9%** | **37.6%** | **59.9%** |

Sources: U.S. Census 2014a, 2014ad, 2014ae, 2014af, 2014ag

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

**Table 21.24 Population below Poverty Level in the San Francisco Bay Area Region, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Alameda County | 1,450,546 | 165,417 | 11.4 |
| Santa Clara County | 1,710,231 | 152,066 | 8.9 |
| San Benito County | 54,160 | 6,323 | 11.7 |
| Napa County | 130,057 | 12,948 | 10.0 |
| San Francisco Bay Area Region | 3,344,994 | 336,754 | 10.1 |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note:

a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

#### *21.3.5.3 Social Services*

Distribution of social services varies for each county. Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the San Francisco Bay Area Region are summarized in Table 21.25.

#### *21.3.5.4 Limited English Proficiency*

The percent of the population that speaks English and other languages at home and the percent of the population that speak English "less than very well" based on the language they speak at home are presented in Tables 21.26 and 21.27.

### 21.3.6 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. SWP water supplies are used directly by municipal and industrial water users, and as part of groundwater replenishment plans to meet municipal, industrial, and agricultural water demands.

#### *21.3.6.1 Minority Populations*

As recorded in the 2010 U.S. Census, the Central Coast Region had a total population of 693,532 in 2010. About 43.1 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.28. The table also shows the minority population distribution for the State of California.

#### *21.3.6.2 Poverty Levels*

Poverty levels presented in Table 21.29 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty status is determined within the Central Coast

Region, 649,348 individuals, 13.8 percent were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a "poverty areas." None of the counties in the Central Coast Region are defined as poverty areas.

#### *21.3.6.3 Social Services*

Distribution of social services varies for each county. Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the Central Coast Region are summarized in Table 21.30.

**Table 21.25 Federal Funds Distributed for Social Programs in the San Francisco Bay Area Region in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Alameda County | $2,556.4 | $318.6 | $529.6 |
| Santa Clara County | $2,000.2 | $334.3 | $466.3 |
| San Benito County | $27.1 | $12.5 | $8.2 |
| Napa County | $102.5 | $32.0 | $21.3 |
| San Francisco Bay Area Region | $4,686.2 | $697.4 | $1,025.4 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.26 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the San Francisco Bay Area Region, 2006–2010**

| Areas | Speaks Only English | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Hindi | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Alameda County | 57.4% | 16.8% | 8.2% | 3.8% | 1.8% | 1.6% | 32.2% |
| Santa Clara County | 49.3% | 19.1% | 7.4% | 3.3% | 6.5% | 1.5% | 37.8% |
| San Benito County | 60.1% | 37.3% | 0.1% | 0.7% | 0.2% | 0.0% | 38.3% |
| Napa County | 66.5% | 26.2% | 0.4% | 2.4% | 0.2% | 0.1% | 29.3% |
| San Francisco Bay Area Region | 53.7% | 18.6% | 7.3% | 3.4% | 4.1% | 1.5% | 35.0% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.9%** | **2.2%** | **1.4%** | **0.4%** | **35.4%** |

Source: U.S. Census 2014f

**Table 21.27 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the San Francisco Bay Area Region that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Hindi |
|---|---|---|---|---|---|
| Alameda County | 8.2% | 4.8% | 1.1% | 1.1% | 0.3% |
| Santa Clara County | 8.9% | 3.6% | 1.1% | 4.0% | 0.2% |
| San Benito County | 20.4% | 0.1% | 0.3% | 0.2% | 0.0% |
| Napa County | 14.6% | 0.2% | 0.9% | 0.2% | 0.04% |
| San Francisco Bay Area Region | 9.0% | 3.9% | 1.1% | 2.5% | 0.2% |
| **STATE OF CALIFORNIA** | **13.6%** | **1.6%** | **0.7%** | **0.9%** | **0.1%** |

Source: U.S. Census 2014f

**Table 21.28 Minority Population Distribution in the Central Coast Region in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| San Luis Obispo County | 269,637 | 82.6% | 2.1% | 0.9% | 3.2% | 0.1% | 7.3% | 3.8% | 20.8% | 28.9% |
| Santa Barbara County | 423,895 | 69.6% | 2.0% | 1.3% | 4.9% | 0.2% | 17.4% | 4.6% | 42.8% | 52.1% |
| Central Coast Region | 693,532 | 74.7% | 2.0% | 1.2% | 4.2% | 0.2% | 13.5% | 4.3% | 34.3% | 43.1% |
| **STATE OF CALIFORNIA** | **37,253,956** | **57.6%** | **6.2%** | **1.0%** | **13.0%** | **0.4%** | **17.0%** | **4.9%** | **37.6%** | **59.9%** |

Sources: U.S. Census 2014a, 2014ah, 2014ai

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

**Table 21.29 Population below Poverty Level in the Central Coast Region, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| San Luis Obispo County | 248,764 | 32,183 | 12.9% |
| Santa Barbara County | 400,584 | 57,463 | 14.3% |
| Central Coast Region | 649,348 | 89,646 | 13.8% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note:

a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

**Table 21.30 Federal Funds Distributed for Social Programs in the Central Coast Region in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| San Luis Obispo County | $176.0 | $70.7 | $44.5 |
| Santa Barbara County | $332.1 | $93.3 | $91.6 |
| Central Coast Region | $508.1 | $164.0 | $136.1 |
| STATE OF CALIFORNIA | $41,931.1 | $11,743.7 | $12,469.4 |

Source: Gaquin and Ryan 2013

#### *21.3.6.4 Limited English Proficiency*

The percent of the population that speaks English and other languages at home and the percent of the population that speak English “less than very well” based on the language they speak at home are presented in Tables 21.31 and 21.32.

### 21.3.7 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

#### *21.3.7.1 Minority Populations*

As recorded in the 2010 U.S. Census, the Southern California Region had a total population of 20,972,319 in 2010. About 64.2 percent of this population identified themselves as a racial minority and/or of Hispanic or Latino origin, regardless of race, as presented in Table 21.33. The table also shows the minority population distribution for the State of California.

#### 21.3.7.2 Poverty Levels

Poverty levels presented in Table 21.34 are calculated on a subset of the total population of a county, as described above in section 21.3.2, Characterization of Conditions Considered in the Environmental Justice Analysis. Of the total population for whom poverty status is determined within the Southern California Region, 20,296,879 individuals, 13.8 percent, were below the poverty level based on the 2006–2010 ACS 5-year dataset (U.S. Census 2014e). The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a "poverty areas." None of the counties in the Southern California Region are defined as poverty areas.

#### 21.3.7.3 Social Services

Distribution of social services varies for each county. Federal grants to the state and local agencies for Medicaid, other health related activities, and nutrition and family welfare; and Federal direct payments made to individuals under the CalFresh and supplemental social security income within counties in the Southern California Region are summarized in Table 21.35.

#### 21.3.7.4 Limited English Proficiency

The percent of the population that speaks English and other languages at home and the percent of the population that speak English "less than very well" based on the language they speak at home are presented in Tables 21.36 and 21.37.

**Table 21.31 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Central Coast Region, 2006–2010**

| Areas | Speaks Only English | Spanish and Spanish Creole | Chinese | Tagalog | French (including Patois and Cajun) | German | Total Excluding English |
|---|---|---|---|---|---|---|---|
| San Luis Obispo County | 83.3% | 13.1% | 0.3% | 0.5% | 0.3% | 0.4% | 14.7% |
| Santa Barbara County | 61.3% | 31.9% | 0.8% | 0.9% | 0.6% | 0.6% | 34.7% |
| Central Coast Region | 70.0% | 24.5% | 0.6% | 0.8% | 0.5% | 0.5% | 26.8% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.9%** | **2.2%** | **0.4%** | **0.3%** | **34.3%** |

Source: U.S. Census 2014f

**Table 21.32 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Central Coast Region that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish and Spanish Creole | Chinese | Tagalog | French (including Patois and Cajun) | German |
|---|---|---|---|---|---|
| San Luis Obispo County | 5.5% | 0.1% | 0.2% | 0.04% | 0.04% |
| Santa Barbara County | 16.5% | 0.4% | 0.4% | 0.1% | 0.1% |
| Central Coast Region | 12.2% | 0.3% | 0.4% | 0.1% | 0.1% |
| **STATE OF CALIFORNIA** | **13.6%** | **1.6%** | **0.7%** | **0.1%** | **0.04%** |

Source: U.S. Census 2014f

**Table 21.33 Minority Population Distribution in the Southern California Region in 2010**

| Areas | Total Population | Races | | | | | | | Hispanic or Latino Origin | Total Minority[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | White | Black/ African American | American Indian and Native Alaskan | Asian | Native Hawaiian and Other Pacific Islander | Some Other Race | Two or More Races | | |
| Ventura County | 823,318 | 68.7% | 1.8% | 1.0% | 6.7% | 0.2% | 17.0% | 4.5% | 40.3% | 51.3% |
| Los Angeles County | 9,818,605 | 50.3% | 8.7% | 0.7% | 13.7% | 0.3% | 21.8% | 4.5% | 47.7% | 72.2% |
| Orange County | 3,010,232 | 60.8% | 1.7% | 0.6% | 17.9% | 0.3% | 14.5% | 4.2% | 33.7% | 55.9% |
| San Diego County | 3,095,313 | 64.0% | 5.1% | 0.9% | 10.9% | 0.5% | 13.6% | 5.1% | 32.0% | 51.5% |
| Riverside County | 2,189,641 | 61.0% | 6.4% | 1.1% | 6.0% | 0.3% | 20.5% | 4.8% | 45.5% | 60.3% |
| San Bernardino County | 2,035,210 | 56.7% | 8.9% | 1.1% | 6.3% | 0.3% | 21.6% | 5.0% | 49.2% | 66.7% |
| Southern California Region | 20,972,319 | 56.3% | 6.7% | 0.8% | 12.1% | 0.3% | 19.2% | 4.6% | 43.1% | 64.2% |
| **STATE OF CALIFORNIA** | **37,253,956** | **57.6%** | **6.2%** | **1.0%** | **13.0%** | **0.4%** | **17.0%** | **4.9%** | **37.6%** | **59.9%** |

Sources: U.S. Census 2014a, 2014aj, 2014ak, 2014al, 2014am, 2014an, 2014ao

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

**Table 21.34 Population below Poverty Level in the Southern California Region, 2006–2010**

| Areas | Total Population[a] | Population Below Poverty Level | Percent of Population Below Poverty Level |
|---|---|---|---|
| Ventura County | 798,863 | 73,842 | 9.2% |
| Los Angeles County | 9,604,871 | 1,508,618 | 15.7% |
| Orange County | 2,925,244 | 296,846 | 10.1% |
| San Diego County | 2,930,875 | 361,248 | 12.3% |
| Riverside County | 2,075,782 | 278,358 | 13.4% |
| San Bernardino County | 1,961,244 | 291,020 | 14.8% |
| Southern California Region | 798,863 | 73,842 | 9.2% |
| **STATE OF CALIFORNIA** | **35,877,036** | **4,919,945** | **13.7%** |

Source: U.S. Census 2014e

Note:

a. Population numbers are only those for whom poverty status was determined and exclude institutionalized individuals

**Table 21.35 Federal Funds Distributed for Social Programs in the Southern California Region in 2010**

| Areas | Grants (millions of dollars) | | Distributed to Individuals (millions of dollars) |
|---|---|---|---|
| | Medicaid and Other Health-Related Items | Nutrition and Family Welfare | CalFresh Benefits and Supplemental Security Income |
| Ventura County | $445.3 | $153.9 | $147.1 |
| Los Angeles County | $13,950.6 | $2,840.6 | $4,259.6 |
| Orange County | $1,678.3 | $610.6 | $633.2 |
| San Diego County | $3,866.8 | $677.8 | $790.1 |
| Riverside County | $966.4 | $347.2 | $488.0 |
| San Bernardino County | $1,236.2 | $390.1 | $751.9 |
| Southern California Region | $22,143.6 | $5,020.2 | $7,069.9 |
| **STATE OF CALIFORNIA** | **$41,931.1** | **$11,743.7** | **$12,469.4** |

Source: Gaquin and Ryan 2013

**Table 21.36 Top Five Non-English Languages Spoken at Home as a Proportion of the Total Population Five Years and Older in the Southern California Region, 2006–2010**

| Areas | Speaks Only English | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Korean | Total Excluding English |
|---|---|---|---|---|---|---|---|
| Ventura County | 62.6% | 29.5% | 1.0% | 1.7% | 0.4% | 0.4% | 33.1% |
| Los Angeles County | 43.6% | 39.4% | 3.6% | 2.5% | 0.8% | 2.0% | 48.3% |
| Orange County | 55.6% | 26.2% | 2.2% | 1.5% | 5.4% | 2.5% | 37.8% |
| San Diego County | 63.7% | 24.4% | 1.4% | 3.1% | 1.3% | 0.5% | 30.6% |
| Riverside County | 60.5% | 33.2% | 0.5% | 1.4% | 0.6% | 0.4% | 36.2% |
| San Bernardino County | 59.5% | 33.6% | 1.0% | 1.4% | 0.6% | 0.5% | 37.1% |
| Southern California Region | 52.3% | 33.7% | 2.4% | 2.2% | 1.5% | 1.5% | 41.3% |
| **STATE OF CALIFORNIA** | **57.0%** | **28.5%** | **2.9%** | **2.2%** | **1.4%** | **1.1%** | **36.1%** |

Source: U.S. Census 2014f

**Table 21.37 Percent of Population Speaking One of the Top Five Non-English Languages Spoken at Home in the Southern California Region that Speaks English "Less than Very Well" as a Proportion of the Total Population Five Years and Older, 2006–2010**

| Areas | Spanish and Spanish Creole | Chinese | Tagalog | Vietnamese | Korean |
|---|---|---|---|---|---|
| Ventura County | 14.1% | 0.5% | 0.5% | 0.2% | 0.2% |
| Los Angeles County | 19.0% | 2.2% | 0.8% | 0.5% | 1.3% |
| Orange County | 13.4% | 1.0% | 0.4% | 3.3% | 1.5% |
| San Diego County | 11.0% | 0.7% | 1.1% | 0.8% | 0.3% |
| Riverside County | 14.5% | 0.3% | 0.4% | 0.4% | 0.2% |
| San Bernardino County | 15.5% | 0.5% | 0.4% | 0.4% | 0.3% |
| Southern California Region | 16.0% | 1.4% | 0.7% | 0.9% | 0.9% |
| **STATE OF CALIFORNIA** | **13.6%** | **1.6%** | **0.7%** | **0.9%** | **0.7%** |

Source: U.S. Census 2014f

## 21.4 Impact Analysis

This section describes the potential mechanisms for change in conditions and analytical methods; results of impact analyses; potential mitigation measures; and cumulative effects.

### 21.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in factors that affect environmental justice or minority and low-income populations specifically related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

The Council of Environmental Quality (CEQ) and U.S. Environmental Protection Agency (USEPA) established guidelines to assist federal agencies in the analysis of environmental justice defines minority and low-income areas summarized in Section 21.3, Affected Environment (CEQ, 1997). The following guidelines are used to determine if minority populations are present in a study area:

- The minority population of the affected area exceeds 50 percent, or
- The population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis.

The CEQ guidelines do not specifically state the percentage considered meaningful in the case of low-income populations. For this analysis, the assumptions set forth in the CEQ guidelines for identifying and evaluating impacts on minority populations also are used to identify and evaluate impacts on low-income populations, including a determination that a low-income population is present if the project area if 50 percent or more of the population is living below the poverty level.

The alternatives considered in this EIS do not include project-specific construction activities. In most portions of the study area, the availability of CVP and SWP water supplies directly or indirectly affects most of the population within a county. Therefore, the entire population of each counties within the study area is considered to determine whether minority or low-income areas could be affected by implementation of the alternatives. In the study area, populations below the poverty level do not include 50 percent or more of the population. The highest proportion of populations below the poverty level occurs in Fresno and Tulare counties in which approximately 23 percent of the populations are below the poverty level. However, minority populations contribute more than 50 percent of the total county populations in 24 of the 35 counties. The following counties have 50 percent or more of the total population as minority populations.

- Central Valley Region: Colusa, Sacramento, Solano, Sutter, Yolo, Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties

- Central Coast Region; Santa Barbara.
- Southern California Region: Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura.

Although, the majority of the populations in the Trinity River Region counties are not minority populations, these counties do include the Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria. Therefore, the Trinity River Region counties are also included in the environmental justice analysis.

The CEQ guidance provides the following three factors to be considered for determination if disproportionately high and adverse impacts may accrue to minority or low-income populations.

The following criteria were used to evaluate the impacts to minority and low-income populations resulting from the operational changes following the implementation of each of the alternatives as compared to the No Action Alternative and the Second Basis of Comparison:

- Whether there is or would be an impact that results in a disproportionately high and adverse human health and environmental impact, including social and economic effects on environmental justice populations.
- Whether the environmental effects are significant and are, or may be, having an adverse impact on environmental justice populations that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group.
- Whether the environmental effects occur or would occur in an environmental justice population affected by cumulative or multiple adverse exposures from environmental hazards.

To determine whether the operational changes resulting from implementation of each of the alternatives as compared to the No Action Alternative and the Second Basis of Comparison will have a "disproportionately high and adverse impact" on minority and low-income populations, various factors were considered, including potential adverse impacts, mitigation, and enhancement measures that will be incorporated into the alternatives; and offsetting benefits.

The environmental justice guidance documents do not specifically define conditions that would result in "high and adverse human health and environmental impact." For this analysis, the potential changes in air quality, cultural resources, public health, and socioeconomics were considered within the counties that had a minority population of 50 percent or greater of the total population.

The changes were then determined if the impacts would be disproportionally high on the minority populations. Potential adverse impacts were evaluated with regard to air quality, public health, and socioeconomics.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could result in disproportionally high effects on minority or tribal populations related to changes in air quality, public health, and socioeconomics.

##### *21.4.1.1 Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Changes in CVP and SWP operations under the alternatives could change the use of individual engines to operate groundwater wells. To evaluate the potential for changes in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants, results from the CVHM model that indicate changes in groundwater withdrawals due to changes in CVP and SWP operations were analyzed. However, it is not known how many of the groundwater pumps use electricity and how many use diesel engines. The diesel engines have the potential to emit criteria air pollutants and precursors, and toxic air contaminants, as described in Chapter 16, Air Quality and Greenhouse Gas Emissions.

Most of the groundwater wells in the Central Valley use electrical pumps. As reported in a recent environmental assessment, approximately 14 to 15 percent of the pumps used diesel fuel in 2003 (Reclamation 2013a). It is assumed for this EIS, that the portion of groundwater pumps that use electricity would remain approximately at 85 percent. Therefore, it is assumed that increases or decreases in groundwater pumping would be indicative of an increase or decrease in the use of diesel engines in the Central Valley as well as in the San Francisco Bay Area, Central Coast, and Southern California regions. Changes in CVP and SWP operations would not result in changes in groundwater pumping in the Trinity River Region; therefore, this analysis does not address Trinity River Region.

##### *21.4.1.2 Changes in Public Health Related to Changes in Potential Exposure to Mercury in Fish Used in Human Consumption*

Changes in CVP and SWP operations under the alternatives could change public health factors related to mercury concentrations in fish used for human consumption as compared to the No Action Alternative and Second Basis of Comparison, as described in Chapter 18, Public Health.

##### *21.4.1.3 Changes in Socioeconomics*

Changes in CVP and SWP operations under the alternatives could change socioeconomic factors related to employment related to irrigated agriculture and municipal and industrial (M&I) water supplies and tribal salmon harvest in the Trinity River Region as compared to the No Action Alternative and Second Basis of Comparison, as described in Chapter 19, Socioeconomics. However, changes in employment related to irrigated agriculture and M&I water supplies would be similar. Therefore, these changes are not analyzed in this EIS.

#### *21.4.1.4 Effects due to Cross Delta Water Transfers*

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future environmental justice conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 21.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions.

Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to environmental justice factors that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *21.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies. Due to climate change and related lower snowfall, end of September low reservoir storage would be lower in critical dry years by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir. Therefore, the potential for reduced reservoir water supplies for wildland firefighting would be greater under the No Action Alternative and Second Basis of Comparison as compared to recent historical conditions.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives.

Under the No Action Alternative and Second Basis of Comparison, it is anticipated that mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions. Phase 1 of the Delta Mercury Program mandated by the Central Valley Regional Water Quality Control Board (RWQCB) is currently being completed to protect people eating one meal per week of larger fish from the Delta, including Largemouth Bass. Phase 1 is focused on studies and pilot projects to develop and evaluate management practices to control methylmercury from mercury sources in the Delta and Yolo Bypass; and to reduce total mercury loading to the San Francisco Bay. Following completion of Phase 1 in 2019, Phase 2 will be implemented through 2030. Phase 2 will focus on methylmercury control programs and reduction programs for total inorganic mercury. Due to the extent of these studies, it is not anticipated that changes in methylmercury or total mercury concentrations in fish tissue will be reduced by 2030. Future mercury reduction and control programs will reduce mercury sources and related fish tissue concentrations; however, that will occur after 2030.

### 21.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

#### *21.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 21.4.3.1.1 Central Valley Region

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would increase by 8 percent under the No Action Alternative as compared to the Second Basis of Comparison. It is not known if the additional groundwater pumping would rely upon electricity or diesel to drive the pump engines. Under the worst case analysis, it is assumed that the increased use of diesel engines would be proportional to the increased use of groundwater. Therefore, under the No Action Alternative, there would be a potential increase in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar (within 5 percent change) in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would increase by 7 percent over long-term conditions under the No Action Alternative as compared to the Second Basis of Comparison. Under dry and critical dry years, mercury concentrations would increase by 7 to 8 percent at Rock Slough, intakes of the Banks and Jones pumping plants, and Victoria Canal. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to environmental justice were identified as loss of employment in the seller's service area if crop idling was used to provide transfer water. The analysis indicated that the proportion of crop idled acreage would be small as compared to the overall regional irrigated acreage, and that this change would not result in in disproportionately high or adverse effects. In addition, beneficial effects could occur in the purchaser's service area if more acreage was cultivated with the water transfer program than without the water transfer program.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 21.4.3.1.2 San Francisco Bay Area, Central Coast, and Southern California Regions

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be decreased by 10 percent and 18 percent, respectively, in the San Francisco Bay Area, Central

Coast, and Southern California regions under No Action Alternative as compared to the Second Basis of Comparison. The decrease in surface water supplies could result in additional use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also increased.

### *21.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because CVP and SWP operations under Alternative 1 are identical to conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 21.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would decrease by 8 percent under Alternative 1 as compared to the No Action Alternative. It is not known if the reduction in groundwater pumping would result in a reduction of the use of electricity or diesel to drive the pump engines. For this analysis, it is assumed that the decreased use of diesel engines would be proportional to the decreased use of groundwater. Therefore, under Alternative 1, there would be a potential decrease in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would decrease by 6 percent over the long-term conditions under Alternative 1 as compared to the No Action Alternative. Under dry and critical dry years, mercury concentrations would decrease by 6 to 8 percent at Rock Slough, intakes of the Banks and Jones pumping plants, and Victoria Canal. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice conditions could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on environmental justice factors would not be substantial due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be increased by 11 percent and 21 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 1 as compared to the No Action Alternative. The increase in surface water supplies could result in the reduction in use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also decreased.

##### 21.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

#### *21.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, as described in Chapter 3, Description of Alternatives; therefore Alternative 2 is only compared to the Second Basis of Comparison.

##### 21.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to environmental justice factors under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 18.4.3.1, No Action Alternative.

#### *21.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 21.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would decrease by 6 percent under Alternative 3 as compared to the No Action Alternative. It is not known if the reduction in groundwater pumping would result in a reduction of the use of electricity or diesel to drive the pump engines. For this analysis, it is assumed that the decreased use of diesel engines would be proportional to the decreased use of groundwater. Therefore, under Alternative 3, there would be a potential decrease in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar (within 5 percent change) in most locations in the Delta, except for San Joaquin River near Antioch and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would decrease by 6 percent over the long-term conditions under Alternative 3 as compared to the No Action Alternative. Mercury concentrations under the dry and critical dry years would be similar throughout the Delta. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on environmental justice factors would not be substantial due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be increased by 9 percent and 17 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 3 as compared to the No Action Alternative. The increase in surface water supplies could result in the reduction in use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also decreased.

#### 21.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would be similar (within a 5 percent change) under Alternative 3 as compared to the Second Basis of Comparison. Therefore, the emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish Used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar throughout the Delta under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Chapter 6, Surface Water Quality. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that impacts on environmental justice factors would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies and emissions from diesel engines used for groundwater pumping would be similar in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 3 as compared to the Second Basis of Comparison.

#### *21.4.3.5 Alternative 4*

The environmental justice conditions under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 21.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in environmental justice conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 12.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *21.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 21.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would be similar under Alternative 5 as compared to the No Action Alternative. Therefore, the emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants would be similar under Alternative 5 as compared to the No Action Alternative.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar throughout the Delta under Alternative 5 as compared to the No Action Alternative, as summarized in Chapter 6, Surface Water Quality. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on environmental justice factors would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies and emissions from diesel engines used for groundwater pumping would be similar in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 5 as compared to the No Action Alternative.

#### 21.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Central Valley Region*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

Groundwater pumping in the San Joaquin Valley portion of the Central Valley Region would increase by 8 percent under Alternative 5 as compared to the Second Basis of Comparison. It is not known if the additional groundwater pumping would rely upon electricity or diesel to drive the pump engines. Under the worst case analysis, it is assumed that the increased use of diesel engines would be proportional to the increased use of groundwater. Therefore, under Alternative 5, there would be a potential increase in emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants as compared to the Second Basis of Comparison.

*Changes in Public Health Factors Related to Mercury in Fish used for Human Consumption*

Mercury concentrations in Largemouth Bass would be similar in most locations in the Delta, except for Rock Slough, San Joaquin River near Antioch, and Montezuma Slough in Suisun Marsh. In these areas, the mercury concentrations would increase by 7 to 8 percent over long-term conditions under Alternative 5 as compared to the Second Basis of Comparison. During dry and critical dry years, mercury concentrations also would increase by 7 percent at intakes to Banks Pumping Plant and Jones Pumping Plant; and 13 percent at Rock Slough. All values exceed the threshold of 0.24 mg/kg ww for mercury.

*Effects Related to Cross Delta Water Transfers*

Potential effects to environmental justice factors could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on environmental justice factors would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Changes in Emissions of Criteria Air Pollutants and Precursors, and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants Related to Changes in Groundwater Pumping*

It is anticipated that CVP and SWP water supplies would be decreased by 10 percent and 18 percent, respectively, in the San Francisco Bay Area, Central Coast, and Southern California regions under Alternative 5 as compared to the Second Basis of Comparison. The decrease in surface water supplies could result in increased use of groundwater pumps and emissions of air pollutants and contaminants if the use of diesel engines is also increased.

#### ***21.4.3.7 Summary of Environmental Consequences***

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 21.38 and 21.39.

**Table 21.38 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Decrease potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 11 to 21 percent in the San Francisco Bay Area Region, and by 21 percent in the Central Coast and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 6 percent decrease near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | None needed |
| Alternative 2 | No effects on environmental justice factors. | None needed |
| Alternative 3 | Decrease potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 6 percent in the Central Valley, 9 to 17 percent in the San Francisco Bay Area Region, and by 17 percent in the Central Coast and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 6 percent decrease near San Joaquin River at Antioch and Montezuma Slough over the long-term conditions. | None needed |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | Similar potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta. | None needed |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

**Table 21.39 Comparison of Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Increase potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | Not considered for this comparison. |
| Alternative 1 | No effects on environmental justice factors. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Similar potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta. | Not considered for this comparison. |
| Alternative 4 | No effects on environmental justice factors. | Not considered for this comparison. |
| Alternative 5 | Increase potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors to substantial concentrations of air contaminants by 8 percent in the Central Valley, 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions. | Not considered for this comparison. |

Note: Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

#### *21.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in changes in air quality or public health that are related to environmental justice factors. Therefore, there would be no disproportionately high or adverse environmental justice effects; and no mitigation measures are required.

#### *21.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Environmental Justice are summarized in Table 21.40.

**Table 21.4 Summary of Cumulative Effects on Environmental Justice of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in all Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>• Implementation of Federal and state policies and programs, including Clean Water Act (e.g., Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>• General plans for 2030.<br>• Trinity River Restoration Program.<br>• Central Valley Project Improvement Act programs<br>• Folsom Dam Water Control Manual Update<br>• FERC Relicensing for the Middle Fork of the American River Project<br>• Lower Mokelumne River Spawning Habitat Improvement Project<br>• Dutch Slough Tidal Marsh Restoration<br>• Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>• Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>• San Joaquin River Restoration Program<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | <u>These effects would be the same in all alternatives.</u><br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce the availability of surface water, including CVP and SWP water supplies. This could result in increased groundwater withdrawals; and a portion of those groundwater pumps would rely upon diesel engines. Therefore, there would be an increased potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors that could cause a disproportionately high and adverse impact on minority and low-income populations.<br>Mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions because Phases 1 and 2 of the Delta Mercury Program would be completed by 2030, as mandated by the Central Valley RWQCB, including methylmercury control programs and reduction programs for total inorganic mercury. Due to the extent of these programs, it is anticipated that the programs would be initiated; however, future reductions in mercury sources and related reductions of mercury and methylmercury concentrations in fish tissue would actually occur after 2030. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Future Actions considered as Cumulative Effects Actions in with all Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>• Bay-Delta Water Quality Control Plan Update<br>• FERC Relicensing Projects<br>• Bay Delta Conservation Plan (including the California WaterFix alternative)<br>• Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>• El Dorado Water and Power Authority Supplemental Water Rights Project<br>• Sacramento River Water Reliability Project<br>• Semitropic Water Storage District Delta Wetlands<br>• North Bay Aqueduct Alternative Intake<br>• San Luis Reservoir Low Point Improvement Project<br>• Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same in all alternatives.</u><br>Future reasonably foreseeable storage and water supply projects would improve surface water reliability. These actions would reduce the potential for increased groundwater withdrawals; and reduce the potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors that could cause a disproportionately high and adverse impact on minority and low-income populations. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce the availability of surface water, including CVP and SWP water supplies. This could result in increased groundwater withdrawals; and a portion of those groundwater pumps would rely upon diesel engines. Therefore, there would be an increased potential for emissions of criteria air pollutants and precursors, and/or exposure of sensitive receptors that could cause a disproportionately high and adverse impact on minority and low-income populations.<br>Mercury concentrations in fish tissue within the Delta will be |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | | either similar or greater than recent historical conditions because Phases 1 and 2 of the Delta Mercury Program would be completed by 2030, as mandated by the Central Valley RWQCB, including methylmercury control programs and reduction programs for total inorganic mercury. Due to the extent of these programs, it is anticipated that the programs would be initiated; however, future reductions in mercury sources and related reductions of mercury and methylmercury concentrations in fish tissue would actually occur after 2030. |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with these added actions. |
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with these added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with these added actions. |
| Alternative 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with these added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with these added actions. |

## 21.5 References

AgAlert. 2014. *Food donations underscore drought impact*, September 10, 2014. Site accessed September 10, 2014. http://agalert.com/story/?id=1709.

Antelope Valley. 2013. *Antelope Valley Integrated Regional Water Management Plan, Final, 2013 Update*.

BARDP (Bay Area Regional Desalination Project). 2015. *About the Project, Schedule*. Site accessed January 12, 2015. http://www.regionaldesal.com/schedule.html

BOP (Federal Bureau of Prisons). 2014. *Federal Correctional Institutions (FCI)–Mendota*. Site accessed October 20, 2014. http://www.bop.gov/locations/institutions/men/

BVWSD (Buena Vista Water Storage District). 2015. *Buena Vista Water Storage District, James Groundwater Storage and Recovery Project*. Site accessed February 15, 2015. http://bvh2o.com/James.html

CCWD (Contra Costa Water District). 2014. *Bay Area Regional Water Supply Reliability Presentation*. November 18.

CDE (California Department of Education). 2013. *Student Poverty – FRMP Data, School Levels Data Files*. Site accessed April 24, 2013. http://www.cde.ca.gov/ds/sd/sd/filessp.asp.

CDSS (California Department of Social Services). 2008a. *Food Stamp Program Participation and Benefit Issuance Report, January 2006.* April 16.

CDSS (California Department of Social Services). 2008b. *Food Stamp Program Participation and Benefit Issuance Report*, *February 2006.* April 16.

CDSS (California Department of Social Services). 2008c. *Food Stamp Program Participation and Benefit Issuance Report, March 2006.* April 16.

CDSS (California Department of Social Services). 2008d. *Food Stamp Program Participation and Benefit Issuance Report, April 2006.* April 16.

CDSS (California Department of Social Services). 2008e. *Food Stamp Program Participation and Benefit Issuance Report, May 2006.* April 16.

CDSS (California Department of Social Services). 2008f. *Food Stamp Program Participation and Benefit Issuance Report, June 2006.* September 3.

CDSS (California Department of Social Services). 2008g. *Food Stamp Program Participation and Benefit Issuance Report*, *July 2006.* April 16.

CDSS (California Department of Social Services). 2008h. *Food Stamp Program Participation and Benefit Issuance Report, August 2006.* April 16.

CDSS (California Department of Social Services). 2008i. *Food Stamp Program Participation and Benefit Issuance Report, September 2006.* April 16.

CDSS (California Department of Social Services). 2008j. *Food Stamp Program Participation and Benefit Issuance Report, October 2006.* April 16.

CDSS (California Department of Social Services). 2008k. *Food Stamp Program Participation and Benefit Issuance Report*, *November 2006.* April 16.

CDSS (California Department of Social Services). 2008l. *Food Stamp Program Participation and Benefit Issuance Report, December 2006.* April 16.

CDSS (California Department of Social Services). 2008m. *Food Stamp Program Participation and Benefit Issuance Report, January 2007.* April 16.

CDSS (California Department of Social Services). 2008n. *Food Stamp Program Participation and Benefit Issuance Report*, *February 2007.* April 16.

CDSS (California Department of Social Services). 2008o. *Food Stamp Program Participation and Benefit Issuance Report, March 2007.* April 16.

CDSS (California Department of Social Services). 2008p. *Food Stamp Program Participation and Benefit Issuance Report*, *April 2007.* April 16.

CDSS (California Department of Social Services). 2008q. *Food Stamp Program Participation and Benefit Issuance Report, May 2007.* April 16.

CDSS (California Department of Social Services). 2008r. *Food Stamp Program Participation and Benefit Issuance Report, June 2007.* September 3.

CDSS (California Department of Social Services). 2008s. *Food Stamp Program Participation and Benefit Issuance Report*, *July 2007.* November 6.

CDSS (California Department of Social Services). 2008t. *Food Stamp Program Participation and Benefit Issuance Report, August 2007.* September 3.

CDSS (California Department of Social Services). 2008u. *Food Stamp Program Participation and Benefit Issuance Report*, *September 2007.* September 3.

CDSS (California Department of Social Services). 2008v. *Food Stamp Program Participation and Benefit Issuance Report, October 2007.* April 16.

CDSS (California Department of Social Services). 2008w. *Food Stamp Program Participation and Benefit Issuance Report, November 2007.* September 3.

CDSS (California Department of Social Services). 2008x. *Food Stamp Program Participation and Benefit Issuance Report*, *December 2007.* September 3.

CDSS (California Department of Social Services). 2008y. *Food Stamp Program Participation and Benefit Issuance Report, January 2008.* September 3.

CDSS (California Department of Social Services). 2009a. *Food Stamp Program Participation and Benefit Issuance Report*, *February 2008.* March 19.

CDSS (California Department of Social Services). 2009b. *Food Stamp Program Participation and Benefit Issuance Report, March 2008.* March 19.

CDSS (California Department of Social Services). 2009c. *Food Stamp Program Participation and Benefit Issuance Report, April 2008.* March 19.

CDSS (California Department of Social Services). 2009d. *Food Stamp Program Participation and Benefit Issuance Report, May 2008.* March 19.

CDSS (California Department of Social Services). 2009e. *Food Stamp Program Participation and Benefit Issuance Report, June 2008.* March 19.

CDSS (California Department of Social Services). 2009f. *Food Stamp Program Participation and Benefit Issuance Report, July 2008.* March 19.

CDSS (California Department of Social Services). 2009g. *Food Stamp Program Participation and Benefit Issuance Report, August 2008.* March 19.

CDSS (California Department of Social Services). 2009h. *Food Stamp Program Participation and Benefit Issuance Report, September 2008.* March 19.

CDSS (California Department of Social Services). 2009i. *Food Stamp Program Participation and Benefit Issuance Report, October 2008.* December 16.

CDSS (California Department of Social Services). 2009j. *Food Stamp Program Participation and Benefit Issuance Report, November 2008.* February 13.

CDSS (California Department of Social Services). 2009k. *Food Stamp Program Participation and Benefit Issuance Report, December 2008.* February 13.

CDSS (California Department of Social Services). 2009l. *Food Stamp Program Participation and Benefit Issuance Report, January 2009.* March 30.

CDSS (California Department of Social Services). 2009m. *Food Stamp Program Participation and Benefit Issuance Report, February 2009.* April 21.

CDSS (California Department of Social Services). 2009n. *Food Stamp Program Participation and Benefit Issuance Report, March 2009.* June 9.

CDSS (California Department of Social Services). 2012a. *Food Stamp Program Participation and Benefit Issuance Report, April 2009.* April 26.

CDSS (California Department of Social Services). 2012b. *Food Stamp Program Participation and Benefit Issuance Report, May 2009.* April 27.

CDSS (California Department of Social Services). 2012c. *Food Stamp Program Participation and Benefit Issuance Report, June 2009.* April 27.

CDSS (California Department of Social Services). 2012d. *Food Stamp Program Participation and Benefit Issuance Report, July 2009.* April 27.

CDSS (California Department of Social Services). 2012e. *Food Stamp Program Participation and Benefit Issuance Report, August 2009.* April 27.

CDSS (California Department of Social Services). 2012f. *Food Stamp Program Participation and Benefit Issuance Report, September 2009.* April 27.

CDSS (California Department of Social Services). 2012g. *Food Stamp Program Participation and Benefit Issuance Report, October 2009.* April 27.

CDSS (California Department of Social Services). 2012h. *Food Stamp Program Participation and Benefit Issuance Report, November 2009.* April 27.

CDSS (California Department of Social Services). 2012i. *Food Stamp Program Participation and Benefit Issuance Report, December 2009.* April 27.

CDSS (California Department of Social Services). 2012j. *Food Stamp Program Participation and Benefit Issuance Report, January 2010.* April 27.

CDSS (California Department of Social Services). 2012k. *Food Stamp Program Participation and Benefit Issuance Report, February 2010.* April 27.

CDSS (California Department of Social Services). 2012l. *Food Stamp Program Participation and Benefit Issuance Report, March 2010.* May 2.

CDSS (California Department of Social Services). 2012m. *Food Stamp Program Participation and Benefit Issuance Report, April 2010.* May 2.

CDSS (California Department of Social Services). 2012n. *Food Stamp Program Participation and Benefit Issuance Report, May 2010.* May 4.

CDSS (California Department of Social Services). 2012o. *Food Stamp Program Participation and Benefit Issuance Report, June 2010.* May 4.

CDSS (California Department of Social Services). 2012p. *Food Stamp Program Participation and Benefit Issuance Report, July 2010.* May 7.

CDSS (California Department of Social Services). 2012q. *Food Stamp Program Participation and Benefit Issuance Report, August 2010.* May 7.

CDSS (California Department of Social Services). 2012r. *Food Stamp Program Participation and Benefit Issuance Report, September 2010.* May 7.

CDSS (California Department of Social Services). 2012s. *Food Stamp Program Participation and Benefit Issuance Report, October 2010.* May 7.

CDSS (California Department of Social Services). 2012t. *Food Stamp Program Participation and Benefit Issuance Report, November 2010.* May 8.

CDSS (California Department of Social Services). 2012u. *Food Stamp Program Participation and Benefit Issuance Report, December 2010.* May 8.

CDSS (California Department of Social Services). 2012v. *Food Stamp Program Participation and Benefit Issuance Report, January 2011.* May 8.

CDSS (California Department of Social Services). 2012w. *Food Stamp Program Participation and Benefit Issuance Report, February 2011.* May 9.

CDSS (California Department of Social Services). 2012x. *Food Stamp Program Participation and Benefit Issuance Report, March 2011.* May 9.

CDSS (California Department of Social Services). 2013a. *Food Stamp Program Participation and Benefit Issuance Report, April 2011.* February 6.

CDSS (California Department of Social Services). 2013b. *Food Stamp Program Participation and Benefit Issuance Report, May 2011.* February 6.

CDSS (California Department of Social Services). 2013c. *Food Stamp Program Participation and Benefit Issuance Report, June 2011.* February 6.

CDSS (California Department of Social Services). 2013d. *Food Stamp Program Participation and Benefit Issuance Report, July 2011*. February 5.

CDSS (California Department of Social Services). 2013e. *Food Stamp Program Participation and Benefit Issuance Report, August 2011*. February 5.

CDSS (California Department of Social Services). 2013f. *Food Stamp Program Participation and Benefit Issuance Report, September 2011*. February 5.

CDSS (California Department of Social Services). 2013g. *Food Stamp Program Participation and Benefit Issuance Report, October 2011*. February 5.

CDSS (California Department of Social Services). 2013h. *Food Stamp Program Participation and Benefit Issuance Report, November 2011*. June 4.

CDSS (California Department of Social Services). 2013i. *Food Stamp Program Participation and Benefit Issuance Report, December 2011*. April 19.

CDSS (California Department of Social Services). 2013j. *The Keys to CalFresh Outreach General Market*.

CDSS (California Department of Social Services). 2014. *Drought Relief Provides Food to California's Hardest Hit Communities, News Release April 17, 2014*. April 17.

CEDD (California Employment Development Department). 2013. Major Employers in Fresno County. Site accessed October 20, 2014. http://www.labormarketinfo.edd.ca.gov/majorer/majorer.asp.

CEDD (California Employment Development Department). 2014. *Unemployment Rates (Labor Force) Huron and Mendota*. Site accessed November 9, 2014. http://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/labForceReport.asp?menuchoice=LABFORCE

CEQ (Council of Environmental Quality). 1997. *Environmental Justice: Guidance under the National Environmental Policy Act*.

City of Carlsbad. 2006. *California Environmental Quality Act (CEQA) Addendum City of Carlsbad, California Precise Development Plan and Desalination Plant Project, Final Environmental Impact Report*. June 13.

City of Fresno. 2011. *City of Fresno Recycled Water Master Plan, Final Environmental Impact Report*. June.

City of Huntington Beach. 2010. *Draft Subsequent Environmental Impact Report, Seawater Desalination Project at Huntington Beach*. May.

City of Long Beach. 2015. *Capital Projects, Seawater Desalination*. Site accessed January 12, 2015. http://www.lbwater.org/overview-long-beach-seawater-desalination-project

City of Los Angeles (Los Angeles Department of Water and Power). 2005. *Integrated Resources Plan, Draft Environmental Impact Report*. November.

City of Los Angeles. 2013. *Tujunga Spreading Grounds Enhancement Project, Final Environmental Impact Report*. April.

City of Oceanside. 2012. *Oceanside Harbor Desalination Testing Project*.

City of Roseville. 2012. *Aquifer Storage and Recovery Program Final Environmental Impact Report*. March.

City of San Diego. 2009a. *Mission Valley Basin*. September 11.

City of San Diego. 2009b. *San Pasqual Basin*. September 11.

City of Santa Barbara. 2015. *Desalination*. Site accessed February 19, 2015. http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp

CWD (Camarosa Water District). 2015. *Local Water Desalination*. Site accessed January 25, 2015. http://www.camrosa.com/self_reliance_lwd.html

DOI and DFG (Department of the Interior and California Department of Fish and Game [now known as Department of Fish and Wildlife]). 2012. *Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report*. December.

DWR (California Department of Water Resources). 2011. *Scoping Report, North Bay Aqueduct Alternative Intake Project*. February.

DWR (California Department of Water Resources). 2013. *North-of-the-Delta Offstream Storage Preliminary Administrative Draft Environmental Impact Report*. December.

EBMUD (East Bay Municipal Utility District). 2014. *Memo to the Board of Directors, Bay Area Regional Reliability Principles*. May 8.

EMWD (Eastern Municipal Water District). 2014a. *Administrative Draft, Mitigated Negative Declaration, Temecula Valley Regional Water Reclamation Facility, 23 MGD Expansion*. January.

EMWD (Eastern Municipal Water District). 2014b. *San Jacinto Regional Water Reclamation Facility*. March.

EMWD (Eastern Municipal Water District). 2014c. *Indirect Potable Reuse Program*. January 8.

EMWD (Eastern Municipal Water District). 2014d. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

FERC (Federal Energy Regulatory Commission). 2015. *FERC: Hydropower-General Information – Licensing*. Site accessed April 29, 2015. http://www.ferc.gov/industries/hydropower/gen-info/licensing.asp

Fresno County (County of Fresno). 2013. Personal Communications between Jessica Ramirez, Fresno County Department of Social Services, and Fatuma Yusuf, CH2M HILL. September 17.

Fresno Bee. 2014. Earth Log: *Food lines have begun in Mendota*, May 2, 2014. Site accessed May 6, 2014. http://www.fresnobee.com/2014/05/02/3906892/food-lines-have-begun-in-mendota.html?sp.

Gaquin and Ryan (Gaquin, Deirdre A. and Ryan, Mary Meghan). 2013. *2013 County and City Extra, Annual Metro, City, and County Data Book, 21st Edition*. Bertram Press.

Hoopa Valley Tribe. 2014a. *Health & Social Services*. Site accessed November 8, 2014. http://www.hoopa-nsn.gov/departments/health-social-services

Hoopa Valley Tribe. 2014b. *Temporary Assistance for Needy Families (TANF)*. Site accessed November 8, 2014. http://www.hoopa-nsn.gov/HoopaTANF

JCSD et al. (Jurupa Community Services District, City of Ontario, Western Municipal Water District). 2010. *Chino Desalter Phase 3*. December.

KRCD (Kings River Conservation District). 2012. *Sustainable Groundwater Management through an Integrated Regional Water Management Plan (IRWMP)*.

Los Angeles County (County of Los Angeles). 2013. *Press Release, LA County Flood Control District Tapped to Receive $28 Million State Flood Protection, Water Supply Grant*. October 3.

MORE (Mokelumne River Water & Power Authority). 2015. *Status and Timeline*. Site accessed January 14, 2015. http://www.morewater.org/about_project/status_timeline.html

MWDOC (Metropolitan Water District of Orange County). *Doheny Desalination Project*. Site accessed January 12, 2015. http://www.mwdoc.com/services/dohenydesalhome

MWDSC (Metropolitan Water District of Southern California). 2010. *Integrated Water Resources Plan, 2010 Update*. October.

NSJCGBA (Northeastern San Joaquin County Groundwater Banking Authority). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

NMFS (National Marine Fisheries Service). 2012a. *Yurok Tribe Fishery Socioeconomics Technical Report, For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. August 31.

NMFS (National Marine Fisheries Service). 2012b. *Hoopa Valley Tribe Fishery Socioeconomics Technical Report, For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. August 31.

NMFS (National Marine Fisheries Service). 2012c. *Karuk Tribe Fishery Socioeconomics Technical Report, For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. August 31.

NMFS (National Marine Fisheries Service). 2012d. *Resighini Rancheria Fishery Socioeconomics Technical Report, For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. August 31.

OMWD (Olivenhain Municipal Water District). 2015. North County Recycled Water Project on Track to Receive Millions More in State Grant Funds. Site accessed February 16, 2015. http://www.olivenhain.com/component/content/article/3-news/236-north-county-recycled-water-project-on-track-to-receive-millions-more-state-grant-funds.

PWD (Palmdale Water District). 2010. *Strategic Water Resources Plan, Final Report*. March.

RCWD (Rancho California Water District). 2011. *2010 Urban Water Management Plan Update*. June 30.

RCWD (Rancho California Water District). 2012. *Agricultural Water Management Plan*. December 13.

Reclamation (Bureau of Reclamation). 2011. *Record of Decision Madera Irrigation District Water Supply Enhancement Project*. July.

Reclamation (Bureau of Reclamation). 2013. *Shasta Lake Water Resources Investigation Draft Environmental Impact Statement*. June.

Reclamation (Bureau of Reclamation). 2014a. *Upper San Joaquin River Basin Storage Investigation, Draft Environmental Impact Statement*. August.

Reclamation (Bureau of Reclamation). 2014b. *Spring Creek Debris Dam and Powerplant*. Site accessed September 19, 2014. http://www.usbr.gov/mp/headlines/2014/June/Photo_of_the_Week6-16-14.pdf.

Reclamation (Bureau of Reclamation). 2014c. *Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report, Public Draft*. September.

Reclamation, CCWD, and Western (Bureau of Reclamation, Contra Costa Water District, and Western Area Power Administration). 2010. *Los Vaqueros Expansion Project, Environmental Impact Statement and Environmental Impact Report*. March.

SDCWA (San Diego County Water Authority). 2009. *Camp Pendleton Seawater Desalination Project Feasibility Study*. December.

SDCWA (San Diego County Water Authority). 2015. *Seawater Desalination*. Site accessed January 12, 2015. http://www.sdcwa.org/seawater-desalination

SEWD (Stockton East Water District). 2012. *Farmington Groundwater Recharge Program*. Site accessed November 30, 2012. http://www.farmingtonprogram.org/index.html

SJRECWA (San Joaquin River Exchange Contractors Water Authority). 2012. *Los Banos Creek Water Restoration Management Plan, Attachment 4 – Project Description*.

SJRRP (San Joaquin River Restoration Program). 2011a. *Draft Program Environmental Impact Statement/Environmental Impact Report*. April.

SJRRP (San Joaquin River Restoration Program). 2011b. *Friant-Kern Canal Capacity Restoration, Draft*. June.

SJRRP (San Joaquin River Restoration Program). 2015. *Madera Canal Capacity Restoration Project*. Site accessed February 21, 2015. http://restoresjr.net/activities/site_specific/madera-canal/index.html

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. December 13.

SWRCB (State Water Resources Control Board). 2013. *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, DRAFT Bay-Delta Plan Workshops Summary Report*. January

U.S. Census (U.S. Census Bureau). 2013a. *2010 Census of Population, American Fact Finder–Summary File 1, DEC_10_DPDP1, Profile of General Population and Housing Characteristics: 2010*. Site accessed February 17, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2013b. *2006–2010 American Community Survey S1701*. Site accessed February 17, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2013c. *2000 Census of Population, American Fact Finder – Summary File 1, DEC_00_SF1_P007*. Site accessed April 23, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2013d. *2000 Census of Population, American Fact Finder – Summary File 1, DEC_00_SF1_P008*. Site accessed May 16, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census Bureau. 2013e. *2000 Census of Population, American Fact Finder – DEC_00_SF3-P088*. Site accessed May 16, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census Bureau. 2013f. *2000 Census of Population, American Fact Finder – DEC_00_SF1_DP1*. Site accessed May 16, 2013. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014a. *2010 Census of Population, American Fact Finder – QT-P3, Summary File 1, Tables P5, P8, PCT4, PCT5, PCT8*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014b. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Trinity County*. Site accessed November 2, http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014c. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Humboldt County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014d. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Del Norte County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014e. *2006–2010 American Community Survey, S1701*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014f. *2006–2010 American Community Survey B16001, Language Spoken at Home by Ability to Speak English for the Population 5 Years and Older*. Site accessed November 10, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?ref=geo&refresh=t&tab=map&src=bkmk#none

U.S. Census (U.S. Census Bureau). 2014g. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Shasta County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014h. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Plumas County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014i. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Tehama County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014j. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Glenn County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014k. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Colusa County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014l. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Butte County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014m. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Yuba County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014n. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Nevada County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014o. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Sutter County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014p. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Placer County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014q. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, El Dorado County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014r. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Stanislaus County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014s. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Madera County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014t. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Merced County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014u. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Fresno County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014v. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Tulare County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014w. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Kings County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014x. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Kern County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014y. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Sacramento County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014z. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Yolo County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014aa. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Solano County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ab. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, San Joaquin County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ac. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Contra Costa County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ad. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Alameda County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ae. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Santa Clara County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014af. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, San Benito County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ag. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Napa County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ah. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, San Luis Obispo County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ai. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Santa Barbara County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014aj. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Ventura County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ak. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Los Angeles County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014al. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Orange County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014am. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, San Diego County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014an. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, Riverside County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census (U.S. Census Bureau). 2014ao. *American Fact Finder – QT-P4, Race, Combinations of Two Races, and Not Hispanic or Latino:2010, 2010 Census Summary File 1, San Bernardino County*. Site accessed November 2, 2014. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

USDA (U.S. Department of Agriculture). 2014a. *Obama Administration Announces Additional Assistance to Californians Impacted by Drought, USDA News Release*. Site accessed November 8, 2014. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/releases/?cid=STELPRDB1245732.

USDA (U.S. Department of Agriculture). 2014b. *Eligibility Manual for School Meals – Determining and Verifying Eligibility*. August.

USDHS (U.S. Department of Homeland Security). 2014. *Emergency Food and Shelter National Board Program*. Site accessed February 24, 2014. https://www.cfda.gov/index?s=program&mode=form&tab=step1&id=cec77944502140249a87acf6de1332c2.

USGVMWD (Upper San Gabriel Valley Municipal Water District). 2013. *Integrated Resources Plan*. January.

WBMWD (Western Basin Municipal Water District). 2011. *Edward C. Little Water Recycling Facility Phase V Expansion, Initial Study/Mitigated Negative Declaration*. March.

WBMWD (West Basin Municipal Water District). 2015a. *Water Recycling Satellite Facilities*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/recycled-water/satellite-facilities

WBMWD (West Basin Municipal Water District). 2015b. *Ocean Water Desalination*. Site accessed January 12, 2015. http://www.westbasin.org/water-reliability-2020/ocean-water-desalination/overview

Yurok Tribe. 2014a. *The Yurok Tribe, Background Information*. Site accessed November 2, 2014. http://www.yuroktribe.org/culture/history/history.html.

Yurok Tribe. 2014b. *Welcome to Yurok Social Services Department*. Site accessed: November 7, 2014. http://www.yuroktribe.org/departments/socialservices/socialservices.htm.

This page left blank intentionally.

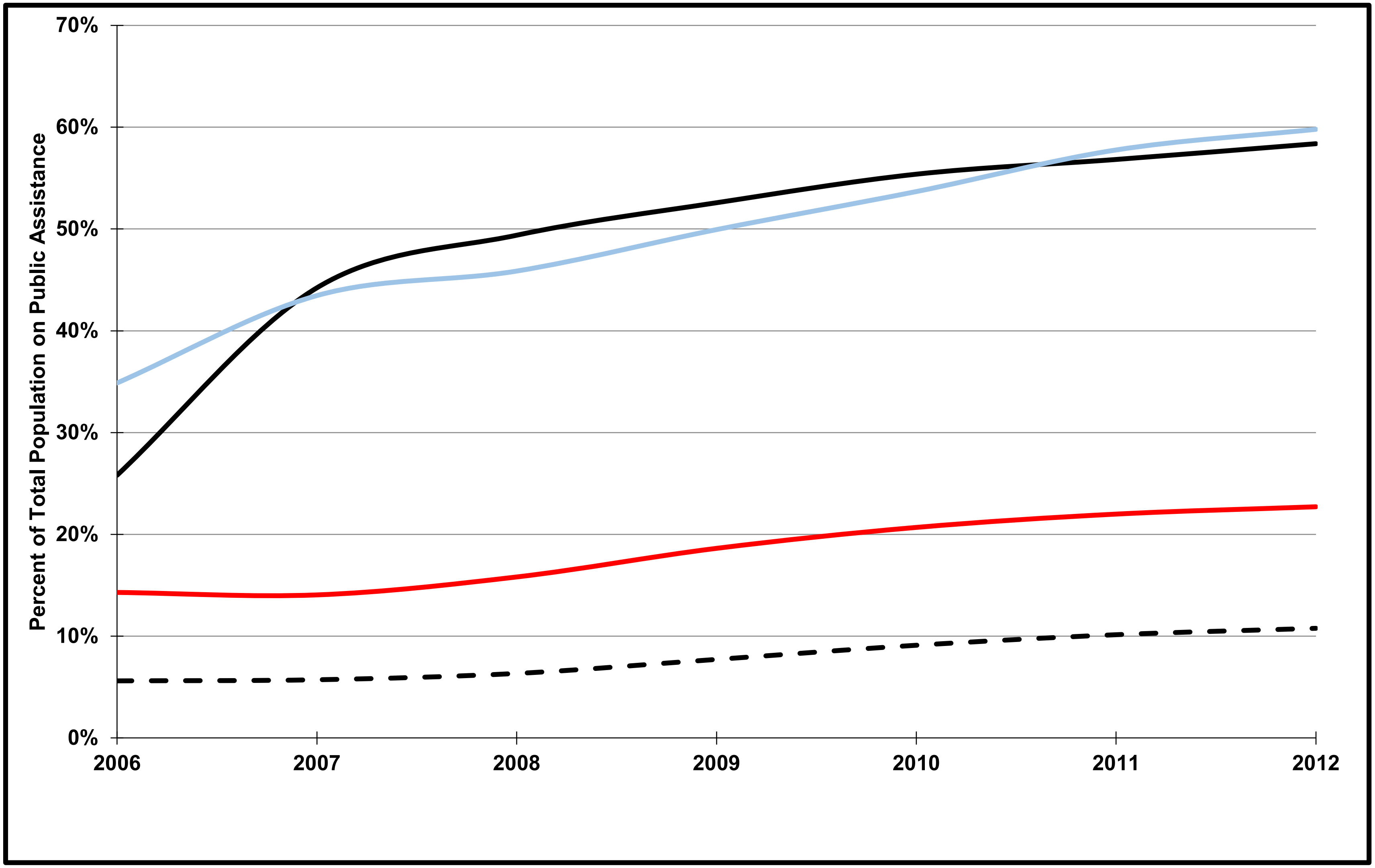



**Figure 21.1 Population on CalFresh Program and CalWORKs Program in Huron and Mendota in 2006 through 2012**

**Source: CDSS 2008a –2008y, 2009a – 2009n, 2012a -2012a, 2013a – 2013i; Fresno County 2013**

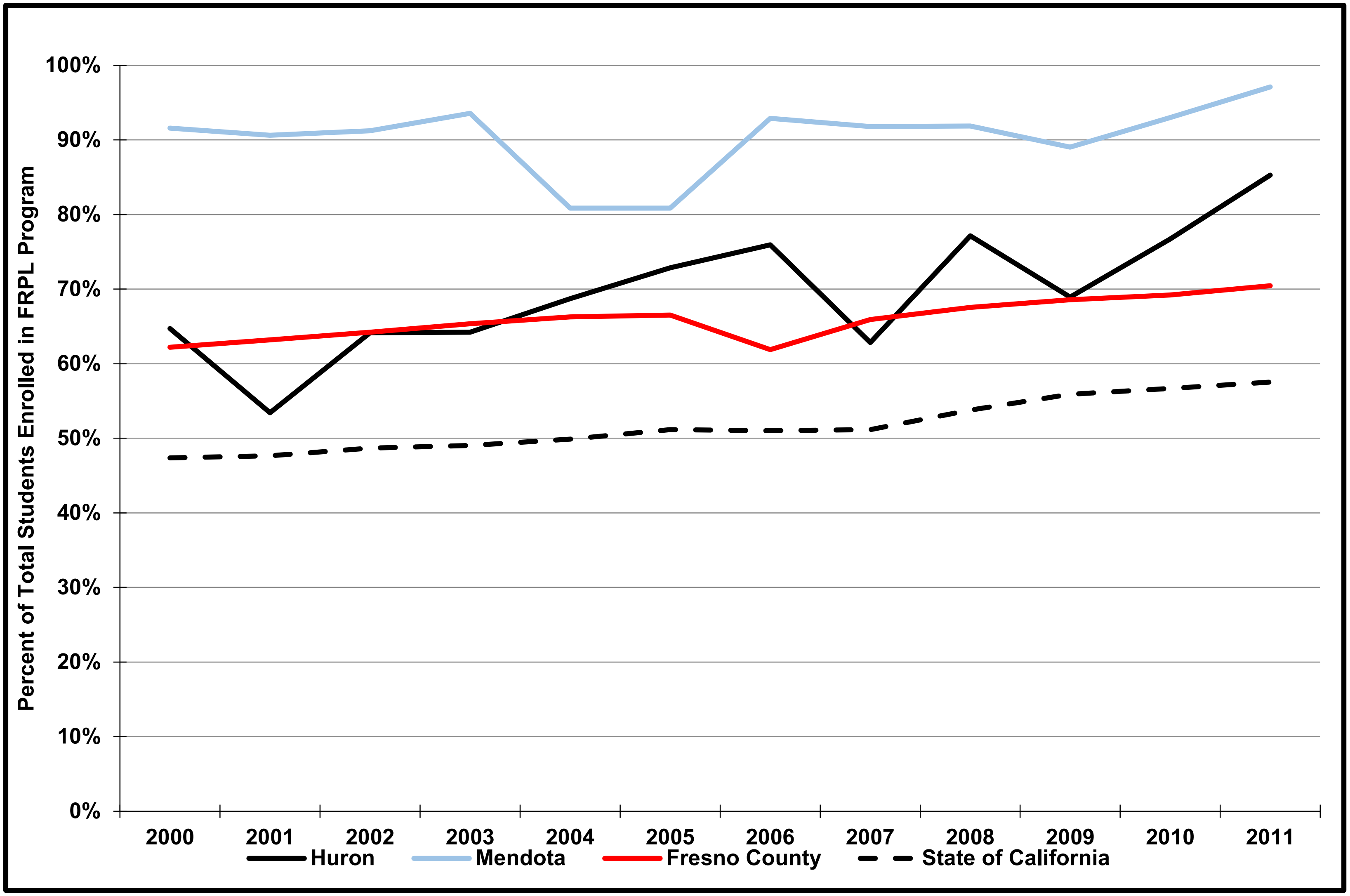



**Figure 21.2 Enrollment in Free or Reduced Price Meals Program in Huron and Mendota in 2000 through 2011**

**Source: CDE 2013**

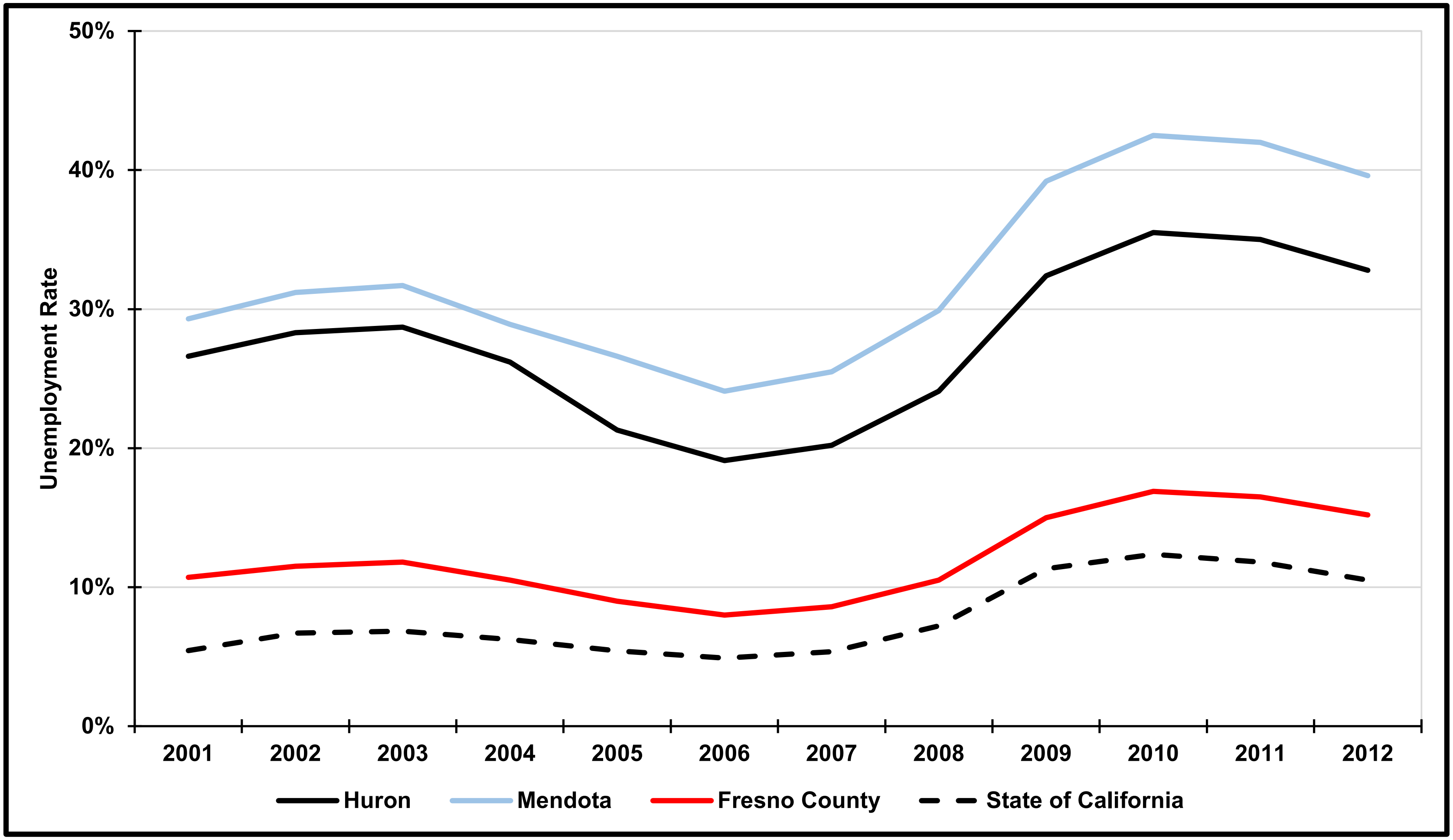



**Figure 21.3 Unemployment in Huron and Mendota in 2001 through 2012**

**Source: BLS 2014; CEDD 2014**

This page left blank intentionally.

**Chapter 22**

# Other NEPA Requirements

## 22.1 Introduction

In addition to the factors described in Chapters 5 through 21, the National Environmental Policy Act (NEPA) requires consideration of the relationship of short-term uses and long-term productivity, consideration of irreversible and irretrievable commitments of resources, and growth-inducing impacts as compared to the No Action Alternative (40 Code of Federal Regulations [CFR] 1508.8). These considerations are described in the following sections of this chapter.

## 22.2 Relationship between Short-term Uses and Long-term Productivity

NEPA requires that an Environmental Impact Statement (EIS) prepared by Federal agencies disclose "…the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity…" (40 CFR 1502.16). As discussed in Chapter 1, Introduction, this EIS evaluates long-term potential direct, indirect, and cumulative impacts on the environment that could result from implementation of alternatives for the continued long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) and implementation of ecosystem restoration. This EIS does not evaluate short-term impacts related to implementing project-specific actions, such as impacts during construction and/or start-up periods for actions that are not fully defined at this time and that may be implemented by Reclamation or other agencies as part of the alternatives. It is recognized that numerous projects would be planned, designed, and constructed under the No Action Alternative and the Second Basis of Comparison, including tidal wetlands and floodplain restoration, as described in Chapter 3, Description of Alternatives. It also recognized that facilities to implement fish passage at CVP reservoirs would be implemented under the No Action Alternative and Alternative 5; and facilities to implement a trap and haul program for steelhead from the San Joaquin River under Alternative 4. Project-specific construction impacts would be addressed in project-specific environmental documents prepared at the time the projects are proposed for approval. At this time, however, the need for, and the nature, magnitude, and extent of specific impacts are not known.

Potential long-term effects (beneficial and adverse) of implementation of Alternatives 1 through 5 as compared to the No Action Alternative with respect to each environmental resource are summarized in Table 22.1.

There would be no long-term effects related to geology and soils resources, agricultural resources, land use, cultural resources, and Indian Trust Assets because the conditions under Alternatives 1 through 5 would be similar to conditions under the No Action Alternative and to the Second Basis of Comparison.

A complete listing of the effects of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and to the Second Basis of Comparison are included Chapter 3, Description of Alternatives.

**Table 22.1 Long-term Effects of Implementation of the No Action Alternative and Alternatives 1 through 5**

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| **Surface Water** | |
| Trinity Lake | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternatives 1, 3, and 4 is higher than under Alternatives 2 and 5 and the No Action Alternative. |
| Trinity River at Lewiston Dam | Flows similar or higher in November-December under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Similar flows in other months. |
| Shasta Lake | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternatives 1, 3, and 4 is higher than under Alternatives 2 and 5 and the No Action Alternative. |
| Sacramento River at Keswick Dam | Flows similar or higher in December-August under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Flows higher in September-November under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Sacramento River at Freeport | Flows similar or higher under Alternatives 1 and 4 than under Alternative 3; and flows higher under Alternative 3 than under Alternatives 2 and 5 and the No Action Alternative in May-June.<br>Flows higher in July-December under Alternatives 2 and 5 and the No Action Alternative than under Alternative 3; and flows higher under Alternative 3 than under Alternatives 1 and 4. |
| Clear Creek near Igo | Flows are similar under Alternatives 1 through 5 and the No Action Alternative in June-April.<br>Flows under Alternatives 2 and 5 and the No Action Alternative are higher in May than under Alternatives 1, 3, and 4. |
| Lake Oroville | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternatives 1, 3, and 4 is higher than under Alternatives 2 and 5 and the No Action Alternative. |
| Feather River downstream of Thermalito Complex | Flows under Alternatives 1, 3, and 4 similar or higher than under Alternatives 2 and 5 and the No Action Alternative. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| Folsom Lake | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternatives 1, 3, and 4 is higher in October-January than under Alternatives 2 and 5 and the No Action Alternative.<br>Storage under Alternatives 2 and 5 and the No Action Alternative are higher in August-September than under Alternatives 1, 3, and 4.<br>Storage similar under February-July in Alternatives 1 through 5 and the No Action Alternative. |
| American River at Nimbus Dam | Flows under Alternatives 1, 3, and 4 similar or higher than under Alternatives 2 and 5 and the No Action Alternative. |
| New Melones Reservoir | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternative 3 is higher than under Alternatives 1 and 4; and storage under Alternatives 1 and 4 are higher than under Alternatives 2 and 5 and the No Action Alternative. |
| Stanislaus River at Goodwin Dam | Flows higher under Alternatives 1 and 4 than under Alternative 3; and flows under Alternative 3 are higher than under Alternative 5 and the No Action Alternative.<br>Flows under Alternative 5 higher than under the No Action Alternative in April-May. |
| San Joaquin River at Vernalis | Flows higher in October under the Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4.<br>Flows higher in April under Alternative 5 than under all other alternatives.<br>Flows higher in May under Alternatives 1 and 4 than under Alternatives 3 and 5 and the No Action Alternative.<br>Flows similar during other months. |
| San Luis Reservoir | Water surface elevations similar in Alternatives 1 through 5 and the No Action Alternative.<br>Storage under Alternatives 1 and 4 higher than under Alternative 3; and storage under Alternatives 2 and 5 and the No Action Alternative.<br>Storage under Alternatives 2 and the No Action Alternative higher than under Alternative 5 in dry and critical dry years. |
| Flows into Yolo Bypass | Flows entering the Yolo Bypass at Fremont Weir higher under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative. |
| Delta Outflow | Delta outflow higher under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Reverse Flows in Old and Middle Rivers | Old and Middle River flows in April-May more positive under Alternative 5 than under Alternative 2 and the No Action Alternative.<br>Old and Middle River flows in July more positive under Alternatives 1 and 4 than under Alternative 3; and under Alternative 3 than under Alternatives 2 and 5 and the No Action Alternative.<br>Old and Middle River flows in other months higher under Alternatives 2 and 5 and the No Action Alternative than Alternative 3; and higher under Alternative 3 than under Alternatives 1 and 4. |
| **Water Supplies** | |
| Non-CVP and Non-SWP Deliveries | Water deliveries under Alternatives 1 through 5 and the No Action Alternative. |
| CVP Water Deliveries | Water deliveries higher under Alternatives 1 and 4 than under Alternative 3; and higher under Alternative 3 than under Alternatives 2 and 5 and the No Action Alternative. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| SWP Water Deliveries | Water deliveries higher under Alternatives 1 and 4 than under Alternative 3; and higher under Alternative 3 than under Alternatives 2 and 5 and the No Action Alternative. |
| **Surface Water Quality** | |
| Salinity in Northern Delta (near Emmaton) | Salinity in September-January under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Salinity in February-August under Alternatives 2 and 5 and the No Action Alternative higher than under Alternatives 1, 3, and 4. |
| Salinity in Western Delta (near Port Chicago) | Salinity in September-January under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Salinity in February-August under Alternatives 2 and 5 and the No Action Alternative higher than under Alternatives 1, 3, and 4. |
| Salinity in Western Central Delta (near Antioch) | Salinity in September-January under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Salinity in February-August under Alternatives 2 and 5 and the No Action Alternative higher than under Alternatives 1, 3, and 4. |
| Salinity in Western Central Delta (near Contra Costa Water District Intakes) | Salinity in September-January under Alternatives 1, 3, and 4 than under Alternatives 2 and 5 and the No Action Alternative.<br>Salinity in February-August under Alternatives 2 and 5 and the No Action Alternative higher than under Alternatives 1, 3, and 4. |
| Salinity in Southern Delta (near CVP and SWP intakes) | Salinity under Alternatives 1 and 4 higher than under Alternative 3; and salinity under Alternative 3 higher than under Alternatives 2 and 5 and the No Action Alternative. |
| Mercury in Delta Fish | Mercury concentrations in fish tissue of large fish in the Delta used for human consumption would exceed guidelines established by the State of California under Alternatives 1 through 5 and the No Action Alternative.<br>In the interior Delta along the San Joaquin River and at the CVP Contra Costa Canal Pumping Plant, mercury concentrations in the tissue of large fish used for human consumption would be the higher under Alternative 5 than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternative 2 and the No Action Alternative. Mercury under Alternative 2 and the No Action Alternative would be higher than under Alternatives 1 and 4.<br>Near Suisun Marsh and Cache Slough, mercury concentrations would be higher under Alternative 2 and the No Action Alternative than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5; and concentrations under Alternative 5 would be higher than under Alternative 3.<br>Along Old River near Clifton Court, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 5. Mercury under Alternative 5 would be higher than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4.<br>Near the CVP Jones Pumping Plant intake, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5. |
| Selenium in Delta and Delta Fish | Selenium concentrations similar under Alternatives 1 through 5 and the No Action Alternative. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| **Groundwater Resources** | |
| Trinity River Region | Similar groundwater conditions under Alternatives 1 through 5 and the No Action Alternative. |
| Central Valley Region: Sacramento Valley | Similar groundwater conditions under Alternatives 1 through 5 and the No Action Alternative. |
| Central Valley Region: San Joaquin Valley | Groundwater pumping would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Pumping would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Pumping would be higher under Alternative 3 than under Alternatives 1 and 4. Increased groundwater pumping would result in lower groundwater elevations and increased subsidence potential. |
| San Francisco Bay Area, Central Coast, and Southern California Region | Groundwater pumping would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Pumping would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Pumping would be higher under Alternative 3 than under Alternatives 1 and 4. Increased groundwater pumping would result in lower groundwater elevations and increased subsidence potential. |
| **CVP and SWP Energy Resources** | |
| Energy Generated and Used by CVP and SWP Water Users | CVP net energy generation would be higher under Alternative 2 and the No Action Alternative than under Alternatives 1 and 4. Net energy generation would be higher under Alternatives 1 and 4 than under Alternative 3. Net energy generation would be higher under Alternative 3 than under Alternative 5.<br>SWP net energy generation would be higher under Alternative 2 and the No Action Alternative than under Alternative 5. Net energy generation would be higher under Alternative 5 than under Alternative 3. Net energy generation would be higher under Alternative 3 than under Alternatives 1 and 4.<br>Energy use by CVP and SWP water users for alternative water supplies would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Energy use would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Energy use would be higher under Alternative 3 than under Alternatives 1 and 4. |
| **Aquatic Resources** | |
| Trinity River: Coho Salmon | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Spring-run Chinook Salmon | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Fall-run Chinook Salmon | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Steelhead | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Green Sturgeon | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity Lake and Lewiston Reservoir: Reservoir Fish | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Pacific Lamprey | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Trinity River: Eulachon | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| Sacramento River System: Winter-run Chinook Salmon | Habitat conditions would be better under Alternative 5 and the No Action Alternative than under Alternative 2. Conditions under Alternative 2 would be better than under Alternatives 3 and 4. Conditions under Alternative 3 and 4 would be better than under Alternative 1. |
| Sacramento River System: Spring-run Chinook Salmon | Habitat conditions would be better under Alternative 5 and the No Action Alternative than under Alternative 2. Conditions under Alternative 2 would be better than under Alternatives 3 and 4. Conditions under Alternative 3 and 4 would be better than under Alternative 1. |
| Sacramento River System: Fall-run Chinook Salmon | Habitat conditions under Alternatives 1, 3, 4, and 5 and the No Action Alternative would be better than under Alternative 2. |
| Sacramento River System: Late Fall-run Chinook Salmon | Habitat conditions under Alternatives 1, 3, 4, and 5 and the No Action Alternative would be better than under Alternative 2. |
| Sacramento River System: Steelhead | Habitat conditions would be better under Alternative 5 and the No Action Alternative than under Alternative 2. Conditions under Alternative 2 would be better than under Alternatives 3 and 4. Conditions under Alternative 3 and 4 would be better than under Alternative 1. |
| Sacramento River System: Green Sturgeon and White Sturgeon | Habitat conditions would be better under Alternative 3 than under Alternatives 1 and 4. Conditions under Alternative 4 would be better than under Alternatives 2 and 5 and the No Action Alternative. |
| Delta: Delta Smelt | Habitat conditions would better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Delta: Longfin Smelt | Habitat conditions would better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Delta: Sacramento Splittail | Habitat conditions would better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Sacramento River System: Reservoir Fish | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Sacramento River System: Pacific Lamprey | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Sacramento River System: Striped Bass, American Shad, and Hardhead | Habitat conditions for Hardhead and American Shad would be similar under Alternatives 1 through 5 and the No Action Alternative.<br>Habitat conditions for Striped Bass would better under Alternatives 1, 2, and 5 and the No Action Alternative than under Alternatives 3 and 4 due to increased harvest limits. |
| Stanislaus River: Fall-run Chinook Salmon | Habitat conditions better under Alternatives 3 and 4 than under Alternatives 1, 2, and 5 and the No Action Alternative. |
| Stanislaus River: Steelhead | Habitat conditions better under Alternative 5 and the No Action Alternative than under Alternatives 3 and 4. Conditions under Alternatives 3 and 4 are better than under Alternatives 1 and 2. |
| Stanislaus River: White Sturgeon | Habitat conditions better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| New Melones Reservoir; Reservoir Fish | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Stanislaus River: Other Fish | Habitat conditions for Hardhead and American Shad would be similar under Alternatives 1 through 5 and the No Action Alternative.<br>Habitat conditions for Striped Bass would better under Alternatives 1, 2, and 5 and the No Action Alternative than under Alternatives 3 and 4 due to increased harvest limits. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| Pacific Ocean: Killer Whale | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Terrestrial Resources** | |
| Terrestrial Resources along Shoreline of CVP and SWP Reservoirs | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Terrestrial Resources along Rivers Downstream of CVP and SWP Reservoirs | Habitat conditions along Trinity, Sacramento, American, and Feather rivers would be similar under Alternatives 1 through 5 and the No Action Alternative.<br>Habitat conditions along the Stanislaus River would be better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| Terrestrial Resources in Yolo Bypass | Habitat conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Terrestrial Resources in Western Delta | Freshwater habitat in the western Delta would be better under Alternatives 2 and 5 and the No Action Alternative than under Alternatives 1, 3, and 4. |
| **Geology and Soils Resources** | |
| Geology and Soils Resources | Geology and soils conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Agricultural Resources** | |
| Agricultural Production and Employment | Agricultural production and employment conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Land Use** | |
| Municipal and Industrial Land Use | Municipal and industrial land use conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Visual Resources** | |
| Visual Resources of Land Irrigated with CVP and SWP Water | Visual resource conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Visual Resources at Reservoirs that Store CVP and SWP Water | Visual resource conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Recreation Resources** | |
| Recreation Resources at Reservoirs that Store CVP and SWP Water | Recreational resource conditions at the reservoirs would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Recreation Resources in Rivers downstream of CVP and SWP Reservoirs | Recreational resource conditions at the along the rivers would be similar under Alternatives 1 through 5 and the No Action Alternative.<br>Recreational resource conditions related to Striped Bass fishing and sport ocean salmon fishing would be better under Alternatives 1, 2, and 5 and the No Action Alternative than under Alternatives 3 and 4 due to increased harvest limitations. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| **Air Quality and Greenhouse Gas Emissions** | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | In the San Joaquin Valley and the San Francisco Bay Area, Central Coast, and Southern California regions, potential emissions from diesel engines used for groundwater pumping would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Emissions would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Emissions would be higher under Alternative 3 than under Alternatives 1 and 4. |
| Increased Greenhouse Gas Emissions (GHG) due to Changes in Energy Resources Related to CVP and SWP Water Use | Overall changes are not known at this time due to complexity of energy demands associated with alternative water supplies. However, GHG emissions could increase due to energy use related to alternative water supplies. Energy use by CVP and SWP water users for alternative water supplies would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Energy use would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Energy use would be higher under Alternative 3 than under Alternatives 1 and 4. |
| **Cultural Resources** | |
| Potential for Disturbance of Cultural Resources | Cultural resource conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Public Health** | |
| Water Supply Availability for Wildland Firefighting | Water supply conditions for fighting wildland firefighting would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Potential Exposure to Mercury in Fish in Delta | Mercury concentrations in fish tissue of large fish in the Delta used for human consumption would exceed guidelines established by the State of California under Alternatives 1 through 5 and the No Action Alternative.<br>In the interior Delta along the San Joaquin River and at the CVP Contra Costa Canal Pumping Plant, mercury concentrations in the tissue of large fish used for human consumption would be the higher under Alternative 5 than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternative 2 and the No Action Alternative. Mercury under Alternative 2 and the No Action Alternative would be higher than under Alternatives 1 and 4.<br>Near Suisun Marsh and Cache Slough, mercury concentrations would be higher under Alternative 2 and the No Action Alternative than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5; and concentrations under Alternative 5 would be higher than under Alternative 3.<br>Along Old River near Clifton Court, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 5. Mercury under Alternative 5 would be higher than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4.<br>Near the CVP Jones Pumping Plant intake, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5. |
| **Socioeconomics** | |
| Agricultural and Municipal and Industrial Employment | Agricultural, municipal, and industrial employment would be similar under Alternatives 1 through 5 and the No Action Alternative. |

| Environmental Resources | Comparison of Alternatives 1 through 5 and the No Action Alternative |
|---|---|
| Municipal and Industrial Water Supply Operating Expenses | Municipal and industrial water supply operating expenses would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Recreational Economics CVP and SWP Reservoirs | Recreational economic conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| Recreational Economics Related to Striped Bass Fishing in Delta | Recreational economic conditions related to Striped Bass fishing would be better under Alternatives 1, 2, and 5 and the No Action Alternative than under Alternatives 3 and 4 due to changes in harvest limitations. |
| Commercial and Sport Ocean Salmon Fishing | Recreational economic conditions related to commercial and sport ocean salmon fishing would be better under Alternatives 1, 2, and 5 and the No Action Alternative than under Alternatives 3 and 4 due to changes in harvest limitations. |
| **Indian Trust Assets** | |
| Potential for Disturbance of Indian Trust Assets | Indian Trust Asset conditions would be similar under Alternatives 1 through 5 and the No Action Alternative. |
| **Environmental Justice** | |
| Emissions of Criteria Air Pollutants and Precursors and/or Exposure of Sensitive Receptors to Substantial Concentrations of Air Contaminants from Diesel Engines at Groundwater Wells | In the San Joaquin Valley, potential emissions from diesel engines used for groundwater pumping would be higher under Alternative 5 than under Alternative 2 and the No Action Alternative. Emissions would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Emissions would be higher under Alternative 3 than under Alternatives 1 and 4. |
| Potential Exposure to Mercury in Fish in Delta | Mercury concentrations in fish tissue of large fish in the Delta used for human consumption would exceed guidelines established by the State of California under Alternatives 1 through 5 and the No Action Alternative.<br>In the interior Delta along the San Joaquin River and at the CVP Contra Costa Canal Pumping Plant, mercury concentrations in the tissue of large fish used for human consumption would be the higher under Alternative 5 than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternative 2 and the No Action Alternative. Mercury under Alternative 2 and the No Action Alternative would be higher than under Alternatives 1 and 4.<br>Near Suisun Marsh and Cache Slough, mercury concentrations would be higher under Alternative 2 and the No Action Alternative than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5; and concentrations under Alternative 5 would be higher than under Alternative 3.<br>Along Old River near Clifton Court, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 5. Mercury under Alternative 5 would be higher than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4.<br>Near the CVP Jones Pumping Plant intake, mercury concentrations in the tissue of large fish used for human consumption would be higher under Alternative 2 and the No Action Alternative than under Alternative 3. Mercury under Alternative 3 would be higher than under Alternatives 1 and 4. Mercury under Alternatives 1 and 4 would be higher than under Alternative 5. |

## 22.3 Irreversible and Irretrievable Commitments of Resources

NEPA requires that an EIS prepared by Federal agencies disclose "…any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented…" (40 CFR 1502.16). An irreversible and irretrievable commitment of resources includes use of natural or depletable resources, including consumption of construction materials and nonrenewable energy sources, and permanent conversion of land uses or habitat.

As described in Chapter 3, Description of Alternatives, there are several ongoing projects that are assumed to be implemented by 2030, such as Grasslands Bypass Project which is currently under construction. It is assumed that these projects would be included in the No Action Alternative, all other alternatives, and Second Basis of Comparison. The 2030 conditions assume the projected long-term conditions for each ongoing project as described in their respective environmental documents. This analysis does not address the construction activities of each ongoing project because those impacts were addressed in separate environmental documents for each project.

The alternatives include several future actions that would require construction, such as implementation of tidal wetlands and floodplains, fish passage facilities, or temperature control devices at CVP dams. Specific details for location and construction of these future projects are not identified at this time and are not addressed in this EIS. Future environmental documents would be prepared to analyze potential environmental consequences related to specific construction and operations. This EIS analyzes implementation of the alternatives with the assumption that these projects would be implemented by 2030; however, this EIS does not address irreversible and irretrievable commitment of resources associated with consumption of construction materials and permanent conversion of land uses or habitat.

Changes in nonrenewable energy resources would occur through implementation of the No Action Alternative and Alternatives 1 through 5. Under the alternatives, energy would be generated by CVP and SWP operations and used to convey water in CVP and SWP facilities. As discussed in Chapter 8, Energy, changes in CVP and SWP energy generation and use would result in the ability to provide additional energy for use by others or the need to purchase additional energy from others to operate the CVP and SWP facilities. Under both long-term average conditions and dry/critical dry water years, Alternative 5 would result in the least demand for electrical generation by others which would generally be produced using fossil fuels. The No Action Alternative and Alternative 2 would require more electrical generation by non-CVP and SWP facilities than Alternative 5; and less electrical generation than under Alternatives 1, 3, and 4. Alternative 1 would require the most electrical generation as compared to other alternatives.

## 22.4 Growth-Inducing Impacts

NEPA requires that an EIS prepared by Federal agencies evaluate indirect growth-inducing effects (40 CFR 1508.8). A project could result in growth-inducing impacts through several measures, including the removal of obstacles to population growth, or actions that encourage and facilitate other activities beyond those proposed by the project. The availability of adequate water supplies, employment opportunities, and improved cultural amenities are examples of actions that could be growth-inducing impacts. Growth inducement may or may not be detrimental, beneficial, or significant. However, if the induced growth impacted the environment, or the ability of agencies to provide public services to an extent not envisioned due to the project actions, the impacts would be considered to be adverse.

As described in Chapter 13, Land Use, and Chapter 19, Socioeconomics, land use and growth projections are not anticipated to change under Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison. Municipal and industrial water users that use CVP and SWP water have prepared Urban Water Management Plans (UWMPs) that project water demand and future water supplies to meet the demands by 2030, including water conservation measures. Projects that had undergone environmental review, were under design, or under construction were considered to exist in 2030 water supply assumptions in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Future projects described in the UWMPs that are under evaluation are considered as options to increase fixed-yield supplies, including additional groundwater pumping, water transfers, recycling water treatment, and desalination water treatment. Existing and future water supplies considered for municipalities by 2030 are presented in Appendix 5B, Future Municipal Water Supplies for CVP and SWP Water Users. For smaller water users that are not addressed in a UWMP, information was obtained from water master plans and integrated regional water management plans. The analysis presented in Chapter 19, indicated that use of the existing and planned future projects would be adequate to meet the water demands in 2030 with or without the CVP and SWP water supply availability under the alternatives considered in this EIS.

Alternatives 1, 3, and 4 would result in higher CVP and SWP water deliveries than the No Action Alternative and Alternatives 2 and 5. However, the additional water supplies under Alternatives 1, 3, and 4 would result in less groundwater pumping and less water transfers which could result in less potential for groundwater overdraft and soil subsidence, and less potential impacts in the service area of the seller for the transfer water. None of the alternatives considered in this EIS would increase the total water supplies to meet 2030 water demands; and therefore, none of the alternatives considered in this EIS are considered to be growth inducing.

This page left blank intentionally.

Chapter 23

# Consultation and Coordination

## 23.1 Introduction

This chapter summarizes completed, ongoing, and anticipated public outreach and agency involvement efforts related to preparation of the Environmental Impact Statement (EIS) for the coordinated long-term operation of the Central Valley Project (CVP) and State Water Project (SWP).

## 23.2 Consultation with the Public and Interested Parties

Consultation activities were initiated in 2012 with the scoping process and continued through the preparation of the Final EIS. In this section, the term "interested parties" includes representatives from agencies, utilities, agencies, organizations, and other entities.

### 23.2.1 Scoping Process

As described in Chapters 1 and 3, the scoping process was initiated on March 28, 2012, with the publication of the Notice of Intent (NOI) in the Federal Register and continued through June 28, 2012. Initially the public scoping process was to be completed on May 29, 2012. During the public scoping process, other agencies and interested persons requested an extension of the public scoping process to allow additional opportunities to provide scoping comments. In response to these requests, U.S. Department of the Interior, Bureau of Reclamation (Reclamation) published a notice on May 25, 2012, to extend the public scoping period through June 28, 2012.

Scoping meetings were held to inform the public and interested stakeholders about the project, and to solicit comments and input on the EIS. The scoping meetings were held in the following locations and resulted in the following level of public participation:

- Madera, California on April 25, 2012 (6 participants)
- Diamond Bar, California on April 26, 2012 (3 participants)
- Sacramento, California on May 2, 2012 (15 participants)
- Marysville, California on May 3, 2012 (2 participants)
- Los Banos, California on May 22, 2012 (230 participants)

Reclamation posted the scoping notices in the Federal Register, on its website, and in newspapers that served areas where the scoping meetings were held. Reclamation also published press releases to news organizations and others that have requested notifications for all press releases.

Each participant in the scoping meetings was invited to sign an attendance sheet and provided with an agenda, fact sheet, comment card, and speaker card. The agenda, fact sheet, and comment card were available in both English and Spanish.

Each scoping meeting began with a presentation by Reclamation. The presentation described the purpose of the meeting and the public scoping process, an overview of the reasons that Reclamation was preparing the EIS, description of the process and schedule that Reclamation will use to complete the EIS, and methods to provide comments at the scoping meeting and subsequently until the end of the public scoping period. The participants were encouraged to submit written comments by mail, email, or fax until the close of the public scoping comment period. During the presentation, Reclamation responded to questions as they arose from the meeting participants. Following the presentation, Reclamation heard testimony from those who presented oral comments. Oral comments were recorded by a transcriber. Reclamation offered to provide Spanish translation of the presentation and oral comments at each scoping meeting; however, the translation service was only requested and provided at the scoping meeting in Los Banos, California.

The scoping comments included suggestions related to:

- Purpose and need for the action.
- Geographical extent of the Project Area.
- Definition and assumptions of the No Action Alternative.
- Definition and assumptions of the action alternatives.
- Important considerations either for description of the affected environment or for the methods of analyses for the following resources:
  - Water resources.
  - Biological resources.
  - Land use and socioeconomics.
  - Air quality.
  - Recreation and visual resources.

Scoping comments were used in the development of a reasonable range of alternatives and identification of key issues that would require analysis in the Environmental Consequences sections of this EIS, as described in Chapters 3.

Scoping comments also were used in development of the level of detail and methods of analyses for water resources, biological resources, land use, socioeconomics, recreation, air quality, and visual resources. These resources are discussed in Chapters 5 through 10, 12 through 17, and 19 through 21.

Reclamation also posted on its website an initial range of alternatives discussed at the meeting on October 19, 2012 of invited stakeholders. As described in Chapter 3, Description of Alternatives, comments received during that process were used to refine the description of the alternatives.

Project status meetings were held with cooperating agencies and other stakeholders during preparation of the Draft EIS, including meetings in Sacramento, California on January 16, May 29, and November 5, 2014; February 20, 2015; and June 24, 2015.

The scoping report is included in Appendix 23A, Scoping Report.

### 23.2.2 Other Activities

Reclamation established a website which includes the background material related to the purpose and need for the action, materials used in the scoping process, scoping comments, and information related to meetings with invited stakeholders and interest groups to discuss assumptions to be considered in the development of the No Action Alternative and action alternatives. As described in Chapter 3, comments received on the information posted on Reclamation's website during that process were used to refine the description of the alternatives.

### 23.2.3 Stakeholder and Public Involvement during Preparation of the Final EIS

The Draft EIS was published for public review in July 2015. The Notice of Availability was published by Reclamation in the Federal Register on July 31, 2015 (Federal Register, Vol 80, No. 147, 45681). A copy of the Notice of Availability is included in Appendix 23B, Public Review of Draft Environmental Impact Statement.

Newspaper advertisements providing the dates and locations of the public meetings for the Draft EIS were published in the following newspapers on the specified dates.

- Sacramento Bee, Sacramento, California – August 26, 2015
- Oakland Tribune, Oakland, California – August 26, 2015
- San Jose Mercury, San Jose, California – August 26, 2015
- Contra Costa Times, Walnut Creek, California – August 26, 2015
- Record Searchlight, Redding, California – August 27, 2015
- Los Banos Enterprise, Los Banos, California – August 28, 2015
- Fresno Bee, Fresno, California – September 1, 2015
- Los Angeles Times, California – September 3, 2015

The distribution list for the Draft EIS is included in Chapter 24, Environmental Impact Statement Distribution List. Reclamation posted notification of the availability of the Draft EIS and the location and timing of public meetings on its website and through press releases.

Four public meetings were held during the public review period for the Draft EIS in the following locations, with the following level of public participation:

- Sacramento, California on September 9, 2015 (9 participants)
- Red Bluff, California on September 10, 2015 (9 participants)
- Los Banos, California on Tuesday, September 15, 2015 (9 participants)
- Irvine, California on September 17, 2015 (2 participants)

The public meetings included an open house preceding a presentation by Reclamation. The open house portion of the meetings included several project information stations staffed by project team members available to respond to attendee's questions. The open house stations included:

- Welcome Station with display boards that described the public meeting format
- Purpose and Need of the Project
- Surface Water and Groundwater Resources
- Aquatic, Wildlife, and Botanical Resources
- Socioeconomics
- Comments with a court reporter to record verbal comments

Fact sheets were provided at each of the open house stations.

Following the open house portion of the public meeting, Reclamation staff led a brief presentation. The open house portion of the public meeting was resumed after the presentation.

Copies of the display boards, fact sheets, and the presentation are included in Appendix 23B, Public Review of Draft Environmental Impact Statement.

Only attendees at the meeting in Red Bluff chose to provide verbal comments to the court reporter. The transcript of those comments also is included in Appendix 23B. Responses to those comments are included in Appendix 1E.

Approximately 860 written and verbal comments were received on the Draft EIS. All of the comments received on the Draft EIS were considered in preparation of the Final EIS. Written responses to all substantial comments received are included in Appendices 1A through 1E of the Final EIS.

## 23.3 Consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Service

As described in Chapter 1, federal agencies also have an obligation pursuant to the Endangered Species Act (ESA) to "…ensure that any discretionary action authorized, funded, or carried out by such an agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification…" of such species' designated "critical habitat," "…unless such agency has been granted an exemption for such action…" by the Endangered Species Committee which the ESA creates (16 United States Code (U.S.C.) section 1536 (a)(2). A discretionary agency action jeopardizes the continued existence of a listed species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 Code of Federal Regulations [CFR] section 402.02). Such action results in the destruction or adverse modification of designated critical habitat if there is "… a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species" (50 CFR section 402.02).

In carrying out its obligations, Reclamation must consult with the appropriate regulatory agency or agencies (e.g., U.S. Fish and Wildlife Service [USFWS] and National Marine Fisheries Service [NMFS]). At the conclusion of this consultation process, those agencies render written statements (known as biological opinions) setting forth their opinion as to how an action being proposed by Reclamation would affect a listed species and its designated critical habitat. If these agencies conclude that an action will jeopardize the continued existence of a listed species or result in the destruction or adverse modification of their designated critical habitat, then they must suggest a reasonable and prudent alternative to the action being proposed by Reclamation.

Pursuant to ESA Section 7(a)(1), Reclamation also considers which it could take under its existing authorities to benefit listed species. However, Section 7(a)(1) does not give Reclamation additional authority to undertake any particular action, regardless of its potential benefit for threatened and endangered species.

The Fish and Wildlife Coordination Act requires that Reclamation consult with fish and wildlife agencies (federal and state) on all water development projects that could affect biological resources. As part of this project, Reclamation has been in continuous consultation with USFWS and NMFS. This continuous consultation also satisfies any applicable requirements of the Fish and Wildlife Coordination Act.

## 23.4 Consultation with Cooperating Agencies and Other Entities

In accordance with requirements of the National Environmental Policy Act (NEPA), Reclamation invited eligible governmental agencies to participate as a cooperating agency. The federal cooperating agencies include the USFWS, NMFS, U.S. Environmental Protection Agency (USEPA), U.S. Army Corps of Engineers (USACE), and Bureau of Indian Affairs (BIA).

Reclamation also provided non-federal agencies with the opportunity to participate in the NEPA process if they qualified under NEPA (as described above) as a cooperating agency. In August of 2012, Reclamation mailed invitations to 747 non-federal entities to be cooperating agencies for this EIS, including:

- California Department of Water Resources

- State Water Resources Control Board
- California Department of Fish and Wildlife
- Agencies that have contracts with the CVP or SWP for water delivery, water service repayment, exchange or settlement, or use of CVP or SWP facilities for conveyance
- State and Federal Contractors Water Agency
- Cities and counties within the CVP and SWP service areas
- Federally-recognized tribes within the CVP and SWP service area or areas affected by CVP or SWP operations

Non-federal entities that meet the specified criteria for cooperating agencies are required to enter into a Memorandum of Understanding (MOU) with Reclamation to memorialize their participation as a cooperating agency.

Reclamation has signed cooperating agency MOUs with the following entities:

- Anderson-Cottonwood Irrigation District
- California Department of Water Resources
- California Valley Miwok Tribe
- City of Hesperia
- Contra Costa Water District
- Friant Water Authority
- Glenn-Colusa Irrigation District
- Metropolitan Water District of Southern California
- Oakdale Irrigation District
- Reclamation District 108
- San Diego County Water Authority
- San Juan Water District
- San Luis & Delta-Mendota Water Authority
- Stockton East Water District
- Sutter Mutual Water District
- Tehama Colusa Canal Authority
- Zone 7 Water Agency

These agencies have participated in preliminary review of written materials that were used to prepare this Draft EIS.

Reclamation also received a request from an interested party to include the Federal Emergency Management Agency (FEMA) as a cooperating agency. However, Reclamation concluded that FEMA does not have special expertise related to environmental issue that would not be addressed by other cooperating federal agencies.

Reclamation also received a request from the State Water Contractors, a non-profit association of 27 public agencies from northern, central, and southern California that purchase water under contract from the SWP (SWC 2015).

However, Reclamation concluded that the State Water Contractors was not a public agency; and therefore, could not be cooperating agency. However, this group and several other non-profit groups (including the Natural Resources Defense Council and The Bay Institute) have participated in preliminary review of written materials that were used to prepare this Draft EIS.

## 23.5 Consultation with Other Federal, State, and Local Agencies

This EIS was prepared in accordance with policies and regulations adopted by federal and state agencies. Brief discussions of relevant policies and regulations for each resource are included in Appendix 4A, Federal and State Policies and Regulations. Reclamation considered the requirements of these policies and regulations during preparation of the EIS and consultation with the related agencies, including the major regulations summarized below.

### 23.5.1 Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act)

The Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), established the institutional structure for the U.S. Environmental Protection Agency (USEPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The Clean Water Act was further amended through the Clean Water Act of 1977 and the Water Quality Act of 1987. The California State Water Resources Control Board (SWRCB) has been designated by the USEPA along with the nine Regional Water Quality Control Boards (RWQCBs) to develop and enforce water quality objectives and implementation plans in California. The provisions of the Clean Water Act which affect water resources in the project area are described below.

- Section 401 of the Clean Water Act requires water discharges into navigable waters of the United States to apply for a Federal license or permit and to certify that the discharge will be in compliance with specified provisions of the Clean Water Act. Federal permits that are issued related to disturbance of waters of the United States (such as streams and wetlands) also require a Water Quality Certification in accordance with Clean Water Act section 401.

- Section 402 established the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source and non-point source discharges of pollutants into waters of the United States. An NPDES permit sets specific discharge limits for point and non-point sources discharging pollutants into waters of the United States and establishes monitoring and reporting requirements. The NPDES permits are issued for long-term discharges, including discharges from treatment plants, and temporary discharges, such as discharges during construction activities (e.g., General Permit for Storm Water Discharges Associated with Construction Activities).

- Section 404 requires the U.S. Army Corps of Engineers (USACE) to issue permits for discharge of dredge or fill material into navigable waters, their tributaries, and associated wetlands. Activities regulated by 404 permits include, but are not limited to, dredging, bridge construction, flood control actions, and some fishing operations.
- Section 303 requires preparation of basins plans. The SWRCB has approved water quality control plans (basin plans) for each watershed basin in the State. The basin plans designate the beneficial uses of waters within each watershed basin, and water quality objectives designed to protect those uses pursuant to Section 303 of the Clean Water Act. The beneficial uses together with the water quality objectives that are contained in the basin plans constitute State water quality standards.
- Under the CWA section 303(d), the SWRCB and USEPA identifies and ranks water bodies for which existing pollution controls are insufficient to attain or maintain water quality standards based upon information prepared by all states, territories, and authorized Indian tribes. Each state must establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for all impaired waters. TMDLs calculate the greatest pollutant load that a waterbody can receive and still meet water quality standards and designated beneficial uses.

### 23.5.2 Rivers and Harbors Act

The navigable waters of the United States in the Study Area, including the major rivers in Sacramento and San Joaquin rivers watersheds and waterways in these watersheds affected by tidal action, are subject to the requirements of the Rivers and Harbors Act. “Navigable waters of the United States” are defined as those waters subject to the ebb and flow of the tide shoreward to the mean high-water mark or those that are used, have been used in the past, or may be susceptible to use in interstate or foreign commerce. Sections 9 and 10 of the River and Harbors Act are applicable to the coordinated long-term operation of the CVP and SWP.

Under the reauthorization of the Rivers and Harbor Act of 1937, Reclamation took responsibility for the operation of the CVP.

#### *23.5.2.1 Section 9 of the Rivers and Harbors Act*

Section 9 of the Rivers and Harbors Act prohibits construction of any dike or dam across any navigable waters without approvals from the Chief of Engineers and the Secretary of the Army.

#### *23.5.2.2 Section 10 of the Rivers and Harbors Act*

Section 10 of the Rivers and Harbors Act of 1899 prohibits alterations of any navigable waters, including construction of structures in, over, or under; excavation of material from; and deposition of material into navigable waters of the United States without permission from the USACE. The approval process generally is completed simultaneously with the approval process under the Clean Water Act Section 404.

### 23.5.3 Federal Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) protects public health by regulating the nation's public drinking water supply. The SDWA authorizes USEPA to set national health-based standards for drinking water to protect against both naturally occurring and human-made contaminants that may be found in drinking water and its sources, including rivers, lakes, reservoirs, springs, and groundwater wells.

### 23.5.4 Wild and Scenic Rivers Act

Congress created the National Wild and Scenic Rivers Act in 1968 (Public Law 90-542; USC 1271 et seq.) to preserve rivers and outstanding natural, cultural, or recreational features in a free-flowing condition. High priority is place on visual resource management of these rivers to preserve or restore their scenic characteristics. Under this act, a Federal agency may not assist the construction of a water resources project that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a wild or scenic river. If the project would affect the free-flowing characteristics of a designated river or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area, such activities should be undertaken in a manner that would minimize adverse impacts and should be developed in consultation with the National Park Service.

Within the study area, the following portions of the rivers have been designated as Wild and Scenic Rivers.

- The Klamath River from the confluence with the Trinity River to the Pacific Ocean was designated to be part of the National Wild and Scenic Rivers System on January 19, 1981.
- The Middle Fork Feather River (from Beckwourth downstream of Lake Davis to Lake Oroville) was designated to be part of the National Wild and Scenic Rivers System on October 2, 1968.
- The American River between Nimbus Dam and the confluence with the Sacramento River was designated to be part of the National Wild and Scenic Rivers System on January 19, 1981.

### 23.5.5 Fish and Wildlife Coordination Act (16 USC Section 651 et seq.)

The Fish and Wildlife Coordination Act, as amended in 1964, was enacted to protect fish and wildlife when federal actions result in the control or modification of a natural stream or body of water. The statute requires federal agencies to take into consideration the effect that water-related projects would have on fish and wildlife resources. Consultation and coordination with USFWS and State fish and game agencies are required to address ways to prevent loss of and damage to fish and wildlife resources and to further develop and improve these resources.

### 23.5.6 Marine Mammal Protection Act (16 USC 1361-1421h)

The Marine Mammal Protection Act (MMPA) was enacted in 1972. All marine mammals are protected under the MMPA. The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. It defines "take" to mean "to hunt harass, capture, or kill" any marine mammal or attempt to do so. Exceptions to the moratorium can be made through permitting actions for take incidental to commercial fishing and other nonfishing activities; for scientific research; and for public display at licensed institutions such as aquaria and science centers.

### 23.5.7 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) implements a series of international treaties that provide migratory bird protection. The MBTA authorizes the Secretary of the Interior to regulate the taking of migratory birds, and the act provides that it shall be unlawful, except as permitted by regulations, "to pursue, take, or kill any migratory bird, or any part, nest or egg of any such bird" (16 USC section 703). This prohibition includes both direct and indirect acts, although harassment and habitat modification are not included unless they result in direct loss of birds, nests, or eggs. The current list of species protected by the MBTA was published in the March 10, 2010 *Federal Register* (*Federal Register*, Volume 75, page 9282 [75 FR 9282]).

### 23.5.8 Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds

Executive Order 13186 (January 10, 2001) directs federal agencies that have, or are likely to have, a measurable negative effect on migratory bird populations to develop and implement a Memorandum of Understanding with USFWS to promote the conservation of migratory bird populations. The Memorandum of Understanding should include implementation actions and reporting procedures that would be followed through each agency's formal planning process, such as resource management plans and fisheries management plans.

### 23.5.9 Executive Order 11990: Protection of Wetlands

Executive Order 11990 (May 24, 1977) established the protection of wetlands and riparian systems as the official policy of the federal government. It requires all federal agencies to consider wetland protection as an important part of their policies and take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

### 23.5.10 Federal Clean Air Act

National air quality policies are regulated through the Federal Clean Air Act (FCAA) of 1970 and its 1977 and 1990 amendments. Basic elements of the FCAA include national ambient air quality standards for criteria air pollutants, hazardous air pollutants standards, state attainment plans, motor vehicle emissions standards, stationary source emissions standards and permits, acid rain control measures, stratospheric ozone protection, and enforcement provisions.

### 23.5.11 National Historic Preservation Act of 1966

Section 106 of the NHPA and its implementing regulations (36 Code of Federal Regulations (CFR) Part 800) require Federal agencies to consider the effects of their undertakings on cultural resources that are, or that may be, eligible for listing in the National Register of Historic Places (NRHP) and to afford the Advisory Council on Historic Preservation an opportunity to comment. NRHP-eligible resources are considered to be "significant." The criteria used to evaluate eligibility for listing on the NRHP are further discussed in the next subsection.

The Section 106 process that is typically associated with NEPA compliance requires consultation of the federal lead agency with other federal, state, and local agencies, the Advisory Council on Historic Preservation, the State Historic Preservation Officer (SHPO), Indian tribes, and interested members of the public, such as historical societies. Throughout the Section 106 process, the federal lead agency and consulting parties work together to identify adverse impacts on sites of cultural significance or historic properties, and seek ways to avoid, minimize, or mitigate the adverse effects. A Memorandum of Agreement or Programmatic Agreement is issued by the participating parties that includes the measures agreed upon to avoid or reduce (i.e., mitigate) adverse effects. For large or complex undertakings, a Programmatic Agreement may also be negotiated to develop a phased approach to historic properties management or alternative Section 106 processes through consultations. Thus, impacts to cultural resources that are identified in a NEPA document are addressed through Section 106.

Section 110 of the NHPA sets out the broad responsibilities of Federal agencies for identifying and protecting historic properties under their jurisdiction, and for avoiding unnecessary damage to them. It is intended to ensure that an historic preservation program is fully integrated into the ongoing program of each Federal agency. Section 110 allows the costs of preservation activities as eligible project costs in all undertakings conducted or assisted by a Federal agency. Federal agencies are directed to withhold grants, licenses, approvals, or other assistance to applicants who intentionally damage or adversely affect historic properties in an effort to avoid the Section 106 process.

### 23.5.12 American Indian Religious Freedom Act

The American Indian Religious Freedom Act of 1978 protects the rights of Native Americans to freedom of expression of traditional religions (24 U.S. Code section 1996). This act established "the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions…including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites."

### 23.5.13 Indian Sacred Sites on Federal Land

Executive Order 13007 provides that in managing Federal lands, each Federal agency with statutory or administrative responsibility for management of Federal lands shall, to the extent practicable and as permitted by law, accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, and avoid adversely affecting the physical integrity of such sacred sites.

## 23.6 Consultation with Tribal Governments

Consistent with President Clinton's April 29, 1994 Memorandum and President Obama's November 5, 2009 Memorandum, Reclamation contacted federally-recognized tribal governments to participate in preparation of this EIS. Reclamation met with the California Valley Miwok Tribe in 2012 and the Miwok Maidu United Auburn Indian Community of the Auburn Rancheria in 2013.

Reclamation will continue to consult with each tribe on a government-to-government basis before taking any action that could affect a tribal government. Under the Federal Trust responsibility, Reclamation will provide full disclosure of the beneficial and adverse impacts of a project to the tribal government in a manner that provides adequate time for review and response. Reclamation will review comments received and consult with the tribal government prior to decisions related to a project.

Tribes and Indian Trust Assets were considered during preparation of this EIS, in accordance with environmental justice considerations identified in Executive Order 12898 (February 11, 1994), as summarized in Chapter 20, Indian Trust Assets, and Chapter 21, Environmental Justice.

## 23.7 References

SWC (State Water Contractors). 2015. "State Water Contractors – About Us." Site accessed June 23, 2015. http://www.swc.org/about-us

**Chapter 24**

# Environmental Impact Statement Distribution List

This chapter provides locations where the Draft and Final Environmental Impact Statement (EIS) are available for review and a list of governmental entities, organizations, and interested parties that received copies of this EIS.

## 24.1 Document Availability

The public distribution of this Draft and Final EIS emphasizes the use of electronic media to ensure cost-effective, broad availability to the public and interested parties. The Draft and Final EIS are available on the Internet at Reclamation's website.

Printed copies of the Draft and Final EIS are available for review at the following locations.

U.S. Department of the Interior, Bureau of Reclamation Library
2800 Cottage Way
Sacramento, CA 95825

U.S. Department of the Interior, Bureau of Reclamation, Bay-Delta Office
801 I Street, Suite 140
Sacramento, CA 95814

Electronic copies of the Draft and Final EIS are available on compact disc for viewing at the following libraries.

Alameda County Library
1247 Marin Avenue
Albany CA 94706

Alameda County Library
200 Civic Plaza
Dublin CA 94568

Alameda County Library
6300 Civic Terrace Avenue
Newark CA 94560

Butte County Library
1108 Sherman Avenue
Chico CA 95926

Colusa County Free Library
738 Market Street
Colusa CA 95932

Contra Costa County Library
501 W. 18th Street
Antioch  CA 94509

Contra Costa County Library
104 Oak Street
Brentwood  CA 94513

Contra Costa County Library
1050 Neroly Road
Oakley  CA 94561

Contra Costa County Library
80 Power Avenue
Pittsburg  CA 94565

Contra Costa County Library
1750 Oak Park Boulevard
Pleasant Hill  CA 94523

El Dorado County Library
345 Fair Lane
Placerville  CA 95667

Fresno County Library
2420 Mariposa Street
Fresno  CA 93721

Glenn County Library
201 North Lassen Street
Willows  CA 95988

Kern County Library
701 Truxton Avenue
Bakersfield  CA 93301

Kings County - Hanford Branch Library
401 N Douty Street
Hanford  CA 93230

Los Angeles County Central Library
630 West 5$^{th}$ Street
Los Angeles  CA 90071

Madera County Library
121 North G Street
Madera  CA 95637

Merced County Library
2100 O Street
Merced  CA 95340

Napa County Library
580 Coombs Street
Napa CA 94559

Orange County Library
11200 Stanford Avenue
Garden Grove CA 92840

Placer County Library
350 Nevada Street
Auburn CA 95603

Plumas County Library
445 Jackson Street
Quincy CA 95970

Riverside County Library
5840 Mission Boulevard
Riverside CA 92509

Sacramento County Library
170 Primasing Avenue
Courtland CA 95615

Sacramento County Library
8900 Elk Grove Boulevard
Elk Grove CA 95624

Sacramento County Library
412 Union Street
Isleton CA 95641

Sacramento Central Library
828 I Street
Sacramento CA 95814

Santa Barbara County Library
40 E Anapamu Street
Santa Barbara CA 93101

San Benito County Library
470 5th Street
Hollister CA 95023

San Bernardino County Library - Norman Feldheym Central Library
555 W 6th Street
San Bernardino CA 92410

San Diego County Public Library
330 Park Boulevard
San Diego CA 92101

San Joaquin County - Escalon Branch Library
1540 2nd Street
Escalon CA 95320

San Joaquin County - Lathrop Branch Library
450 Spartan Way
Lathrop CA 95330

San Joaquin County - Manteca Public Library
320 W Center Street
Manteca CA 95336

San Joaquin County - Margaret K Troke Branch Library
502 W Benjamin Holt Drive
Stockton CA 95207

San Joaquin County - Cesar Chavez Central Library
605 N El Dorado Street
Stockton CA 95202

San Joaquin County - Tracy Branch Library
20 E Eaton Avenue
Tracy CA 95376

San Luis Obispo County Library
995 Palm Street
San Luis Obispo CA 93403

Santa Clara County - Cupertino Library
10800 Torre Avenue
Cupertino CA 95014

Santa Clara County - Milpitas Library
160 N Main Street
Milpitas CA 95035

Shasta County - Redding Public Library
1100 Parkview Avenue
Redding CA 96001

Solano County - Fairfield Civic Center Library
1150 Kentucky Street
Fairfield CA 94533

Solano County Fairfield Cordelia Library
5050 Business Center Drive
Fairfield CA 94534

Solano County - John F Kennedy Library
505 Santa Clara Street
Vallejo CA 94590

Solano County - Springstowne Library
1003 Oakwood Avenue
Vallejo  CA 94591

Solano County - Vacaville Public Library
1 Town Square Place
Vacaville  CA 95688

Solano County - Vacaville Public Library
1020 Ulatis Drive
Vacaville  CA 95687

Solano County - Rio Vista Library
44  S  2nd Street
Rio Vista  CA 94571

Solano County - Suisun City Library
601 Pintail Drive
Suisun City  CA 94585

Stanislaus County Library
1500  I  Street
Modesto  CA 95354

Sutter County Library
750 Forbes Avenue
Yuba City  CA 95991

Tehama County Library
645 Madison Street
Red Bluff  CA 96080

Trinity County Library
351 N Main Street
Weaverville  CA 96093

Tulare County Library
200 W Oak Avenue
Visalia  CA 93291

Ventura County - Ojai Library
111 E Ojai Avenue
Ojai  CA 93023

Ventura County - E P Foster Library
651 E Main Street
Ventura  CA 93001

Ventura County - Oak Park Library
899 Kanan Road
Oak Park  CA 91377

Yolo County - Clarksburg Branch Library
52915 Netherlands Road
Clarksburg CA 95612

Yolo County - Mary L Stephens Davis Branch Library
315 E 14th Street
Davis CA 95616

Yolo County - Winters Branch Library
708 Railroad Avenue
Winters CA 95694

Yolo County Library
250 1st Street
Woodland CA 95695

Yolo County Branch Library
37750 Sacramento Street
Yolo CA 95697

## 24.2 Agencies and Organizations Receiving Copies of the Draft Environmental Impact Statement

All persons, agencies, and organizations listed in this chapter have been informed of the availability of and locations to obtain the Draft and Final EIS. Parties listed below have received an electronic copy on a compact disc of the Draft and Final EIS.

### 24.2.1 Federal Agencies

- Bureau of Indian Affairs
- National Marine Fisheries Service
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- Western Area Power Administration

### 24.2.2 Tribal Interests

- California Valley Miwok Tribe
- United Auburn Indian Community

### 24.2.3 State Agencies

- California Department of Fish & Wildlife
- California Department of Water Resources
- Delta Stewardship Council

### 24.2.4 Regional and Local Entities

- Alameda County Zone 7

- Anderson-Cottonwood Irrigation District
- Central Delta Water Agency
- Contra Costa Water District
- East Bay Municipal Utility District
- El Dorado County Water Agency
- El Dorado Irrigation District
- El Dorado Water and Power Authority
- Folsom, City of
- Friant Water Authority
- Glenn-Colusa Irrigation District
- Hesperia, City of
- Lower Tule River Irrigation District
- Oakdale Irrigation District
- Placer County Water Agency
- Reclamation District 108
- Roseville, City of
- Sacramento, City of
- San Diego County Water Authority
- San Juan Water District
- San Luis & Delta Mendota Water Authority
- Santa Clara Valley Water District
- South Delta Water Agency
- South San Joaquin Irrigation District
- Stanislaus, County of
- Stockton East Water District
- Sutter Mutual Water Company
- Tehama-Colusa Canal Authority
- Westlands Water District

### 24.2.5 Other Interested Parties

- AquAlliance
- The Bay Institute
- California Farm Bureau Federation
- Coalition for a Sustainable Delta
- California Water Impact Network
- California Sportfishing Protection Alliance
- The Center for Environmental Science Accuracy and Reliability
- Environmental Water Caucus
- Friends of the River
- Golden Gate Salmon Association
- Kern County Water Agency
- Northern California Water Agency
- Natural Resources Defense Council
- North Coast Rivers Alliance

- Pacific Coast Federation of Fisherman's Associations
- Restore the Delta
- South Valley Water Association
- State and Federal Contractors Water Authority
- State Water Contractors
- Water 4 Fish

**Chapter 25**

# List of Preparers

The following individuals contributed to the preparation of this Environmental Impact Statement.

**Bureau of Reclamation**

| Name | Title | Years of Experience |
|---|---|---|
| Theresa Olson | Chief, Conservation and Conveyance Division | 23 |
| Amy Aufdemberge | Assistant Regional Solicitor | More than 20 |
| Andrew Shultz | Fish Biologist | 20 |
| Ann Stine | Natural Resources Specialist | 32 |
| Ben Nelson | Natural Resources Specialist | 5 |
| Bonnie Van Pelt | Natural Resources Specialist | 9 |
| Carolyn Bragg | Natural Resources Specialist | 8 |
| David O'Connor | Water Resource Modeler | 9 |
| David van Rijn | Chief, Science Division | 22 |
| Donna Garcia | Project Manager | – |
| Erwin Van Nieuwenhuyse | Supervisory Fish Biologist | 15 |
| Greg Krzys | Natural Resources Specialist | 20 |
| Janice Piñero | Endangered Species Act Compliance Specialist | 15 |
| Jason Hassrick | Fish Biologist | 17 |
| Joel Sturm | Geologist | 40 |
| John Dealy | Project Manager | More than 30 |
| John Hannon | Fisheries Biologist | 25 |
| Josh Israel | Fish Biologist | 11 |
| Kaylee Allen | Assistant Regional Solicitor | 16 |
| Kirk Nelson | Civil Engineer (Hydraulic) | 11 |
| Kristin White | Hydraulic Engineer | 11 |
| Laureen Perry | Regional Archaeologist | 25 |
| Michael Mosley | Physical Scientist | 7 |
| Michael Tansey | Climate Change Coordinator | 40 |
| Michele Palmer | Fisheries Biologist | 20 |
| Michelle Banonis | BDCP Program Manager | 16 |

| Name | Title | Years of Experience |
|---|---|---|
| Nancy Parker | Hydraulic Engineer (Water Resources Engineer) | 25 |
| Patti Idlof | Supervisory Natural Resources Specialist | 30 |
| Paul Zedonis | Supervisory Natural Resource Specialist | 25 |
| Rain Emerson | Supervisory Natural Resource Specialist | 6 |
| Rebecca Victorine | Natural Resource Specialist | 18 |
| Ronald Silva | Chief, Engineering and O&M Division | 30 |
| Russell Grimes | Chief, Environmental Compliance and Habitat Conservation Branch | 24 |
| Scott Springer | Outdoor Recreation Planner | 21 |
| Stanley Parrott | Geologist | 29 |
| Steve Pavich | Agricultural Economist | 18 |
| Traci Michel | Water Management Goal Supervisor | 22 |

**CH2M HILL**

| Name | Project Role | Education |
|---|---|---|
| Gwendolyn Buchholz, Professional Engineer (P.E.) | Project Manager | M.S., Civil Engineering, 1976<br>B.A., Physics, 1974 |
| Derya Sumer, P.E. | Deputy Project Manager, Modeling Lead | Ph.D., Civil Engineering–Water Resources, 2007<br>M.S., Civil Engineering–Water Resources, 2002<br>B.S., Civil Engineering, 1999 |
| Robert Antel | Graphics | B.A., Art, 1990 |
| Nathan Brown, Professional Geologist (PG) | Groundwater | M.S., Hydrogeology, 1995<br>B.S., Geology, 1993 |
| Earl Byron | Water Quality | Ph.D., Ecology and Limnology, 1979<br>B.A., Marine Biology, 1973 |
| Chandra Chilmakuri, P.E. | Water Supply, Surface Water, Water Quality | Ph.D., Hydrodynamics and Environmental Modeling, 2005<br>M.S., Civil and Environmental Engineering, 2002<br>B.S., Civil Engineering, 2000 |

| Name | Project Role | Education |
|---|---|---|
| Heidi Chou, P.E. | Water Supply, Surface Water | M.S., Civil Engineering,<br>B.S., Civil Engineering, 2010 |
| David Christophel | Biological Resources | M.S., Biological Sciences, 1989<br>B.S., Biological Sciences, 1979 |
| Tapash Das | Water Supply, Surface Water, Groundwater | Ph.D., Hydrology, 2006<br>M.T., Water Resources Development and Management, 2002<br>B.S., Agricultural Engineering, 1999 |
| Tyson Daus | Graphics | B.S., Graphic Design, 2008 |
| Rosemarie Dimacali | Water Quality | M.S., Civil Engineering<br>B.S. 2009 |
| Fawn Elhadidi | GIS Mapping | Certificate in Business Management and Accounting, 1989 |
| Al Farber | Cultural Resources | M.A., Anthropology, 1982<br>B.A., Anthropology, 1976 |
| Tyler Hatch, P.E. | Groundwater | Ph.D., Civil and Environmental Engineering, 2013<br>M.S., Civil and Environmental Engineering, 2011<br>B.S., Civil Engineering, 2008 |
| Steven Hatchett | Agriculture, Socioeconomics | Ph.D., Agricultural Economics, 1984<br>M.A., Administration, 1980<br>B.S., Forestry, 1977 |
| David Julian | Water Supply, Surface Water, Water Quality | M.S. Civil Engineering, 2013<br>B.S., Civil Engineering, 2011 |
| Kevin Kasberg | Agriculture, Socioeconomics | M.S., Agricultural and Resources Economics, 2012<br>B.A., Environmental Studies/Economics, 2009 |
| Justin LaNier | Groundwater | M.S., Civil Engineering, 2006<br>B.S., Civil Engineering, 2002 |
| Peter Lawson, P.G. | Groundwater | M.S., Hydrology, 1988<br>B.S., Geology, 1985 |
| Robert Leaf, P.E. | Water Supply<br>Surface Water, Water Quality | M.S., Civil Engineering, 1994<br>B.S., Civil Engineering, 1992<br>B.S., Forest and Resource Management, 1987 |
| Chakri Malakpet, P.E. | Water Supply | M.S., Civil Engineering, 2007<br>B.S., Civil Engineering, 2005 |

| Name | Project Role | Education |
|---|---|---|
| Armin Munévar, P.E. | Water Supply<br>Surface Water, Water Quality | M.S., Civil Engineering, 1997<br>B.S., Civil Engineering, 1991 |
| Neil Nikirk | Biological Resources | M.S., Fisheries Science, 1992<br>B.S., Fisheries Science, 1987 |
| Harry Ohlendorf | Water Quality | Ph.D., Wildlife Science, 1971<br>M.S., Wildlife Science, 1969<br>B.S., Wildlife Management, 1962 |
| Lisa Porta, P.E. | Groundwater, Water Quality | M.S., Environmental Science and Engineering, 2007<br>B.S., Biological Systems Engineering, 2004 |
| Reed Thayer | Water Supply, Surface Water | M.S., Civil Engineering, 2015<br>B.S., Civil Engineering, 2013 |
| Elisabeth Towers | GIS Mapping | B.A., Human Geography and Planning, 2013 |
| Robert Tull, P.E. | Water Supply, Surface Water | M.S., Environmental Engineering, 10986<br>B.S., Environmental Planning, 1981 |
| Jeff Tupen | Biological Resources | B.S., Environmental and Systematic Biology, 1989 |
| Pamela Vanderbilt | Air Quality and Biological Resources | M.A., Biology, 1979<br>B.A., Biology, 1977 |
| Brian Van Lienden, P.E. | Water Supply, Energy Resources | M.S., Civil Engineering, 2000<br>B.S., Civil Engineering, 1998 |
| Kyle Winslow, P.E. | Water Quality | Ph.D., Environmental Fluid Mechanics, 2001<br>M.S., Environmental Water Resources, 1996<br>B.S., Civil Engineering, 1995 |
| Fatuma Yusuf | Socioeconomics | Ph.D., Agricultural Economics, 2000<br>M.S., Statistics, 1999<br>M.A., Agricultural Economics, 1994<br>B.S., Range Management, 1990 |

**Ag-Recon**

| Name | Project Role | Education |
|---|---|---|
| David Olson | Agricultural Resources | B.S., Agricultural Engineering, 1985 |

1 **Cramer Fish Sciences**

| Name | Project Role | Education |
|---|---|---|
| Paul Bergman | Aquatic Resources | M.S., Fisheries, 2007<br>B.S., Fisheries and Biology, 1994 |
| Brad Cavallo | Aquatic Resources | M.S., Aquatic Ecology, 1997<br>B.S. Wildlife and Fisheries Biology, 1994 |
| Travis Hinkelman | Aquatic Resources | Ph.D., Biological Sciences, 2012<br>M.S., Aquaculture, Fisheries and Wildlife, 2004<br>B.S., Fisheries and Wildlife, 2001 |
| Steven Zeug | Aquatic Resources | Ph.D., Wildlife and Fisheries Sciences, 2007<br>B.S., Fisheries Biology, 2001 |

2 **ERA Economics**

| Name | Project Role | Education |
|---|---|---|
| Duncan MacEwan | Agricultural Resources | Ph.D., Economics, 2012<br>M.S., Economics, 2008<br>B.S., Economics, 2006 |

3 **InCommunications**

| Name | Project Role | Education |
|---|---|---|
| Christine Kohn | Consultation and Coordination | M.S., Journalism and Public Affairs, 1993<br>B.A., Journalism, 1991 |

4 **Kearns and West**

| Name | Project Role | Education |
|---|---|---|
| Michael Harty | Consultation and Coordination | J.D., Georgetown University Law Center, 1986<br>B.A., Political Philosophy, 1978 |

5 **QEDA**

| Name | Project Role | Education |
|---|---|---|
| Noble Hendrix | Aquatic Resources | Ph.D., Aquatic and Fisheries Sciences, 2003<br>M.S., Aquatic and Fisheries Sciences, 2000 |

**Resource Management Associates**

| Name | Project Role | Education |
|---|---|---|
| Stacie Grinbergs, P.E. | Surface Water Modeling | M.S., Civil Engineering, 1998 |
| Donald Smith, P.E. | Water Temperature Modeling | B.S., Civil Engineering, 1968 |

**RMann Economics**

| Name | Project Role | Education |
|---|---|---|
| Roger Mann | Socioeconomics | Ph.D., Agricultural Economics, 1978 |

**Stillwater Associates**

| Name | Project Role | Education |
|---|---|---|
| Ethan Bell | Aquatic Resources | M.S., Biology, 2001 |
| Joshua Strange | Aquatic Resources | Ph.D., Fisheries Biologist, 2001 |

## Chapter 26

# Index

### A



### B

**D**



**E**

**F**



**G**



**H**



**I**



**J**

## K



## L



## M



## N



## O

**P**



**R**



**S**

**T**