Appendix 5B
Responses to Reduced South of Delta Water Supplies

5B.1 Introduction

California faces a future of increased population growth coupled with the potential for water shortages and pressures on the Sacramento-San Joaquin Delta (Delta). The availability of water supplies may be highly variable as the Delta faces numerous challenges to its long-term sustainability. The Delta is the key to the Central Valley Project's (CVP) and State Water Project's (SWP) ability to deliver water to agricultural and urban contractors throughout the state. Most water contractors receive water from the south Delta pumping plants (the Harvey O. Banks Pumping Plant, the Barker Slough Pumping Plant, and the Jones Pumping Plant) (California Department of Water Resources 2012a).

Challenges affecting exported water supplies include the threat of a catastrophic levee failure from potential seismic events as water pressure increases on fragile levees around subsided islands. The long-term sustainability of the Delta's levee system is of significant interest to the recipients of south of Delta water supplies both to preserve water quality and sustain reliable conveyance. Climate change poses the threat of increased variability in hydrology (floods and droughts). In addition to potentially affecting the ability to convey south of Delta water supplies, sea level rise complicates efforts to manage salinity levels and preserve water quality in the Delta so that the water remains suitable for urban and agricultural uses. Protection of endangered and threatened fish species is also an important concern for the Delta and those dependent on its water supplies. Ongoing regulatory restrictions, such as those imposed by federal biological opinions on the SWP and CVP operations, contribute to the challenge of determining the water delivery reliability (California Department of Water Resources 2012a).

This appendix is intended to provide background on the foreseeable events following a reduction in Delta water exports that could result from regulatory restrictions to operations, selection of a reduced-export alternative, export interruption based on seismic or other risks, and impacts of climate change and sea level rise. Background is provided on the current regulatory impacts on south of Delta water supplies. Following in Section 5B.2 is a discussion of potential scenarios that could lead to reduced south of Delta water supplies. Reductions or disruptions to Delta water supplies could occur in three general scenarios: (1) near-term reductions in the export of Delta water supplies due to regulatory and/or policy decisions; (2) disruption of exports due to levee failure; and (3) mid- to long-term reductions in south of Delta water supplies as a result of climate change impacts or other unforeseen events. Section 5B.3 outlines the potential urban and agricultural responses to reduced water supplies, which include water conservation, reservoir storage, groundwater, water transfers, recycled water, desalination, and contingency plans. The environmental effects of those responses are discussed in Section 5B.4.

If none of the BDCP action alternatives were implemented, current reductions in the quantity of south of Delta water supplies would likely continue, and the reliability of these supplies would remain dependent upon existing infrastructure and programs in an uncertain future. In addition, the condition of many Delta levees, probability of a large seismic event, and effects of climate change create the potential for the failure of one or more Delta levees, which could impede the pumping of Delta water supplies from the current facilities in the south Delta for a period of time.

5B.1.1 Legislative and Regulatory Context Regarding South of Delta Water Supplies

Changes to CVP and SWP operations pursuant to federal and state laws, such as the Central Valley Improvement Act (CVPIA), Clean Water Act, Endangered Species Act (ESA), and Porter-Cologne Water Quality Control Act, have often reduced the quantity and reliability of south of Delta water supplies.

5B.1.1.1 Legislative Actions

5B.1.1.1.1 Central Valley Project Improvement Act

In 1992, the CVPIA amended previous authorizations of the CVP to add fish and wildlife protection, habitat restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses (the original project purposes). A number of key CVPIA provisions affect south of Delta water supplies, including:

- Section 3404(a), precludes the issuance of any new short term, temporary, or long term CVP contracts for any purpose other than fish and wildlife.
- Section 3406(b)(2), authorizes and directs the dedication and management of up to 800 thousand acre-feet (taf) of CVP water per year for environmental purposes.
- Section 3406(b)(23), addresses restoration efforts for the Trinity River Division.
- Section 3406(d)(1), requires annual 480 taf of water be delivered to federal, state and some private wildlife refuges. (San Luis & Delta-Mendota Water Authority [SLDMWA] 2006).

Section 3406(d)(1) of the CVPIA requires firm water supplies to be delivered to federal, state, and some private wildlife refuges in the Central Valley, as defined in the CVPIA. This supply is referred to as “Firm Level 2 water” as outlined in the Refuge Water Supply Report (U.S. Bureau of Reclamation 1989 [Reclamation]) and the San Joaquin Basin Action Plan (U.S. Bureau of Reclamation and California Department of Fish and Game 1989) and is greater than the amount of CVP water previously delivered to the refuges (U.S. Bureau of Reclamation and California Department of Fish and Game 1989).

In addition, Section 3406(d)(2) of the CVPIA requires the acquisition of 133,264 acre-feet per year of additional water for the refuges, termed Incremental Level 4 Water, for wetland habitat supporting resident and migratory waterfowl, threatened and endangered species, and wetland-dependent aquatic biota (U.S. Bureau of Reclamation 2011).

Pursuant to Section 3406(b)(2), the Department of the Interior has been dedicating and managing CVP water since 1993, the first water year following passage of the CVPIA. Since enactment of the statute, Interior has pursued ways to use (b)(2) water (for environmental purposes) in conjunction with modification of CVP operations and water acquisitions to meet the goals of the CVPIA (San Luis & Delta-Mendota Water Authority 2006).

Section 3406(b)(23) of the CVPIA required the Department of the Interior to complete a flow study in the Trinity River and make a recommendation regarding the potential for increased flows to restore fisheries. The Trinity River Flow Evaluation Study assessed the potential for increased flows, which were then recommended in the Trinity River Mainstream Fishery Restoration Draft EIS/EIR. The Department of the Interior adopted the Trinity River Mainstem Fishery Restoration Program Record of Decision (ROD) on December 19, 2000, which proposed implementation of the increased flow regime. CVP water and power users filed suit in January 2001, and a U.S. District Court issued a preliminary injunction in March 2001. On July 5, 2005, after the issuance of a decision by the Ninth Circuit Court of Appeal upholding the ROD (see *Westlands Water District v. United States Department of Interior*, 376 F.3d 853 [2004]), the U.S. District Court entered an amended final judgment, which resolved the legal challenges to the ROD (San Luis & Delta-Mendota Water Authority 2006). As a result, about 50% of the water coming into Trinity Lake now flows down the river (Trinity River Restoration Program, undated) via instream flow releases that range from 369 taf of water in critically dry years to 815 taf in extremely wet years (San Luis & Delta-Mendota Water Authority 2006). These increased flows have reduced the amount of CVP water that can be diverted to the Sacramento River and the Delta and reduced south of Delta water supplies.

5B.1.1.2 State Water Resources Control Board Actions

The State Water Resources Control Board (SWRCB) is responsible for the regulation of activities and factors that may affect the quality of the waters of the state (Water Code, §§ 13000, 13001), and in doing so, has implemented a number of actions that affect south of Delta water supplies. For example, in 1978, the SWRCB released Water Right Decision 1485 (D-1485), which set flow and water quality standards for the protection of "beneficial uses of Delta water supplies," and required the SWP and CVP to meet those standards as water rights conditions for the projects. The standards were based on the premise that beneficial uses would be protected at a level equal to the protection received had the CVP and SWP never been in operation and had construction of those two projects never taken place (San Luis & Delta-Mendota Water Authority 2006). Reclamation and California Department of Water Resources (DWR) protested many of the requirements of D-1485, including the ability of new water rights applicants to change Delta inflows that would need to be corrected through modification of SWP and CVP operations to continue to meet Delta water quality requirements.

Water Right Decision 1641 (D-1641) superseded D-1485 in December 1999. D-1641 includes the "X2" objectives, whereby the SWRCB can regulate the Delta estuary's salinity gradient during the months of February to June (the X2 objectives also are included in the Bay-Delta Plan, described below). Meeting the X2 objectives can require a relatively large volume of water for outflow during dry months that follow months with large storms, which can reduce exports from the south Delta. D-1641 also established an export/inflow ratio, which is designed to protect the fish and wildlife beneficial uses in the Bay-Delta estuary by limiting the fraction of Delta inflows that is exported. When other restrictions are not controlling, Delta exports are limited to 35 percent of total Delta inflow from February through June and 65 percent of inflow from July through January (California Department of Water Resources 2012a).

The SWRCB also has undertaken proceedings under its water quality authority to develop and update a Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). The SWRCB initially developed the Bay-Delta Plan in 1978 and undertook proceedings to update it in 1991, 1995, and 2006. The 2006 Bay-Delta Plan governs today. However, the SWRCB is currently reviewing the 2006 Bay-Delta Plan and is scheduled to update that Plan by August 2013. Important objectives in the 2006 Bay-Delta Plan include: Salinity/Chloride Objectives, Outflow Objectives, Export to Inflow Ratio Objectives, San Joaquin River Flow Objectives, Delta Cross

Channel Gate Objectives, Suisun Marsh Objectives, and the Narrative Objective for Salmon Protection. In D-1641, the SWRCB assigned to the CVP and SWP significant responsibility for implementation of the Bay-Delta Plan.

5B.1.1.3 Actions under the Federal and State Endangered Species Acts

Because of their effects on species protected under the ESA, SWP and CVP operations are affected by biological opinions prepared by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). Operations could also be affected by Incidental Take Permits issued by the California Department of Fish and Game (DFG).

5B.1.1.3.1 U.S. Fish and Wildlife Service Biological Opinion

Through a 2008 USFWS Delta smelt biological opinion, the CVP and SWP are required to manage flows in Old River and Middle River beginning as early as December 1 of each year through June, based on USFWS's determination. The restriction has three phases that are intended to protect delta smelt at various life stages. The USFWS, after consultation with DWR, Reclamation, and various working groups, determines the required Old River and Middle River flow target, which is largely based on delta smelt survey information. Managing Old River and Middle river flow is accomplished primarily by setting SWP and CVP pumping rates. The biological opinion also requires an additional salinity requirement (commonly referred to as "Fall X2") in the Delta in September and October in wet and above normal water years. In these years, fresher water must be maintained at locations farther west than during other types of water years. In November during years when this requirement would be in place, inflow to the SWP and CVP reservoirs would be passed downstream to augment Delta outflow until the prior month's required location for the fresher water is reached.

5B.1.1.3.2 National Marine Fisheries Service Biological Opinion

For the protection of listed salmonids and other species, the 2009 NMFS biological opinion required additional operational modifications. These requirements included an Old River and Middle River requirement and expanded the duration of a springtime operation that reduces CVP and SWP exports.

Also, under the biological opinion, the Delta Cross Channel gates are closed more frequently from October through December 14, and are completely closed between December 15 and January 31. Previously, as defined in D-1641, the Delta Cross Channel was closed up to 45 days between November 1 and January 31. This operation can require additional pumping reductions.

A number of additional actions under the biological opinion impose temperature, flow, and storage requirements on the CVP system. These additional actions or requirements could also have an effect on real-time SWP and CVP operations.

5B.1.1.3.3 California Department of Fish and Game Incidental Take Permit

Conditions under the 2009 Longfin Smelt Incidental Take Permit have not impacted SWP and CVP operations but could in the future, particularly in dry and critically dry years.

5B.1.2 Ongoing Regulatory Impacts on Delivery Reliability of South of Delta Water Supplies

5B.1.2.1.1 Effects on SWP Operations

Since 2003, DWR has been required to prepare a Delivery Reliability Report every two years that describes, under a range of hydrologic conditions, the existing overall delivery capability of the SWP facilities and the allocation of that capacity to each SWP contractor. The 2009 SWP Delivery Reliability Report (California Department of Water Resources 2010a) differed from those prepared in 2003, 2005, and 2007 because it included revised estimates of reductions to SWP delivery reliability due to future climate changes and sea level rise and also due to restricted operations to comply with the USFWS and NMFS biological opinions (reductions due to prior legislative and regulatory actions already were accounted for in the 2003 and subsequent reports). The 2009 report also discusses the risk of conveyance disruption due to Delta levee failure. (The relationship between climate change and water supplies is discussed under Section 5B.2.3, and risks from levee failure are addressed in Section 5B.2.2.) The 2009 Report showed a continuing decrease in the ability of the SWP to deliver water and concluded that for current conditions, a substantial factor for these reductions is the restrictive operational requirements contained in the federal biological opinions. For future conditions, these requirements and the forecasted effects of drought and climate change are the dominant factors affecting water supply reliability (California Department of Water Resources 2010a). The 2007 SWP Delivery Reliability Report incorporated the interim, and less restrictive, operation rules established by the U.S. District Court in 2007. The 2005 SWP Delivery Reliability Report was based upon much less restrictive operational rules contained in the biological opinions issued in 2004 and 2005.

As discussed in the 2009 Report, the median value estimated for the primary component of SWP Table A[1] annual deliveries for Current Conditions in the 2005 Report was 3,170 taf . As a result of different modeling assumptions to represent changes in the regulations controlling the operations of the SWP, the median value in the 2007 Report was reduced to 2,980 taf, and in the 2009 Report, it was further reduced to 2,680 taf. This is an overall reduction of almost 500 taf and represents a 6% reduction between 2005 and 2007 and a 15% reduction between 2005 and 2009.

The 2011 SWP Delivery Reliability Report indicates that many of the same specific challenges to SWP operations described in the 2009 Report remain in 2011, and that "most notably, the effects on SWP pumping caused by issuance of the 2008 and 2009 federal biological opinions, which were reflected in the 2009 Report, continue to affect SWP delivery reliability today" (California Department of Water Resources 2012a).

5B.1.2.1.2 Effects on CVP Operations

As discussed above, CVP operations have been affected by various legislative, regulatory, and judicial decisions. These include the CVPIA, Bay-Delta Plan, D-1485, and D-1641. In the 2006 Westside Integrated Water Resources Plan, SLDMWA estimated that these legislative and regulatory actions, in addition to state and federal ESA provisions, had resulted in an approximately 30 percent reduction of their long-term average delivery allocation. Previously, Westside agricultural

[1] Table A Amount is named for the "Table A" in each SWP contractor's Water Supply Contract. It contains an annual buildup in Table A Amounts of SWP water, from the first year of the Water Supply Contract through a specific year, based on growth projections made before the Water Supply Contract was executed.

contractors had received 100 percent of their CVP contracted supply in almost every year since deliveries to the region began in June, 1951, except during severe drought conditions (San Luis & Delta-Mendota Water Authority 2006). The 30 percent reduction estimate does not include the effects of the 2008 USFWS Delta smelt biological opinion and 2009 NMFS salmonid biological opinion. The assumed additional effects of those opinions to CVP agricultural allocations could be assumed to be similar to the estimated additional reduction to the SWP contractors (approximately 15 percent).

5B.1.2.1.3 Reliability and Uncertainty of South of Delta Water Supplies

Despite the substantial variation in annual precipitation patterns, the SWP and CVP systems historically were able to provide relatively consistent deliveries, except in periods of severe or prolonged drought. The reallocation of south-of-Delta water supplies, starting in 1992 (from the various legislative and regulatory actions discussed above), has reduced the reliability of both systems (Howitt et al. 2009; Cody et al. 2009).

Figure 5B-1 shows that deliveries of SWP Table A water from the Delta for 2001–2010 range from an annual minimum of 1,049 taf to a maximum of 2,963 taf, with an average of 2,087 taf. (This figure includes Table A water exported through the North Bay Aqueduct, which is less than 2%.) Historical deliveries of SWP Table A water from the Delta over this 10-year period are less than the maximum of 4,133 taf/year. Total requested amounts vary slightly from year to year, but usually remain at or slightly below the maximum of 4,133 taf/year. The water-year types vary over the period from critical-dry to wet. The minimum requested was 3,914 taf/year in 2002. Average annual Delta exports have generally decreased since 2005. (California Department of Water Resources 2012a)

For example, the reduced reliability of SWP and CWP water deliveries – especially during droughts – has adversely affected the ability of farmers to make decisions related to crop selection and planting (California Department of Water Resources 2010b). Because of the time required to arrange capital, prepare and sign contracts, acquire materials and equipment, and schedule labor, decisions about crop selection are often made in late winter or early spring, after initial water delivery allocations are made. Low initial allocations and subsequent conservatively-low revisions have delayed planting decisions, or have created an inability to take advantage of additional water availability after crop planting decisions have been made (California Department of Water Resources 2010c). As a result, farmland is sometimes fallowed based on initial or preliminary water allocations and less water-intensive (and lower value) crops have been planted, even though final allocations would have made other, more-profitable crop selections feasible (California State Board of Food and Agriculture [CSBFA] 2009; California Department of Water Resources 2010d).

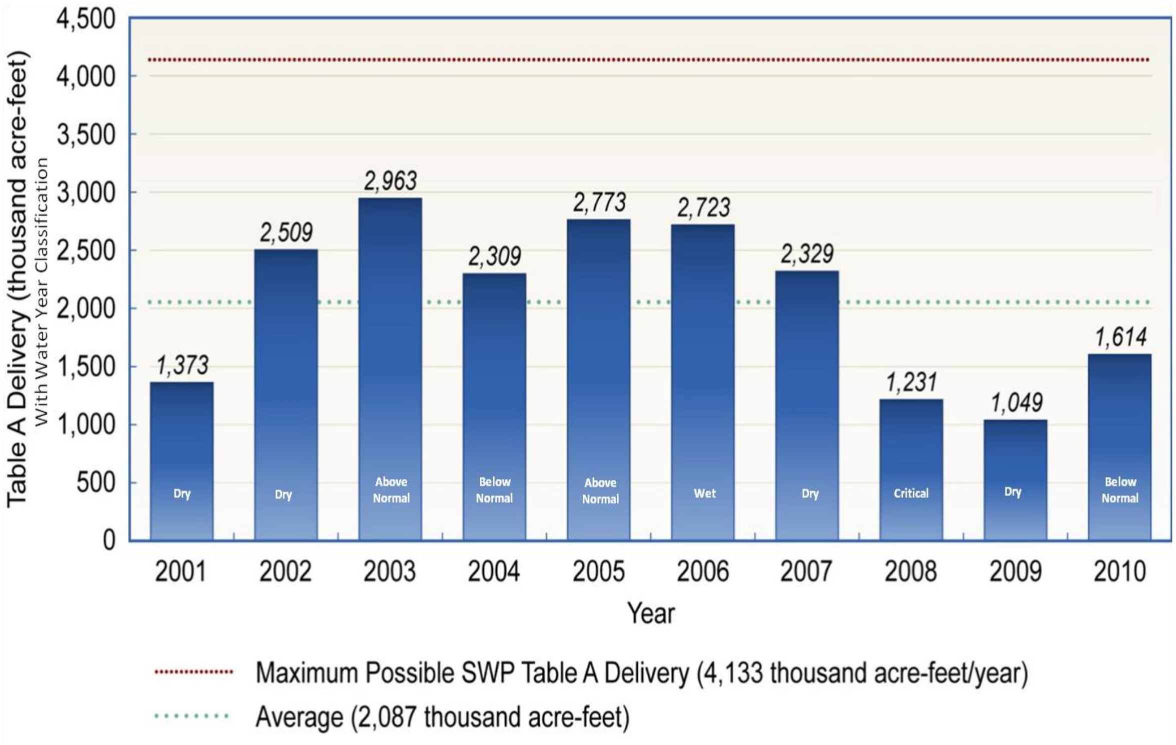

Figure 5B-1: SWP Table A Water Deliveries from the Delta, 2001–2010

5B.2 Scenarios Leading to Reductions or Disruptions of South of Delta Water Supplies

Based on past occurrences and projected trends, a number of scenarios could occur under which Delta water supplies would be reduced, possibly by a substantial amount. The following provides a brief discussion of several key scenarios. The three scenarios contributing to water supply reductions are regulatory actions and policy decisions, selection of a No-Action Alternative, potential abrupt, short-term reductions (such as levee failure), and potential mid- to long-term reductions (from climate change.)

5B.2.1 Future Regulatory Actions or Policy Decisions

5B.2.1.1 Actions under the Federal and State Endangered Species Acts

As discussed above, both the USFWS and NMFS are in the process of developing new biological opinions on the operations of the CVP and SWP. Future opinions could impose new conditions that could further restrict the amount of exports or the timing of exports from the south Delta. Future DFG Incidental Take Permits could also restrict the amount of exports or the timing of exports. Additional species could be added to federal and state lists of endangered and threatened species resulting in further restrictions.

5B.2.1.1.1 SWRCB Delta Water Quality Objectives and Flow Criteria

D-1641 implements the objectives set forth in the SWRCB's 1995 Bay-Delta Plan and imposes flow and water quality objectives upon projects to protect beneficial uses in the Delta. The objectives could change if the SWRCB revisits them per petition or as a consequence of revisions to the Plan, which could result in changes in the amount of water from the Bay-Delta that is available for export/delivery.

The SWCRB is currently (1) reviewing and updating water quality objectives, including flow objectives, and the program of implementation in the 2006 Bay-Delta Plan (California State Water Resources Control Board 2006); and (2) making any needed changes to water rights and water quality regulation consistent with the program of implementation.

The first phase of the review of the Bay-Delta Plan focuses on water quality objectives for the protection of southern Delta agriculture; San Joaquin River flow objectives for the protection of fish and wildlife; and the program of implementation for achieving those objectives. The second phase is examining whether changes are needed related to: (1) Delta outflow objectives, (2) export/inflow objectives, (3) Delta Cross Channel Gate closure objectives, (4) Suisun Marsh objectives; (5) potential new reverse flow objectives for Old and Middle rivers; (6) potential new floodplain habitat flow objectives; (7) potential changes to the monitoring and special studies program, and (8) other potential changes to the program of implementation. The comprehensive update of the Bay-Delta Plan is expected to be completed in 2013.

In 2009, in response to the Revised Notice of Preparation for the BDCP EIR/EIS, the SWRCB requested that a reduced diversion alternative be analyzed to inform the SWRCB and others of the potential tradeoffs between water exports and protection of fish and wildlife beneficial uses. The SWRCB suggested that the:

> …reduced diversion alternative should be lower than diversions allowed for in the current delta smelt biological opinion and … salmonid and green sturgeon biological opinions for the Long-Term CVP and SWP Operations, Criteria, and Plan (California State Water Resources Control Board 2009a).

The SWRCB subsequently provided additional information on this suggested alternative, which was characterized as Enhanced Spring Delta Outflow, and would provide additional Delta outflow in all water year types and modify Delta inflows to promote a more natural hydrograph in order to promote abundance and productivity of longfin smelt and other estuarine species.

In 2010, the SWRCB received a report that evaluated flow criteria for the Delta in response to SBX7-1, which amended the California Water Code[2]. Based on various assumptions, the criteria would increase outflow from the Delta and inflow from the Sacramento and San Joaquin rivers, including their tributaries as follows:

- 75% of unimpaired Delta outflow from January through June;
- 75% of unimpaired Sacramento River inflow from November through June; and
- 60% of unimpaired San Joaquin River inflow from February through June.

[2] Water Code § 85086(c)(1): For the purpose of informing planning decisions for the Delta Plan and the Bay Delta Conservation Plan, the board shall, pursuant to its public trust obligations, develop new flow criteria for the Delta ecosystem necessary to protect public trust resources. In carrying out this section, the board shall review existing water quality objectives and use the best available scientific information. The flow criteria for the Delta ecosystem shall include the volume, quality, and timing of water necessary for the Delta ecosystem under different conditions.

The SWRCB report does not adopt these criteria; as such action could only occur after a long public process involving stakeholder input and environmental review. The report cautions, moreover, that the flow criteria do not reflect any consideration of any balancing of resource protection with public interest needs for water supply. The report states that sufficient information was considered to support the need for increased flows to protect certain ecological public trust resources, but the report also describes significant uncertainty in establishing specific numeric Delta flow criteria. It also includes a specific caution:

> In order for any flow objective to be reasonable, the State Water Board must consider and balance all competing uses of water in its decision-making. More broadly, the State Water Board will factor in relevant water quality, water rights, and habitat needs as it considers potential changes to its Bay-Delta objectives. Any attempts to portray the recommendations contained in this report as an indicator of future State Water Board decision-making ignores this critical, multi-dimensional balancing requirement and misrepresents current efforts to analyze the water supply, economic, and hydropower effects of a broad range of alternatives (California State Water Resources Control Board 2010).

Updated flow objectives, along with water rights proceedings to implement these flow objectives, are expected to be completed by 2014. Development of flow criteria for high-priority Delta tributaries is expected by 2018.

Although neither the BDCP scoping comments nor the report on Delta flow objectives represents a specific action, if the BDCP process fails, the SWRCB may act to further reduce exports of Delta water supplies via the Delta flow objectives or revisions to the Bay-Delta Plan.

No Action Alternative Analysis of Responses to Reduced Water Supply

The assumptions that form the basis of the No Action Alternative are outlined in Chapter 3, Section 3.5.1 and described in detail in Appendix 3A, *Alternatives Development Report [in preparation*]. Additional information on the specific elements of existing programs and facilities that are included in the No Action Alternative are provided in Appendix 3D, Table 3D-1. The assumptions used to define the No Action Alternative include existing conditions, programs that were adopted during the early stages of development of the EIR/EIS, facilities that are permitted or under construction during the early stages of development of the EIR/EIS, and changes due to climate change that would occur with or without the proposed action or alternatives. Together, these assumptions represent continuation of the existing plans, policies, operations and conditions that represent continuation of trends in nature.

Since south of Delta water supplies already have been reduced from previous levels, continuing with no project would likely result in the continuation of those reductions. In addition, as discussed above, other regulatory actions could further reduce exports from the south Delta. For example, Table 3D-1 includes an acknowledgement that SWP and CVP water rights could be affected “per water rights and SWRCB Decisions for Existing Facilities.” In addition, if the No Action Alternative were implemented, there is a potential for regulatory agencies (USFWS, NMFS) to reopen consultation for continuing operations of the SWP and CVP under Section 7 of the federal ESA depending on the status of listed species. Additional regulation could also be imposed by the California Department of Fish and Game under the California ESA.

5B.2.1.1.2 BDCP Water Supply Analysis

The Preliminary Draft EIR/EIS water supply analysis (Chapter 5, February 2012) focuses on changes to water supply for SWP and CVP water users since BDCP alternatives would modify the operations of the SWP and CVP facilities but would not modify the operations of water resources facilities owned and/or operated by other water rights holders (Section 5.3.1.1). The analysis assumes that SWP and CVP water supply operations are managed to meet instream flow requirements, water rights agreements (including Delta rights holders); and refuge water supply agreements in a consistent manner under existing conditions, the No Action Alternative, and proposed alternatives (Section 5.3.1.1). The primary factors considered in the analysis are Delta outflows and SWP/CVP reservoir storage.

Figure 5-4 in Chapter 5, *Water Supply*, illustrates how Delta exports and water deliveries to the SWP and CVP contractors have increased since the CVP initiated water deliveries in 1956. It characterizes trends in annual Delta exports for the period 1956 through 2009 for CVP, SWP, Contra Costa Water District, and the North Bay Aqueduct. As noted in the Preliminary Draft EIR/EIS (p. 5-22), California water demand has continued to increase as a consequence of population growth, expanded agricultural production, and more recently, the dedication of water supplies for environmental (refuge) needs.

5B.2.1.2 Potential Effects on the Export of Delta Water Supplies from Regulatory Actions

As discussed above, the combined effects of the CVPIA, D-1485, Bay-Delta Plan, and D-1641, coupled with ESA requirements, have reduced CVP south of Delta deliveries by approximately 30 percent since their implementation. The 2008 USFWS and 2009 NMFS biological opinions have resulted in an approximately 12 to 15 percent reduction in SWP exports from the Delta (in addition to reductions from prior regulatory actions), and it is reasonable to assume that similar reductions were experienced by the CVP. Although it would be speculative to quantify future changes resulting from the pending and possible future regulatory actions or policy decisions described above, it is reasonable to assume that Delta water exports and supplies could be further reduced.

5B.2.2 Potential for Abrupt Disruptions of South of Delta Water Supplies

The levee system in the Delta is composed of approximately 1,100 miles of levees in the Delta and another 230 miles of levees in the Suisun Marsh area (California Department of Water Resources 2012b). Some of these are project levees that are part of the State Plan of Flood Control (SPFC) and subject to state and federal oversight and regulation. The majority of Delta Levees are non-project levees, built and improved by local interests, primarily to drain islands and tracts in the Delta so they could be put into agricultural use (California Department of Water Resources 2012b); they also serve other purposes, including preservation of water quality and conveyance for export water flows. These levees were built without State and/or federal assistance but have status under California Water Code. The non-project levees are under the jurisdiction of public agencies (reclamation districts) and eligible for State assistance due to their acknowledged special benefits to State interests. There are also other levees that may be owned by private or public entities that do not have the same eligibility status as the Delta's non-project levees. Emergency preparedness and response is primarily a local responsibility, although State assistance is available after local entities have reached their capacity to respond. The federal government may also have an interest due to public safety, environmental and socioeconomic concerns.

The construction of levees in the Delta began about 150 years ago. Delta levees are vulnerable to failure because they continuously hold back water and most were built with soils dredged from nearby channels and were not subject to engineering standards. Because the land on many Delta islands is currently 25 feet or more below sea level, deep flooding could occur at any time due to a levee failure event. Such an event could degrade the quality and disrupt the availability of Delta water (California Department of Water Resources 2012a).

Levee failure can result from many causes, including the combination of high river inflows, high tide, and high winds, or seismic events. Levees can also fail in fair weather—even in the absence of a flood or seismic event—in a so-called "sunny day event." Damage caused by rodents, piping (in which a pipe-like opening develops below the base of the levee), or foundation movement can cause sunny-day levee breaches (California Department of Water Resources 2012a).

A breach of one or more levees and the associated island flooding could affect Delta water quality and SWP and CVP operations. Depending on the hydrology and the size and locations of the breaches and flooded islands, salt water may be pulled into the interior Delta from Suisun and San Pablo bays. When certain islands are flooded, Delta exports may need to drastically decrease or even cease to avoid drawing saline water toward the Banks and Jones pumping plants.

Although the condition of the Delta levees is improving due to the investment of State funds, the failure of an individual levee could happen at any time because the Delta islands are below sea level. Such a sunny day failure occurred in 2004 on Middle River, which flooded Upper and Lower Jones Tract, inundating 12,000 acres of farmland with about 160,000 acre feet (AF) of water. Following the levee break, Delta export pumping was curtailed for several days to prevent the intrusion of saline water into the Delta. Water shipments down the California Aqueduct were continued through unscheduled releases from San Luis Reservoir. Also, Shasta and Oroville reservoir releases were increased to provide for salinity control in the Delta (URS Corporation and Benjamin & Associates 2008a).

According to the Delta Risk Management Strategy (DRMS), Phase 1: Risk Analysis (URS Corporation and Benjamin & Associates 2008b), the risk of levee failure in the Delta is significant. Since 1900, 158 levee failures have occurred (URS Corporation and Benjamin & Associates 2009). Some islands have been flooded and recovered multiple times. A few islands, such as Franks Tract, have never been recovered.

Levee failures may be isolated events that affect only a single island, or they may involve multiple islands at the same time. The potential for a single-island event to affect conveyance depends on the location of the island, the conditions in the Delta, and timing of the event. The failure of an island located along current conveyance routes (e.g., Old and Middle rivers) could have a much greater effect on Delta water exports than a failure at some other locations. In addition, because the operation of the export pumps varies over the course of a year, the effects of a single-island levee failure event on conveyance would vary from no effect to disruption of pumping for several days or weeks, according to the time of year at which it occurred.

As noted above, sea-level rise could result in an increased risk of levee failure if the levees are not maintained and improved to accommodate the additional load. However, the State has programs and partners in the local agencies to support necessary levee improvements to minimize any increase in risk. It will be important to continue supporting these programs and to provide funds for the improvement of the levees in order to minimize the potential for inundation of the Delta islands. Without the programs and funding the potential effects on Delta water supplies could be very significant.

5B.2.2.1 Seismically Induced Levee Failures

The Delta is in an area of moderate seismic risk. A moderate to strong earthquake could cause simultaneous levee failures on several Delta islands, with resultant island flooding. The potential for levee failure to result from a seismic event was the subject of analyses conducted by the CALFED program and Phase I of the Delta Risk Management Study (DRMS). In 2002, the Working Group on California Earthquake Probabilities estimated that an earthquake of magnitude 6.7 or greater has a 62 percent probability of occurring in the San Francisco Bay Area before 2032, and could cause 20 or more islands to flood at the same time (URS Corporation and Benjamin & Associates 2009).

As discussed in the DRMS analysis, a major earthquake could flood many islands simultaneously, which would result in the influx of saline water into the Delta and could require the immediate cessation of water exports. The subsequent repair of levee breaches after the earthquake could require several months, after which the Delta would have to be restored to a fresh condition. Freshening the Delta could involve releases from upstream reservoirs to flush saline water from the Delta. Emergency provisions of existing laws may be used in order to provide the ability to pump water for SWP and CVP to avoid or minimize adverse health and safety effects resulting from the reduced water supply conditions related to a seismic event.

5B.2.2.2 Flood-Related Failures

The potential for a flood event to result in damage to levees, structures, and result in the loss of life has been evaluated in several studies, including DRMS and the Central Valley Flood Protection Plan (California Department of Water Resources 2011b). Generally, these studies have focused on characterizing the potential flood risk, estimating the extent of flood damage, and describing options to mitigate flood risks and reduce flood damage. Storm-related flooding tends to fill the Delta and Suisun Marsh with fresh water, thereby making disruption of the export supply less likely. The 2009 SWP Reliability Report (California Department of Water Resources 2010a) acknowledges the potential for disruption of Delta exports from a flood event would depend on the number of flooded islands, the timing and size of the flood flows, and the water quality in the Delta and Suisun Bay at the time of the flood.

In the future, increased ambient air temperatures are expected to alter precipitation and runoff patterns, such as a rise in snow line elevations, earlier snowmelt occurrence, more precipitation falling as rain instead of snow, and reductions in the volume of overall snowpack. Increased ambient air temperatures also are expected to result in sea level rise, which, if not addressed, would increase flood risk in coastal areas, including the Delta (Heberger et al. 2009). The current State programs, including Delta Levees Subventions and Delta Special Flood Control Projects Programs provide funding to reclamation districts to help with Delta levee system maintenance, repair, and levee improvement. These programs will become more important to ensure export water quality and water system conveyance through the Delta as hydrologic conditions associated with sea level rise and global climate change advance.

The combination of earlier snowmelt and shifts from snowfall to rainfall could increase flood peak flows and flood volumes (California Department of Water Resources 2012b), which will require modification of the Delta levee system to account for the associated increased flood risk. Higher snow lines could increase flood risk because more watershed area contributes to direct runoff (California Department of Water Resources 2008b).

Funding from the Delta Levees Subventions and Delta Special Flood Control Projects Programs have assisted reclamation districts with system maintenance, levee repairs, and levee improvements, which have improved overall levee performance in the Delta. The annual funding has ranged from 2 million to 50 million dollars. Continued funding of those programs would likely result in additional improvements to levee performance. However, the cost of a comprehensive program to manage risk across the Delta has been estimated at between $10.5 and $17.5 Billion (URS Corporation and Benjamin & Associates 2011). Costs of this magnitude likely exceed the funding ability of local reclamation districts and may not be available from the State or federal governments. Thus, the ability to implement widespread levee improvements in advance of anticipated increases in flood peaks or sea-level rise or due to climate change is uncertain.

As noted above, the potential consequences for water exports as a result of a levee failure during flood conditions would depend on the specific levee reach and its relation to export conveyance. Since the Delta and Suisun Marsh will contain significantly more fresh water, the potential for salt contamination and any need to curtail exports for water quality reasons is reduced. However, once flood flows subside, saline water would be expected to re-enter the Delta system. The levee breaches remaining after the flood could have altered flow patterns in the Delta and would have to be evaluated for their effects on exports and in-Delta water quality. Where adverse effects remain, closure of the breaches would restore the function of the levee system in preserving water quality and conveyance. It is unlikely that a single-island failure during flood conditions could result in a reduction or disruption to Delta water exports, although it is possible that multiple-island levee failure events, unless repaired, could affect water exports for a longer period.

5B.2.2.3 Potential Effects on the Export of Delta Water Supplies from Levee Failures

In the past several years, DWR, USACE, the Delta Protection Commission, and local agencies have worked to improve the response to an in-Delta flood emergency, such as a levee failure. As a result, DWR and local agencies are better prepared to respond effectively through improved planning and coordination and the stockpiling of materials. Thus, in the event of a threatened levee breach, local agencies will respond immediately and will notify the County Office of Emergency Services and DWR Flood Center of an event. If needed, additional supplies and support are available. If a levee breach were to occur on a single island (such as occurred at Jones Tract), a unified response effort would be pursued. As part of the implementation of that response, planning teams consider impacts on systems, including the export water system. If the export water system were compromised, restoration of its full function would be incorporated into the response plan so that repairs could be completed in a relatively short timeframe (e.g., a few weeks or months). Thus, for most single-island events, the effect on Delta water exports would generally be limited to a relatively short interruption, until it is confirmed that the resumption of exports would not draw saline water into the Delta.

Various analyses have been undertaken to understand the risk and probability of a more widespread levee failure event, and to determine the potential impact to conveyance of water across the Delta. This included DRMS, an action envisioned by the CALFED ROD in 2000, which provided data to meet the requirements of Assembly Bill (AB) 1200 (California Department of Water Resources and California Department of Fish and Game 2008). Adopted by the legislature in 2005, AB 1200 amended the California Water Code[3] to require that DWR conduct an analysis of the potential for potential impacts on Delta water supplies from subsidence, earthquakes, floods, and changes in precipitation, temperature, and ocean levels. For further discussion of impacts of seismic risks and climate change see Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies*.

5B.2.3 Potential for Mid- to Long-Term Disruptions of South of Delta Water Supplies from Climate Change

Over the next several decades, changes in precipitation, snowpack, and runoff patterns could reduce the availability of Delta water supplies. Increases in ambient air temperatures would increase water demand, as additional irrigation water would likely be required for urban landscapes and agricultural uses. Sea-level rise would increase the amount of saline water that enters the Delta from tidal forces, which could reduce the ability to convey water across the Delta to the south Delta export facilities. These changes are anticipated to occur over the mid- to long-term, and increase in magnitude over this period. It is likely that changes in precipitation could result in more severe flood events. (See Table 5B-1 for information on the types and lengths of disruptions).

The 2009 SWP Delivery Reliability Report (California Department of Water Resources 2010a) concluded that the operational restrictions imposed by the USFWS and NMFS biological opinions in addition to the incorporation of potential climate change impacts results in an estimated additional reduction of 970 taf when compared to the median value for annual SWP deliveries for Future Conditions in the 2005 SWP Delivery Reliability Report (3,570 taf) (which did not include climate change).

As shown in the 2011 SWP Delivery Reliability Report (California Department of Water Resources 2012a), under future conditions, the average annual delivery of Table A water is estimated to be 2,466 taf/year, about 1% less than the 2,487 taf/year estimate for the future-conditions scenario presented in the 2009 Report. The estimated average annual SWP exports decrease from 2,600 taf/year to 2,524 taf per year (86 taf/year or about 3%) between the existing- and future-conditions scenarios presented in the 2009 Report.

[3] California Water Code § 139.2: The department shall evaluate the potential impacts on water supplies derived from the Sacramento-San Joaquin Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts on the delta: (1) Subsidence; (2) Earthquakes; (3) Floods; (4) Changes in precipitation, temperature, and ocean levels; (5) A combination of the impacts specified in paragraphs (1) to (4), inclusive.

Table 5B-1. Summary of Potential Conveyance Disruptions to Exports of Delta Water Supplies

		Potential Geographic Extent			Potential Effect on Conveyance			Potential Length of Disruptions		
Type of Disruption or Reduction	Potential Time Horizon	Single Island	Multiple Islands	Delta Wide	Little of None	Reduction	Complete Loss	Days	Months	Years
Levee Failure										
Sunny Day (e.g., Jones Tract)	Anytime, due to existing levee conditions	✓			✓	✓		✓		
Flood-Induced	Any rainy season, with potential to increase over time if levee maintenance programs are not supported	✓	✓	✓	✓	✓		✓	✓	
Seismic-Induced	Anytime, with increased probability over time	✓	✓	✓	✓	✓	✓	✓	✓	✓
Climate Change Effects										
Sea Level Rise	Mid- to long-term (e.g., 25 to 50 years)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Changes in Precipitation and Runoff	Mid- to long-term	✓	✓	✓	✓	✓		✓	✓	✓
More Severe Flood Events	Mid- to long-term	✓	✓	✓	✓	✓		✓	✓	✓

5B.2.3.1 Potential Disruptions from Changes in Precipitation Patterns and Sea Level Rise

Similar reductions are anticipated for the CVP. The Biological Assessment prepared by Reclamation for the Operational Criteria and Plan (OCAP) (U.S. Bureau of Reclamation 2008) noted that:

> …future warming would be expected to cause greater fraction of annual runoff to occur during winter and early spring and reduced fraction of annual runoff to occur during late spring and summer. This relates to how warming leads to more rain and less snow, more rainfall-runoff during winter and early spring, and less snowmelt volume during late spring and summer (U.S. Bureau of Reclamation 2008).

In the future, increased ambient air temperatures are expected to alter precipitation and runoff patterns, such as a rise in snow line elevations, earlier snowmelt occurrence, more precipitation falling as rain instead of snow, and reductions in the volume of overall snowpack. Increased ambient air temperatures also are expected to result in sea level rise, which would increase flood risk in coastal areas, including the Delta (Heberger et al. 2009). The combination of earlier snowmelt and shifts from snowfall to rainfall could increase flood peak flows and flood volumes (California Department of Water Resources 2012b), which is likely to affect associated flood risk. Higher snow lines could increase flood risk because more watershed area contributes to direct runoff. In addition, higher snow lines could increase erosion rates that would result in greater sediment loads and turbidity, altering channel shapes and depths, and possibly increasing sedimentation behind dams and affecting habitat and water quality (California Department of Water Resources 2008b).

With respect to potential effects of climate change on CVP/SWP operations, the Reclamation 2008 report summarized modeling results as follows:

> Sea level rise impacts on salt water intrusions result in a significant decrease in both CVP and SWP deliveries, ignoring the effects of regional climate change. Sea level rise also leads to greater salinity intrusion into the Delta, indicated by simulated X2 results (U.S. Bureau of Reclamation 2008).

More detailed discussions on the effects on delta water supplies from climate change can be found in Appendix 29 A, B, and C (29A,. *Climate Change Effects on Hydrology in the Study Areas used for CALSIM Modeling Analysis*; 29B, *Climate Change and the Effects of BDCP Reservoir Operations on Water Temperatures in the Study Area*; 29C, *Effects of Sea Level Rise on Delta Tidal Flows and Salinity*) These appendices are dedicated to climate change and sea level rise impacts on water within the study area.

5B.2.3.2 Potential Effect on the Export of Delta Water Supplies from Climate Change

Climate change would have multiple effects on water resources and will likely reduce the reliability, by reducing the probability of full water deliveries, of the SWP and CVP water supply systems (California Department of Water Resources 2012a).There are several potential climate change effects on water supplies in the study area (upstream, Delta, and CVP and SWP service areas). Some climate change effects on water supplies include reduced precipitation/runoff volumes, shift from snowfall to rainfall, increased evapotranspiration, increased frequency/severity of flood events, increased frequency/severity of droughts, and increased salinity intrusion. All of these situations could severely impact south of Delta water supplies.

5B.2.4 Summary of Potential Effects on Delta Water Supplies from Levee Failures and Climate Change

The types of potential disruptions or reduction to Delta export water supplies, the potential geographic extent of those disruptions, the effect on conveyance or export water supplies, and the potential length of these disruptions are summarized in Table 5B-1.

5B.3 Responses to Reductions or Disruptions of Delta Water Supplies South of the Delta

Reductions or disruptions to Delta water supplies covered in this document include three general scenarios: (1) near-term reductions in the export of Delta water supplies (due to regulatory and/or policy decisions); (2) an abrupt disruption of exports (such as levee failure); and (3) mid- to long-term reductions in south of Delta water supplies as a result of climate change.

The near-term and abrupt disruptions described above would occur with little or no advance notice. Abrupt reductions resulting from regulatory and/or policy decisions would leave water agencies with little opportunity to proactively implement measures that might ameliorate the impacts of a supply reduction or disruption (beyond those measures that have already been implemented, such as the expansion of both groundwater and surface storage south of the Delta). Disruptions from levee failure would be dependent on the extent of the damage. Disruptions lasting days or months would have limited impacts on water supplies, but those of longer duration could have consequences similar to those described for regulatory/policy decisions. A long-term reduction in south of Delta water supplies due to climate change would likely occur over several decades, and thus water agencies could plan and implement appropriate measures. It is assumed that future reductions or disruptions of south of Delta water supplies would be shared between SWP and CVP contractors per existing delivery agreements and contracts and that could affect the timing of water deliveries.

The following discussion describes potential responses from urban and agricultural water contractors for these three general scenarios.

5B.3.1 Responses to Further Regulatory Reductions in Exports of Delta Water Supplies

5B.3.1.1 Urban Responses

Exports of Delta water supplies already have been reduced as a result of legislative and regulatory actions, with estimated reductions of approximately 15% for the SWP as a result of the 2008 USFWS and 2009 NMFS biological opinions and 30% for CVP as a result of legislative actions; additionally, the CVP also has experienced reductions assumed to be similar to those of the SWP as a result of the 2008 USFWS and 2009 NMFS biological opinions. Additional regulatory actions could result in further reductions, although a specific estimate would be difficult to quantify. Prior responses from urban water agencies in periods of drought provide useful examples of how those agencies could respond to further reductions of Delta water supplies. Reductions that occur as a result of regulatory or policy decisions are likely to remain in place for some time (unless and until some alternative program or projects can address the underlying issues which were the impetus for the regulatory action). Thus, it is likely that any such reductions would at a minimum remain in place for a period of years, or could essentially be permanent.

The effect on individual water agencies would vary considerably, as some are almost entirely reliant on exports of Delta water supplies, while for others these sources provide only a portion of their water supply portfolios, and other water sources could remain available. For example, in 2010, supplies exported from, or diverted in, the Delta comprised approximately 89 percent of the total water supplies for the Zone 7 Water Agency (Zone 7 Water Agency 2010), while the SWP provides less than 30 percent of water supplies for Metropolitan.

The timing of the reduction would also influence the potential response: if the reduction occurred during an ongoing drought, the response would be more significant than if it occurred during a period of above-average precipitation, when water agencies would likely have more options available. However, as any such reductions would remain in place for a considerable period, it is assumed that most urban water agencies would likely proceed cautiously.

5B.3.1.1.1 Voluntary Conservation

The most likely response from urban agencies would be to convey a request to the public at large and other water users for voluntary conservation. Such communications would likely convey the significance of the reduction, describe the availability of other water resources, and provide information on how to implement additional conservation measures. However, as many urban agencies have well established conservation programs, their prior success may limit the ability to substantively expand conservation measures due to "demand hardening," in which customers lose the ability to easily institute emergency conservation during drought or other crises because they have already captured all their conservation savings (California Department of Water Resources et al. 2010). The State of California's plan to reduce per capita water consumption by 20 percent by the year 2020 will result in the widespread implementation of water conservation measures across the state (California Department of Water Resources et al. 2010). Additional demand reductions beyond the 20 percent mandated in that plan could be more difficult, as it would require additional capital investments and may achieve incrementally smaller results. Ultimately, more significant water conservation may also require substantial lifestyle and behavioral changes by urban water users (e.g., elimination of turf grass lawns) that may not be readily accepted by the public. However, given recent experience in Australia, the implementation of water rationing and other demand management measures can achieve substantial reductions in per capita water use (Cahill and Lund 2011).

5B.3.1.1.2 Reservoir Storage

Many urban water agencies (e.g., Contra Costa Water District, the Metropolitan Water District of Southern California, Santa Barbara County Flood Control and Water Conservation District, San Luis Obispo County Flood Control and Water Conservation District) include water held in storage in reservoirs as part of their overall supply. Some of these agencies store water provided through the SWP and CVP systems, while others store local supplies. Although some urban water agencies can call upon this water with little notice, it is likely that agencies would be very cautious about using surface storage to replace lost supplies. The availability of such supplies is not always assured, given the variability of precipitation patterns and the timing of a supply reduction, as some reservoirs provide seasonal storage, with substantial declines in supplies during the summer and early fall. Further, utilization of water supplies in reservoirs would reduce the potential for withdrawals in subsequent years, especially if drought conditions diminished the anticipated reservoir replenishment from winter rains. In addition, drawdown of storage may leave agencies vulnerable in the event of other local supply emergencies, such as those that result from pipeline or other equipment failures.

5B.3.1.1.3 Groundwater

Urban water suppliers could also elect to expand reliance on groundwater; however, this is not possible in areas served by adjudicated basins, located primarily in Southern California, and the ability to expand groundwater utilization would depend on groundwater levels and the capacity of infrastructure needed to pump, treat, and deliver the water. Over the long-term, cumulative impacts associated with expanded reliance on groundwater could include subsidence and lowering of groundwater levels, which could have adverse effects on instream flows, springs or artesian wells fed by groundwater and riparian and wetland vegetation that is dependent on groundwater.

5B.3.1.1.4 Contingency Plans

As reductions in exports of Delta water supplies could be substantive and in place indefinitely, water agencies could be forced to implement water shortage contingency plans, such as those mandated in by DWR's Urban Water Management Plan (UWMP) guidelines (California Department of Water Resources 2011a). For example, Santa Clara Valley Water District's 2010 UWMP describes a range of actions and implementation triggers, identifies mandatory prohibitions on water use, penalties or charges for excessive use, and actions that could be implemented to reduce the length of a catastrophic interruption to water supplies (Santa Clara Valley Water District 2010).

The type of actions that urban agencies might implement could include across-the-board reductions in water deliveries (e.g., to retail agencies), curtailment of certain water uses, such as groundwater replenishment or deliveries to customers with interruptible supplies (which may include local agricultural users), or to reduce the amount of water available for in-stream water uses in some locations. As many urban agencies currently take advantage of the availability of "surplus" SWP (or Article 21) water to augment native groundwater replenishment, it is likely that surplus water would be unavailable if additional reductions in exports of Delta water supplies occurred, and thus long-term decline of groundwater levels could result in some basins.

5B.3.1.1.5 Recycled Water

Expansion of recycled water use is another likely response to potential future supply reductions. The experience with, and application of, recycled water programs varies considerably across California, with substantial use in some portions of Southern California (e.g., Orange and Los Angeles counties) and little or none in other areas. The potential for substantial expansion of recycled water use may exist in many areas, but the capital costs associated with implementation can be substantial, and are driven by the proximity of recycled water sources to potential uses, which traditionally have included industrial processes and landscape irrigation. Further expansion is also limited by public perceptions and concerns about the salt buildup, as recycled water typically has a higher content of minerals and salts than the original source water. This has resulted in the move toward salt management plans particularly in watersheds were local water supplies already have elevated levels of dissolved solids (often termed "hard" water). The SWRCB's recycled water policy finds that salt and nutrient issues can be appropriately addressed through the development of regional or subregional salt and nutrient management plans (California State Water Resources Control Board 2009b). One such mechanism for such planning is their incorporation into Integrated Regional Water Management (IRWM) plans, as those plans are required to consider the Resource Management Strategies included in the 2009 (and subsequent) updates of the California Water Plan (California Department of Water Resources 2011c).

5B.3.1.1.6 Water Transfers

Water transfers in California would be more likely in the event of a further reduction to exports of Delta water supplies. However, because of such reductions in exports of water from the Delta, there would be a reduction in pumping in the south Delta. So, the potential for water to be transferred from areas that are north of the Delta to areas south of the Delta could decline sharply in some years. Such water transfers might no longer be feasible in some cases. However, increased east-to-west water transfers could be expected to occur between water agencies and water users located south of the Delta, such as within the SWP/CVP service area. These new south-of-Delta water transfers could also occur in areas which use Colorado River water, and would most likely involve the transfer of water from agricultural agencies to urban water agencies. Some new short-term transfers might include south-to-north transfers within the San Joaquin Valley or from Southern California to the San Joaquin Valley. Many new water transfers could involve conjunctive use agreements, groundwater banking or groundwater substitution, farmland fallowing, and multi-year transfer agreements. Some water transfers might even involve the retirement of irrigation on certain farmlands and the transfer of water rights.

Because most of these transfers would be a response to a long-term trend, it is possible they would be implemented for significant periods of time, which could result in long-term farmland fallowing programs – or even the permanent retirement of some irrigated agricultural lands. For example, between 1989 and 2009, the amount of fallowed or retired land in the service area of the San Luis-Delta Mendota Water Authority more than doubled as water supplies were reduced by drought conditions and as a result of regulatory actions (San Luis & Delta-Mendota Water Authority 2009).

5B.3.1.1.7 Desalination

Projects to desalinate seawater or brackish groundwater could also be a long-term response to the further reduction of Delta water supplies as part of a larger portfolio approach that includes the other responses listed above (California Department of Water Resources 2003). However, because of the high price tag and extensive time generally required to plan, permit, and construct new desalination facilities and their associated distribution infrastructure, it is highly unlikely that such actions would be available quickly (California Department of Water Resources 2008a). For example, the Bay Area Regional Desalination Project is underway with the goal of providing a reliable water source during contract delivery reductions using water from the Delta withdrawn from eastern Contra Costa County. Pre-feasibility studies began in 2003 and construction is scheduled for 2018–2020 with a low-end estimate of $150 million for a 20-million-gallons-per-day capacity project (www.regionaldesal.com). Also, saline water desalination tends to be an expensive and energy-intensive source of water. See the Public Policy Institute of California (PPIC) Report, California Water Myths, for a cost comparison table of desalination to other responses to water supply reduction (Public Policy Institute of California 2009). There are also environmental impacts and associated potential mitigation measures to consider, including concentrated brine and chemical discharges to the marine environment, the emissions of air pollutants, and the energy demand of the process (Lattemann and Hopner 2008). However, the further reduction of Delta export water supplies may push the initiation of desalination projects in California.

5B.3.1.1.8 Water Use Restrictions

Depending of the magnitude of the water supply reduction and the availability of other supplies, the imposition of more severe restrictions on urban water use could be implemented (such as the prohibition of landscape irrigation), or in more dire situations, sharp water rate increases or water rationing could be implemented. However, most SWP and CVP contractors operate as wholesale water agencies and therefore lack the direct authority to restrict the specific use of treated water at the individual customer level. These agencies could work with local water retailers to implement strong demand management measures, including rationing, at the discretion of the water retailers.

Such strong demand management measures would likely have significant negative socio-economic impacts. Some water-intensive businesses may struggle, go bankrupt, or leave the state. Some businesses and wealthy home-owners would simply drill their own wells, rather than be subject to the strong demand management measures of their local water retailers. This could worsen groundwater overdraft in certain south-of-Delta water basins. Some businesses would choose not to locate, or expand operations, in California. Some small Southern California farmers who irrigated with treated water could be forced to sell out to developers. Certain populations, such as recent retirees, would be less likely to remain or move into the south-of-Delta region.

Many water retailers have adopted water shortage contingency provisions, such as those included in the City of Santa Barbara's 2010 Urban Water Management Plan, which identify a range of measures depending on the magnitude of the projected shortfall (which are termed water shortage stages) and are estimated to result in a demand reduction of up to 50 percent (City of Santa Barbara 2011).

5B.3.1.2 Agricultural Responses

This section discusses the impacts on San Joaquin Valley agriculture of reduced water supplies. The San Joaquin Valley is among the most productive agricultural regions in the world, each year generating more than $23 billion in farm output and supporting more than 200,000 jobs. This success can largely be attributed to the availability of water supplies through the Delta and delivered by the SWP and CVP.

Reduced exports of Delta water supplies have already occurred as a result of legislative and regulatory actions, with estimated reductions of 15% for SWP and more than30% for CVP deliveries. Additional regulatory actions could result in further reductions, although a specific estimate may not be feasible, given the multiple options and tools available to regulatory agencies. However, responses from individual agricultural water agencies and agriculture overall, to previous reductions and during periods of drought provide useful examples of how those agencies would respond. Reductions that occur as a result of a regulatory or policy decision are assumed to remain in place for some time. Thus, it is likely that any such reductions would remain for several years or could be permanent.

The responses of water agencies to extended droughts provide good insights into the effects of further reductions in exports of Delta water supplies. The 1987-1992 drought had severe impacts on water agencies. Many purchased water from alternative sources to offset reduced Delta supplies, often at very high costs which some clients were unable to afford. Farmers responded to the resultant higher costs by increasing their own groundwater pumping and reducing their purchases from water agencies, but also fallowed large acreages of both annual and permanent crop land. The financial viability of some water agencies themselves suffered and was reflected in increased credit risks and downgrades by credit rating agencies because of these reduced supplies (Moody's Investors Service 1994).

The effect on individual agricultural agencies would vary considerably, as some are almost entirely reliant on exports of Delta water supplies, while for others these sources provide only a portion of their water supply portfolios, and those other water sources could remain available. For example, during the period of 1978 to 2006, Westlands Water District relied on CVP deliveries for an average of 73 percent of its total supplies (Westlands Water District 2007).

The timing of the reduction would also influence the potential response: if the reduction occurred during an ongoing drought, the response would be more significant than if it occurred during a period of above-average precipitation, as water agencies would have more options available. In prolonged droughts, however, water supply reductions impact agriculture and extend in other directions as well. In many small San Joaquin Valley towns, agriculture is the dominant business sector and employer. The city of Mendota, for example, was devastated by the drought and regulatory water reallocations (Villarejo 1996). The small agricultural towns in the San Joaquin Valley suffered severe losses of output and income and jobs with attendant increases in social service costs.

5B.3.1.2.1 Reservoir Storage

Many agricultural water agencies rely upon water held in storage in reservoirs, and some can call upon this water with little notice. However, given the expectation that a regulatory action would result in a long-term reduction, it is likely that agencies would be cautious about using surface storage to replace lost supplies, as the availability of such supplies is not always assured and some reservoirs primarily provide seasonal storage. Further, utilization of reservoir storage would reduce the potential for subsequent withdrawals and would leave agencies vulnerable in the event of drought conditions or local supply emergencies.

5B.3.1.2.2 Groundwater

In some areas, agricultural agencies or individual land owners could expand reliance on groundwater. However, this is not possible in areas served by adjudicated basins and the ability to expand groundwater utilization would depend on groundwater levels and the capacity of infrastructure needed to pump and deliver the water. Over the long-term, cumulative impacts associated with expanded reliance on groundwater could include subsidence and lowering of groundwater levels, which could have adverse effects on instream flows, springs or artesian wells fed by groundwater, and riparian and wetland vegetation that is dependent on groundwater. The effect of groundwater withdrawals that exceed natural recharge has been well documented in the Tulare Lake Basin, where groundwater levels declined significantly and subsidence on the order of 20 feet occurred over a wide area (Central Valley Regional Water Quality Control Board 2006).

Previous studies have shown the severe effects on San Joaquin Valley agriculture resulting from prolonged reductions in Delta water exports. The studies, by authors in both the public and private sectors and spanning more than 30 years, have shown clearly how reliant San Joaquin Valley agriculture is on Delta supplies. DWR analyzed the effects of the 1991 drought in California (California Department of Water Resources 1991). In that year, CVP supplies were reduced by 25 to 75 percent. SWP deliveries to Feather River water rights contractors were reduced by 50 percent, while no agricultural deliveries of SWP water were made elsewhere (including the San Joaquin Valley). Some 455,000 acres of cropland were idled throughout the state, resulting in a loss of $500 million in farm output. Another study found that for the single drought year of 1992, 172,000 acres of cropland were not farmed or abandoned and another 33,300 acres had reduced yields. Farm revenues fell by $157 million, water costs increased by $259 million, and well-related costs rose $80 million. Total income losses exceeded $500 million, and job losses totaled 4,900 (Northwest Economic Associates 1993).

5B.3.1.2.3 Water Transfers

Water transfers are a potential response to a further reduction of Delta water supplies. However, given the historic costs of transferred water, likely competition from urban agencies and infrastructure limitations, the potential for transfers between agricultural suppliers is assumed to be low. Moreover, all agricultural agencies that use Delta exports will be subject to similar limitations. While there have been some transfers among agricultural water agencies based on the willingness of farmers in the service areas to fallow land and not utilize the water which would otherwise be allocated to irrigate the land, that does not represent a viable long-run source of supply. The Westlands Water District estimates that fallowed land will increase from approximately 55,000 acres in 2006 to 125,000 acres in 2020, due to reductions in water supplies as a result of the reallocation of water supplies and other regulatory restrictions (Westlands Water District 2007).

5B.3.1.2.4 Water Conservation Programs

To the extent that utilization of surface storage or groundwater are not viable options, agricultural operations would have no option other than to endure the reduction. Implementation of additional water conservation measures may be feasible in some locations; however, many agricultural operations have already implemented such measures, such as drip irrigation for permanent crops. If additional conservation measures are not feasible, then changes in crop selection or fallowing of lands could occur.

As discussed above in Section 5B.2, current reductions in Delta water supplies have decreased the reliability of water deliveries, particularly for the CVP. As a result of the decreased reliability, changes in crop planting and increased land fallowing have already occurred. Thus, if further reductions in exports of Delta water supplies did occur, it is anticipated that the reliability of water deliveries would decline, and additional adverse impacts on agricultural operations would occur.

The impacts on San Joaquin Valley agriculture of reduced Delta exports attributable to the District Court decisions have been addressed in several studies Based on a report from the American Farmland Trust in 2010, about 200,000 acres of farmland (south of the Delta) were left idle or taken out of production as a result of drought and reduced water deliveries from the Delta. This number would have been much greater if it were not for water transfers from other areas (American Farmland Trust 2010).

Some suggest reduced agricultural water supplies can be remedied by farmers in the San Joaquin Valley switching to less water-intensive crops such as vegetables and fruits and nuts. Converting hundreds of thousands of acres of land historically used to grow cotton, alfalfa, and grains to fruits, nuts, and vegetables would alter market conditions for cotton, alfalfa and grains, which could cause significant supply disruptions in the affected markets. Similarly, prices of fruits, nuts, and vegetables would likely decline as a result of increased supply, which could make continued reliance of those crops infeasible for many agricultural operations.

Thus, it may not be reasonable to assume that rapid, large changes in cropping patterns will occur in response to reduced water supplies. The state and national demands for vegetables and fruits and nuts translate into requirements for many fewer crop acres than the demands for, e.g., alfalfa, cotton, and rice. In addition the cultural practices, machinery, equipment, and establishment costs for permanent crops and cultural and equipment costs for vegetables are much different than those for other crops. While changes in cropping patterns over time have correlated somewhat to reductions in water supplies, cropping practices and patterns are affected by many other factors such as market conditions. As a result, long-term or permanent reductions in agricultural water supplies can reasonably be assumed to have important adverse impacts on local and regional economies.

5B.3.2 Responses to Abrupt Disruptions of Delta Water Supplies

5B.3.2.1 Urban Responses

As discussed above in Section 5B.2.2, abrupt, short-term disruptions of the export of Delta water supplies could result from a levee failure on a single island. Somewhat longer disruptions could result from failure of multiple island levees during an earthquake, flood event, or other disaster, which may require an immediate halt of the export of Delta water supplies. The outage could last days, months, or longer.

The abrupt loss of Delta water supplies could, depending on its duration, substantially affect SWP and CVP operations. However, the extent of the effect would depend on the perceived duration of the disruption. In most instances, a sunny day failure on a single island would result in little or no disruption to Delta water supplies or conveyance capacity. To the extent that a minor disruption does occur, the responses from urban water agencies would be to utilize available resources, including surface and groundwater storage, to avoid service disruptions. If a disruption to Delta water exports extended beyond a few days, urban agencies could call for voluntary conservation measures to temporarily reduce demand during the outage.

More lengthy disruptions would require a more substantive response, which would again depend on the perceived length of the disruption. Following a large-scale event, the full magnitude of the levee failures' impact on the water supply will not be understood for several days, or possibly longer. In addition to public calls for water conservation, most urban agencies would require some time to assess the status of other supply options and to prepare to implement the water shortage contingency plans included in their adopted UWMPs, including those related to a catastrophic water shortage. The then-current hydrologic conditions (e.g., dry, average, or above-average water years) would affect the options available for a response. During drought periods, available options may be limited, while multiple alternatives may be feasible during above average conditions.

5B.3.2.1.1 Reservoir Storage

Many urban water agencies rely upon water held in storage in reservoirs, some of which are part of the SWP and CVP systems, while others provide storage for local uses. Some urban water agencies can call upon this water with little notice, and thus reservoir storage south of the Delta represents an opportunity for an immediate, or very quick, response to a supply reduction or loss. However, the availability of such supplies is not always assured, given the variability of precipitation patterns and the timing of a supply reduction, as some reservoirs only provide seasonal storage, with substantial declines in supplies during the summer and early fall. In addition, the utilization of water supplies in reservoirs is not inexhaustible, and thus the perceived duration of a supply reduction would likely influence the willingness of urban water suppliers to meet demands entirely from storage, as that would reduce the potential for future withdrawals, especially if drought conditions diminish the anticipated reservoir replenishment from winter rains. In addition, drawdown of storage could leave agencies vulnerable in the event of other local supply emergencies, such as those that result from pipeline or other equipment failures.

5B.3.2.1.2 Groundwater

Although not all urban water suppliers have access to groundwater, many utilize groundwater as a supplemental, or in some instances, a major water source. In those locations, reliance upon groundwater during periods of drought is a common practice and it is likely that urban water agencies would utilize this resource to replace lost Delta water supplies. However, the ability to expand groundwater extraction in response to an abrupt, long-term supply disruption would vary considerably, depending on groundwater levels, infrastructure capacity, and whether the underlying basin is adjudicated. Groundwater levels in those basins would be expected to decline as a result, which could have cumulative effects related to subsidence, reduction of stream and spring flows, and adverse effects on the riparian and wetland vegetation dependent on those sources.

5B.3.2.1.3 Water Transfers

Water transfers from sources located south of the Delta represent another likely response to the loss of Delta water supplies. In the event of a disruption in the Delta, this most likely would involve the transfer of water from agricultural agencies to urban water agencies, but would be limited to agricultural agencies located south of the Delta and areas served by the Colorado River. However, water transfers typically require a substantial effort to reach an agreement, both to acquire and transport (or "wheel") the water and to comply with necessary regulatory requirements. Thus, although water transfers may be probable, they are unlikely to be an initial response. In some instances, such transfers would result in the fallowing of agricultural lands.

5B.3.2.1.4 Recycled Water

The substantial expansion of recycled water or the implementation of desalination projects could be a response to the abrupt disruption of Delta water supplies. Because of the time required to plan and construct new plants and their distribution infrastructure, it is unlikely that such actions would be available prior to the resumption of exports of Delta water supplies. However, the loss of Delta water supplies could serve as an impetus for these projects, assuming financing is available. Because the cost of replacement water supplies during an extended Delta outage could be substantial, those costs could limit the ability of some urban agencies to implement new projects.

5B.3.2.1.5 Water Use Restrictions

To the extent that surface storage, groundwater, or water transfers are not viable options, or cannot replace Delta water supplies, or if an extended disruption occurs, urban water agencies may have no option other than to endure the shortage. As many urban water agencies already have contingency plans in place, it is assumed that certain water uses would be curtailed, such as deliveries to customers with interruptible supplies (such as local agricultural users), groundwater replenishment would not occur, and other demand management measures would be implemented. As noted above most SWP and CVP contractors operate as wholesale water agencies and lack the direct authority to restrict the specific use of water at the individual customer level. Urban agencies would have to work with local water retailers to implement most significant demand management measures, including rationing. During the 1986–1991 drought, the City of Santa Barbara implemented a range of measures, including tiered pricing and a ban on watering lawns that ultimately reduced demand by 45 percent (Ferguson and Whitney 1993). The economic impact of an extended loss of Delta water exports would likely be much greater.

5B.3.2.2 Agricultural Responses

By definition, the durations of droughts or other events with comparable effects on Delta water exports are unknown at their inception. Based on the 1987–1992 and 2006–2009 droughts, reduced water supplies can be expected to lead to increased groundwater pumping as well as increased demands for water transfers and other offsetting supplies. In 1992, San Joaquin Valley groundwater pumping increased by 5.528 MAF while surface water deliveries decline 5.921 maf, a net decline of about 400 taf (Northwest Economic Associates 1993). Over the entire 1987–1992 drought, neither groundwater nor water transfers could make up for the entire reduction in surface water supplies.

As discussed above in Section 5B.2.2, abrupt short-term disruptions of the export of Delta water supplies could result from a single levee failure; longer term disruptions may result from a seismic event affecting multiple islands. It is possible that a catastrophic Delta-wide event would require an immediate halt of the export of Delta water supplies and the outage could last a few days, many months, or longer.

In most instances, a sunny day failure on a single island will result in little or no disruption to Delta water supplies. To the extent that a minor disruption does occur, agricultural water agencies would utilize available resources, including surface and groundwater storage, to avoid service disruptions. However, in some instances, minor disruptions to water deliveries could occur.

Extended disruptions would require a more significant and measured response, which would depend on the timing of the event, the perceived length of the disruption, and current hydrologic conditions to determine the appropriate level of action. As discussed above for urban responses, it is likely that the full magnitude of water supply disruption would not be understood for several days, or possibly longer, and thus agricultural water agencies and individual farming operations would assess their individual situations and proceed accordingly. Then-current hydrologic conditions would also influence any potential responses. During drought periods, options would be probably be limited, while multiple alternatives may be feasible during above average water year conditions.

5B.3.2.2.1 Reservoir Storage

Although some agricultural agencies rely upon reservoir storage, because of the immediate impact of a water supply disruption, there could be a desire to quickly expand that utilization. If permanent or row crops are in the ground, short-term decisions may focus on salvaging the value of those crops, even if reservoir drawdowns would reduce the availability of future supplies. Thus, some reservoirs could be depleted, which would reduce their associated future benefits, potentially including hydropower generation and recreation.

5B.3.2.2.2 Groundwater

In areas where groundwater is available (and not adjudicated), agricultural agencies or individual land owners would likely expand their reliance on groundwater to replace lost water supplies. Although reliance on groundwater would be relatively short-term (e.g., three years or less), cumulative impacts from groundwater pumping could include lowering of groundwater levels, subsidence, and reduced water quality, which could have adverse effects on instream flows, springs or artesian wells, and the associated riparian and wetland vegetation. For example, groundwater pumping increased to approximately 600,000 AF annually during 1991 and 1992 in the Westlands Water District because of the drought conditions and regulatory decisions when the District received only 25 percent of its contractual entitlement of CVP water. This increased pumping caused the groundwater surface to decline by 151 feet to 62 feet below mean sea level, the lowest elevation since 1977. DWR estimated the amount of subsidence since 1983 to be almost 2 feet in some areas of the District, with the most of that subsidence occurring since 1989 (Westlands Water District 2007).

Water bank projects have enhanced groundwater storage capacity and availability some parts of the San Joaquin Valley. However, the amount of water stored is finite and must be replaced subsequent to withdrawals. Moreover, recharge of those water banks is limited by the availability of Article 21 and Section 215 water, and some of the water stored in the water banks is committed for urban users in the Bay Area and Southern California and consequently unavailable to agricultural users.

5B.3.2.2.3 Water Transfers

Because the loss of Delta water conveyance would affect both the CVP and SWP, it is unlikely that water transfers would provide substantive relief for agricultural agencies, as competition from urban agencies would likely raise the price of water to levels that would be infeasible for agricultural operations. A more likely scenario would be for transfers to be arranged from agricultural water rights holders located south of the Delta to urban water agencies. As noted above, Westlands Water District estimates that land fallowing will more than double between 2006 and 2020.

5B.3.2.2.4 Water Conservation Programs

Given the immediate impacts of a levee failure event, it is unlikely that agricultural operations could immediately implement conservation measures, as it is unlikely that crops already in the ground could adapt to a new watering regime. Implementation of additional water conservation measures may be feasible in subsequent years. However, many agricultural operations have already implemented such measures in response to previous supply reductions and prior droughts. Measures include the usage of drip irrigation and micro sprinklers as well as increased recovery and usage of tailwater. If additional conservation measures are not feasible, then changes in crop selection or fallowing of lands could occur, although as noted above, market forces can limit the ability to make changes in crop patterns.

Significant declines in CVP deliveries could also result in other changes in water deliveries in the Central Valley. For example, the San Joaquin River Exchange Contractors hold water rights established as early as 1871 to divert water from the San Joaquin and North Fork of the Kings rivers. In cooperation with Reclamation and to facilitate the development of the Friant unit of the CVP, the major farm interests in the San Joaquin Valley (the heirs of Miller and Lux) agreed to "exchange" their pre-1914 appropriative and riparian water from the San Joaquin and Kings rivers for guaranteed deliveries of "substitute" water from the Sacramento River by means of the Delta-Mendota Canal and other facilities of the United States. In normal years, the Exchange Contractors are guaranteed 100% of their contractual water allotment (840,000 AF), and in critical years the amount is 75% (650,000 AF). However, the Exchange Contractors did not abandon their San Joaquin River water rights. Instead, they agreed not to exercise those San Joaquin and Kings rivers' water rights if guaranteed water deliveries continued through the Delta-Mendota Canal or other facilities of the United States. In the event that Reclamation is unable to make its contracted deliveries of substitute water to the Exchange Contractors, the Exchange Contractors have the right to receive their water from the San Joaquin River to satisfy their historic water rights. Thus, if exports were curtailed and deliveries to the Exchange Contractors limited below the contractual water allotments, waters would be released from Friant Dam and be delivered via the San Joaquin river to Mendota Pool and the San Joaquin River Exchange Contractors. This water would not be available for delivery to the Friant Division of the CVP – primarily to agricultural agencies from Chowchilla to Bakersfield; thus, declines in CVP deliveries would lead to a reduction in deliveries of other water supplies to agricultural entities.

5B.3.3 Responses to Reductions of Delta Water Supplies due to Climate Change

5B.3.3.1 Urban Responses

Changes in precipitation, snowpack, and runoff patterns could reduce the availability of Delta water supplies. Increases in ambient air temperatures would increase water demand, as additional irrigation water would likely be required for urban landscapes. Sea-level rise would increase the amount of saline water that enters the Delta from tidal forces, which could reduce the ability to convey water across the Delta. As these changes are anticipated to occur over the mid- to long-term, urban water agencies could have several decades to adjust to the potential reductions in Delta water supplies and the potential increase in demand associated with increased ambient air temperatures.

5B.3.3.1.1 Water Conservation Programs

In anticipation of potential future supply reductions, urban water agencies would likely continue the implementation of water conservation programs. As noted above, many urban agencies have well established conservation programs, with a long record of success, which may limit the ability of some agencies to implement further conservation measures due to demand hardening. The State of California's plan to reduce per capita water consumption by 20 percent by the year 2020 will result in the widespread implementation of water conservation measures across the state. Further improvements beyond the 20 percent reduction mandated in that plan would likely be more difficult, as it would require additional capital investments and substantial lifestyle changes by urban water users (e.g., elimination of turf grass lawns). The perception that potential water supply reductions associated with climate change may not occur for several decades could limit public acceptance of such measures.

5B.3.3.1.2 Reservoir Storage

Climate change may make water availability and demands even more variable, placing more demands on existing storage. While water agencies continue to expand their water storage, the average early spring snowpack, California's natural water storage, in the Sierra Nevada decreased by about 10 percent during the last century, a loss of 1.5 million acre-feet; and very considerable additional losses in snowpack are expected due to climate change (California Department of Water Resources 2008b). Potential changes in surface runoff patterns could increase interest in the expansion of surface storage in the SWP and CVP service areas. The CALFED program conducted several surface storage investigations, including the enlargement of Lake Shasta, North-of-Delta Offstream Storage, Los Vaqueros Expansion (which was implemented), in-Delta storage, and the Upper San Joaquin River Basin (at Temperance Flat), and it is possible that those studies could be pursued further. (See Water Storage Appendix for further discussion.)

5B.3.3.1.3 Groundwater

Urban water suppliers could elect to expand reliance on groundwater; however, as noted above, this is not possible in areas served by adjudicated basins. If Delta water supplies are reduced, then local supplies could also be reduced, which could limit native groundwater recharge. Over the long-term, cumulative impacts associated with expanded reliance on groundwater could include lowering of groundwater levels and subsidence, which could have adverse effects on instream flows, springs or artesian wells fed by groundwater and riparian and wetland vegetation that is dependent on those flows.

5B.3.3.1.4 Recycled Water

Expansion of recycled water use is another likely response to potential future supply reductions. The application of recycled water programs varies considerably in California, with substantial use in Southern California and little utilization in many other areas. The potential for substantial expansion of recycled water exists in many areas, but to date has been limited by the capital costs associated with implementation. As local and Delta water supplies become more limited (due to changes in precipitation patterns and runoff), the cost of water will likely increase, which could make recycled water a more cost-effective option in some areas. Concerns about salt buildup will require the consideration of salt (and nutrient) management, particularly in groundwater basins.

5B.3.3.1.5 Water Transfers

Water transfers from agricultural to urban agencies would be likely in anticipation of long-term reduction of those supplies. To the extent that in-Delta conveyance capacity remains available, then such transfers could be expected anywhere within the SWP/CVP service area as well as areas served by the Colorado River. Because these transfers would be a response to a long-term trend, it is likely they would be implemented for significant periods of time, which could result in the long-term fallowing of agricultural lands. For example, in 2004, Metropolitan approved a 35- year program with the Palo Verde Irrigation District that will pay farmers to annually set aside a portion of their land, rotate their crops, and transfer up to 3.63 MAF of saved water over the term of the program to urban Southern California. The program could result in the fallowing of up to 25,000 acres of farmland on a rotating basis (Metropolitan Water District of Southern California 2004).

5B.3.3.1.6 Desalination

Projects to desalinate seawater or brackish groundwater could also be a long-term response to the further reduction of Delta water supplies as part of a larger portfolio approach that includes the other responses listed above (California Department of Water Resources 2003). However, because of the high price tag and extensive time generally required to plan, permit, and construct new desalination facilities and their associated distribution infrastructure, it is highly unlikely that such actions would be available quickly (California Department of Water Resources 2008a). For example, the Bay Area Regional Desalination Project is underway with the goal of providing a reliable water source during contract delivery reductions using water from the Delta withdrawn from eastern Contra Costa County. Pre-feasibility studies began in 2003 and construction is scheduled for 2018–2020 with a low-end estimate of $150 million for a 20-million-gallons-per-day capacity project (www.regionaldesal.com). Also, saline water desalination tends to be an expensive and energy-intensive source of water. See the PPIC Report, California Water Myths, for a cost comparison table of desalination to other responses to water supply reduction (Public Policy Institute of California 2009). There are also environmental impacts and associated potential mitigation measures to consider, including concentrated brine and chemical discharges to the marine environment, the emissions of air pollutants, and the energy demand of the process (Lattemann and Hopner 2008). However, the further reduction of Delta export water supplies could help spur the initiation of a few such desalination projects in California.

5B.3.3.2 Agricultural Responses

As discussed above, changes in precipitation, snowpack, and runoff patterns could reduce the availability of Delta water supplies. Increases in ambient air temperatures would increase water demand, as additional irrigation water would be required for agricultural operations. Sea-level rise would increase the amount of saline water that enters the Delta from tidal forces, which could reduce the ability to convey water across the Delta. As these changes are anticipated to occur over the mid- to long-term, agricultural water agencies could have several decades to adjust to potential reductions in Delta water supplies and the potential increase in demand associated with increased ambient air temperatures.

5B.3.3.2.1 Reservoir Storage

Many agricultural water agencies rely upon water held in storage in reservoirs. However, it is unlikely that agencies would use existing surface storage to replace lost supplies as a long-run measure because storage levels can change dramatically between years. Given the long-term nature of the anticipated reduction, it is likely that agricultural agencies would consider options to expand existing reservoirs and create new storage options, such as those identified in CALFED surface storage studies. However, the availability of financing for such proposals is not certain.

5B.3.3.2.2 Groundwater

In some areas, agricultural agencies or individual land owners could expand reliance on groundwater. However, this is not possible in areas served by adjudicated basins and the ability to expand groundwater utilization in other areas would depend on groundwater levels and infrastructure capacity. Over the long-term, cumulative impacts associated with expanded reliance on groundwater could include subsidence and lowering of groundwater levels, which could have adverse effects on instream flows, springs or artesian wells fed by groundwater, and riparian and wetland vegetation that is dependent on groundwater. As noted above, the Tulare Basin historically experienced substantial declines in groundwater levels and subsidence of up to 20 feet as a result of groundwater extractions in the mid-20th century.

5B.3.3.2.3 Water Transfers

Water transfers are a potential response to a further reduction of Delta water supplies. However, given the historic costs of transferred water, likely competition from urban agencies, and infrastructure limitations, the potential for transfers between agricultural suppliers is assumed to be low. Alternatively, a reduction in Delta water supplies could provide the impetus for additional transfers from agricultural to urban water agencies. With long-term supply reductions, agricultural operations could seek alternative options for productive use of fallowed lands, which might include alternative energy production (e.g., wind or solar energy).

5B.3.3.2.4 Water Conservation Programs

To the extent that utilization of surface storage or groundwater are not viable options, agricultural operations may be able to implement additional water conservation measures. However, many agricultural operations have already implemented such measures. Many water agencies have considered various conservation measures arrayed by their respective additions to water supplies and costs. The decisions on which projects to implement depend directly on the financial feasibility of the projects, including the ability of water users to pay for increased water supply reliability.

If additional conservation measures are not feasible, then changes in crop selection, to the extent feasible or fallowing of lands could occur.

5B.3.4 Summary of Potential Responses

As discussed above, further reductions in the export of Delta water supplies could occur as a result of regulatory actions, or as a result of mid- to long-term trends as a result of climate change. Abrupt, short-term or long-term disruptions to the export of Delta water supplies could also occur as a result of the failure of one or more levees. In general, water agencies may have many years to plan a response to reductions in water supplies associated with climate change, while reductions or disruptions associated with regulatory action or levee failure could occur with little or no warning. Based on the time available to implement a response, the urban and agricultural responses described above can be summarized as either short-term (e.g., those that could be implemented quickly) or long-term (e.g., those that would be implemented over many years). The characterization of a response as either short- or long-term is not intended to imply that a regulatory action or catastrophic disruption of the export water system would occur in the short-term (although either is possible). Instead, this characterization acknowledges that responses would vary depending on the time available for implementation.

Table 5B-2 summarizes the potential agency responses to supply reductions or disruptions, characterized as either short- or long-term. The available short- and long-term responses can be summarized as: water conservation, reservoir storage, groundwater storage, water transfers, desalination, water recycling, and contingency plans. For each of these topics, a short-term and long-term response is possible. For example, requests for voluntary water conservation would be a short-term response, while implementation of additional demand management measures would be long-term response.

Table 5B-2. Summary of Potential Agency Responses

Response Category	Short Term Responses	Long Term Responses
Water Conservation	Public requests for voluntary conservation	Expand demand management programs
Reservoir Storage	Utilization of water held in reservoir storage (as feasible)	Reoperate reservoirs and/or expand surface storage
Groundwater Storage	Expand groundwater utilization (as feasible)	Expand groundwater management programs
Water Transfers	Water transfers from agricultural to urban agencies	Long term transfers from agricultural to urban agencies
Recycled Water	Initiate/expedite proposals to expand recycled water use	Expand utilization of recycled water
Desalination	Initiate/expedite proposals to desalinate seawater or brackish groundwater	Expand desalination of seawater and brackish groundwater
Contingency Plans	Implement water shortage contingency plans	Implement water shortage contingency plans as needed

5B.4 Environmental Effects of Potential Responses on Reduced South of Delta Water Exports

5B.4.1 Potential Impacts of Water Conservation, Demand Management, and Contingency Plans

5B.4.1.1 Voluntary Water Conservation

Short-term voluntary water conservation is likely to result in few physical environmental impacts, although reduced irrigation or voluntary land fallowing could result in short term aesthetic impacts (associated with loss of landscape vitality or land fallowing) and air quality impacts (from dust associated with land fallowing).

5B.4.1.2 Demand Management Programs

Long-term implementation of demand management programs would involve replacement of equipment (e.g., high-efficiency fixtures), which could result in some minor impacts associated with installation of the equipment (e.g., use of hazardous materials, such as solvents, and disposal of solid waste – the old equipment). Reduced landscape irrigation or expanded land fallowing could result in aesthetic impacts (e.g., conversion to xeriscape gardens or land fallowing), terrestrial species impacts (e.g., reduced food source and habitat for certain species that utilize irrigated crops) and air quality impacts (e.g., dust from land fallowing).

5B.4.1.3 Mandatory Contingency Plans

The implementation of contingency plans would have similar impacts on those listed above for voluntary water conservation and demand management programs, but the impacts may be increased. There is potential for a contingency plan to require immediate restrictions on irrigation, which can have aesthetic, and air quality impacts. Many contingency plans are phased and can be implemented as a last resort from a prolonged drought or from an abrupt disruption in water supply. Because groundwater recharge programs are usually halted during the implementation of a contingency plan, impacts on groundwater levels may occur.

5B.4.2 Potential Impacts of Reservoir Storage

The short-term utilization of reservoir storage (or reservoir reoperation) could have short term aesthetic impacts (depending on the visibility of exposed land surfaces due to reservoir drawdown, and potential air quality impacts if exposed land surfaces are exposed to wind erosion.

Long-term reservoir reoperation could have impacts that are similar to the utilization of reservoir storage, including aesthetic impacts from exposed land surfaces and air quality impacts if exposed land surfaces are exposed to wind erosion.

Implementation of new or expanded reservoir storage could result in adverse impacts during both the construction and operation of the new/expanded reservoir.

Short-term impacts during construction could include:

- Aesthetics (depending on the visibility of the area affected by construction);

- Air quality emissions from construction activities and equipment, including greenhouse gas emissions, and wind erosion of exposed soil surfaces;
- Potential direct impacts on special-status species or the habitat of those species, including wetlands and other sensitive habitats, or interfere with the movement of resident or migratory fish or wildlife species.
- Adverse effects on cultural resources (from ground-disturbing activities or from inundation by water within the area of the reservoir pool);
- Exposure to hazardous materials (if encountered during ground-disturbing activities) or hazards associated with use of hazardous substances (such as solvents, paints and fossil fuels);
- Disruption of surface drainage patterns, exposure of soil surfaces to erosion from rainfall and runoff, and water quality impacts associated with runoff from areas subject to construction;
- Noise from construction activities and equipment;
- Population and housing impacts, to the extent that displacement of either would result;
- Construction traffic, including construction worker trips, delivery of materials and equipment; and occasional detours or disruptions along existing roads; and
- Utility impacts, such as short-term service interruptions due to utility re-routing.

Operational impacts from new or expanded reservoir storage could include:

- Aesthetics (depending on the visibility of the reservoir and the extent of exposed land surface as a result of reservoir drawdown);
- Loss of agriculture or forestry resources (depending on existing land uses within the area occupied by the dam or subject to inundation);
- Biological impacts due to reservoir drawdowns may include invasive plant and animal species colonizing exposed shoreline resulting in increased management costs, decreased habitat value, and reduced property value;
- Conflicts with local ordinances protecting biological resources, or the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other adopted habitat plan.
- Adverse effects on cultural resources from more frequent and longer duration reservoir drawdowns, resulting in greater disturbance and security risk of sensitive sites;
- Exposure to hazards associated with flooding;
- Potential loss of mineral resources (to the extent such resources are located within the area subject to inundation)
- Geology and soils impact from erosion and landslides associated with continued reservoir fluctuations;
- Noise from reservoir operations (e.g., spillways or other equipment, such as hydroelectric generators);
- Recreation impacts either associated with loss of existing resources (e.g., hiking trails) or beneficial impacts associated with new water-related recreation; and

- Growth-inducing impacts associated with new water supplies.

5B.4.3 Potential Impacts of Increased Reliance on Groundwater Resources

In areas where groundwater is available (and not adjudicated), reductions in south of Delta surface water supplies generally would increase reliance on groundwater resources in the SWP and CVP service areas located south of the Delta. Increases in groundwater pumping in these areas would cause groundwater levels to decline below current levels.

Declines in groundwater levels could cause direct effects and indirect effects that may also be cumulative. Direct effects caused by declines in groundwater levels include increases in pumping costs, reductions in well production rates, and a reduction in groundwater supply and water supply reliability. Indirect cumulative effects that can be caused by groundwater declines relate to (1) subsidence, (2) reduced groundwater quality, (3) reduced spring and stream flows, and (4) reduced drainage, as discussed below.

1. Some groundwater basins, notably in the San Joaquin Valley, are susceptible to land subsidence. Land subsidence, which can be triggered by declines in groundwater levels, is caused by the compaction of fine-grained sediments in the aquifer system. Damage from land subsidence can include changes in canal gradients, structural damage to buildings, roads, pipelines and bridge abutments, and collapse of well casings.

2. Increases in pumping can cause adverse changes in groundwater quality. An increase in groundwater pumping in coastal aquifers can induce or accelerate the intrusion of sea water into fresh-water aquifers. Increased groundwater pumping within the San Joaquin Valley also would likely cause declining water tables, which would cause the downward migration of poor-quality groundwater from shallow aquifers into the deeper potable aquifers. Key water quality concerns would be salinity (total dissolved solids), nitrates, and/or pesticides.

3. Spring and stream flows can be reduced by increases in groundwater pumping. Groundwater is the source of spring flows, as well as base flow to streams. When pumping reduces the level of groundwater that feeds a spring, flows from the spring are reduced. If groundwater levels are higher than stream stage levels, increases in groundwater pumping can capture water that would otherwise discharge to streams. On the other hand, if groundwater levels are below stream levels, increases in pumping can induce an increase in stream recharge to the groundwater system. In either case, increased pumping reduces surface water availability, which can adversely affect habitat and biological resources.

4. Finally, under limited conditions, increased groundwater pumping can cause a reduction in drainage pumping. In a narrow band of low-lying area along some rivers, including the San Joaquin River, the groundwater table is near land surface and can inundate the root zones of crops. Irrigation with imported surface water causes groundwater levels to rise. To control this problem, drainage pumping in these lowlands is periodically required to reduce the level of groundwater. In addition, percolating water from irrigation can increase the salinity of groundwater, especially in the water table. As a result, high salinity conditions can occur in shallow groundwater. This high salinity water cannot be used for irrigation. If surface water supplies were reduced and replaced with groundwater, the resulting reduction in groundwater levels might somewhat reduce the acreage and amount of drainage pumping required.

Subsidence, reduced groundwater quality, and reduced spring and stream flows would be adverse impacts, while the reduction of drainage pumping would be a small, but beneficial, impact in some lowland areas.

A short-term increase in the use of groundwater may have predictable effects. Groundwater use and groundwater levels fluctuate seasonally and cyclically with periodic droughts. Increased use of groundwater for a period of a few years could have effects similar to those of past droughts, which have included the following:

- Decline in groundwater levels
- Increase in pumping costs
- Reduction in production rates
- Reduction in groundwater supply and water supply reliability
- Land subsidence
- Degradation of groundwater quality
- Reduction in stream and spring flows resulting in
    - Potential impacts on special-status species or the habitat of those species, including wetlands and other sensitive habitats, or interference with the movement of resident or migratory fish or wildlife species.
    - Potential conflicts with local ordinances protecting biological resources, or the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other adopted habitat plan.
- Reduction in drainage pumping

A long-term increase in the use of groundwater would have larger-scale effects than a short-term increase. The effects of a long-term increase in groundwater pumping could be similar to the groundwater conditions that occurred during the period between the 1920s and 1960s, prior to construction of the SWP and CVP. Groundwater levels would continue to decline over time, and related cumulative effects (noted above) would correspondingly increase in occurrence and magnitude.

5B.4.4 Potential Impacts of Water Transfers

As with the SWP and CVP, the 2008 USFWS and 2009 NMFS Biological Opinions have also impacted and limited water transfers that are conveyed through the Delta. Specifically, the net effect of the Biological Opinions has been to shift much of the exports of the CVP and SWP water supplies to the summer months when there are fewest restrictions. Simultaneously, the Reasonable and Prudent Actions (RPAs) restrict the conveyance of transfer water across the Delta to the period of July through September. This is the same period when exports of CVP and SWP water supplies are taking place. Thus, there is competition for conveyance capacity between project water supplies and water transfers. However, project water has priority and thus, the conveyance of water transfers becomes uncertain.

The impacts on water transfers have been in general in tandem with the impacts on CVP and SWP water supplies. This is because of regulatory actions that curtail exporting of water. Future regulatory actions that curtail exports or seek to reduce exports will have a similar impact on water transfers.

Under all of the potential regulatory scenarios, it is possible that regulatory actions may reduce CVP and SWP supplies but have no direct impact on water transfers. A potential scenario includes the dedication of current CVP and SWP supplies to enhance Delta outflows, as could occur under the SWRCB's Water Quality Control Plan for the Delta. Under such scenarios demand for water transfers may increase. The source of water for these transfers could be additional idling of rice and other crops such as alfalfa and groundwater substitution water transfers. The potential impacts from these transfers could include the following:

- Increased greenhouse emissions (GHG), which are substantial, from the export of water to southern California.
- Additional energy consumption and GHG emissions from pumping of groundwater for irrigation that would otherwise be supplied by mostly gravity-flowing surface water.
- Falling water table caused by the enhanced groundwater pumping for water transfers will require additional energy consumption and GHG emissions. This is the incremental energy and GHG emissions caused by pumping not related to water transfers.
- Depletion of surface water caused by stream recharge of groundwater in response to the additional groundwater pumping for water transfers. The magnitude of this impact depends on the location of the wells from surface water, the aquifer being tapped, the water year type proceeding, during, and following the transfer. To the extent that the recharge occurs when the Delta is out of balance, this is a cost to the CVP and SWP and as such an injury to a legal user of water.
- Groundwater pumping that occurs in smaller watersheds and near important fishery rearing streams can deplete these small streams of flow. Although, these depletions may be small, these streams may already be deficient in flows to support the native fisheries and the incremental loss of flows may be biologically significant.
- Potential impacts on the threatened giant garter snake which uses flooded rice land as important habitat. The impacts have not been documented but potentially the giant garter snake could be harmed by reduced habitat, additional expenditure of energy relocating to suitable habitat, enhanced predation in relocating to alternative habitat, and reduced fecundity.
- Potential impacts of fallowing or changing crop type fields that provide wildlife habitat for other species, including Swainson's Hawk and Greater Sandhill Crane.
- Potential impacts on economies of the water transfer source area due to reduced crop production and economic output.
- Potential impacts due to loss of topsoil of the water transfer source area due to fallowed or non-irrigated land.

Growth-inducing impacts from water transfers would be minimal if the project is implemented as proposed. This is primarily due to the higher cost of transfer water. Currently, contract prices for SWP and CVP project water are significantly lower than those paid for water generated by a transfer between a willing seller and buyer. That said, water transfers outside of the Projects currently occur primarily in dry year types, and usually serve to supplement shortages in the supply of Project water caused by dry conditions. Transfers between willing sellers and buyers are typically negotiated on an annual basis and are usually only in dry years.

5B.4.5 Potential Impacts of Recycled Water

Implementation of new or expanded recycled water facilities could result in adverse impacts from construction and operation of the recycled water facility.

Short-term impacts during construction could include:

- Aesthetics (depending on the location of the new recycled water plant and the associated recycled water distribution lines);
- Air quality emissions from construction activities and equipment, including greenhouse gas emissions, and wind erosion of exposed soil surfaces;
- Potential direct impacts on special-status species or the habitat of those species, including wetlands and other sensitive habitats, including habitats in ocean waters;
- Adverse effects on cultural resources (from ground-disturbing activities either at the site of the recycled water plant or along the route of distribution lines);
- Exposure to hazardous materials (if encountered during ground-disturbing activities) or hazards associated with the use of hazardous substances (such as solvents, paints and fossil fuels);
- Noise from construction activities and equipment;
- Construction traffic, including construction worker trips, delivery of materials and equipment; and occasional detours or disruptions along existing roads; and
- Utility impacts, such as short-term service interruptions due to utility re-routing.

Operational impacts from new or expanded recycled water facility could include:

- Aesthetics (depending on the visibility of the recycled water plant);
- Criteria pollutant and greenhouse gas emissions associated with the generation of electricity used in the recycled water facility;
- Loss of agriculture or forestry resources (depending on existing land uses within the area occupied by the recycled water facilities);
- Potential impacts on surface water quality associated with elevated salt levels in recycled water, and/or impacts on groundwater quality if recycled water is used for groundwater recharge;
- Noise from operation of the recycled water facilities;
- Growth-inducing impacts associated with new water supplies.

5B.4.6 Potential Impacts of Desalination

Implementation of desalination facilities for either seawater or brackish groundwater could result in adverse impacts from construction and operation of the desalination facility.

Short-term impacts during construction could include:

- Aesthetic and recreation impacts (depending on the location of the desalination facility and the associated water distribution and brine disposal lines);
- Air quality emissions from construction activities and equipment, including greenhouse gas emissions, and wind erosion of exposed soil surfaces;
- Potential direct impacts on special-status species or the habitat of those species, including wetlands and other sensitive habitats;
- Adverse effects on cultural resources (from ground-disturbing activities either at the site of the desalination plant or along the route of water distribution and brine disposal lines);
- Exposure to hazardous materials (if encountered during ground-disturbing activities) or hazards associated with the use of hazardous substances (such as solvents, paints and fossil fuels);
- Noise from construction activities and equipment;
- Construction traffic, including construction worker trips, delivery of materials and equipment; and occasional detours or disruptions along existing roads; and
- Utility impacts, such as short-term service interruptions due to utility re-routing.

Operational impacts from new or expanded desalination facility could include:

- Aesthetics (depending on the location and visibility of desalination facility);
- Loss of agriculture or forestry resources (depending on existing land uses within the area subject to inundation);
- Potential direct impacts on special-status species or the habitat of those species associated with brine disposal at coastal locations;
- Criteria pollutant and greenhouse gas emissions associated with the generation of electricity used in the desalination facility;
- Mineral resource impact of increased use of non-renewable natural gas to provide power to desalination facilities;
- Noise from facility operations;
- Water quality impact of risks to drinking water supplies associated with potential tsunami damage to desalination facilities; and
- Growth-inducing impacts associated with new water supplies.

5B.4.7 Other Potential Environmental Effects

Other potential environmental effects from responses to reduced south of Delta water supply could include:

- Potential Impact from Reduction in Energy Generation and Grid Reliability Services. As described in DWR's Climate Action Plan (California Department of Water Resources 2012c), delivery of water through the SWP system both consumes and generates electricity. On average, the SWP is a net consumer of electricity. The amount consumed depends on how much and where the water is conveyed. The SWP system also generates electricity as water is released from dams and flows through pipelines and hydroelectric generating turbines. However, this does not mean that DWR uses all of the power it generates to operate the SWP. In fact, DWR attempts to provide grid reliability services by operating the SWP to maximize the amount of energy generated when the statewide demand is highest, not when DWR's demand is highest. Historically, about two-thirds of DWR's generated electricity is sold into the California electricity market through CAISO to be used during peak demand periods. Conversely, DWR aims to schedule its consumption of electricity (primarily the operation of the pumps) during off-peak demand periods to the maximum extent possible. The coordinated operation of SWP facilities plays an important role in modulating daytime and nighttime demand for electricity throughout California. In dry years, less water is released from dams and less energy is generated. Consequently, reduced exports south of the Delta would reduce electricity supplies and the electricity demand-modulating benefits of the SWP.

- Aesthetic impact of reduced crop planting and replacing crops with wind/solar energy farms, which have glare impacts;
- Agricultural impact of lower yield or fallowing due to salinity intrusion, also converting prime farmland to non-farming use and conflicts with the Williamson Act contracts and zoning;
- Air quality impacts from emissions associated with transport of food following agricultural land conversion;
- Biological impact of additional listings under ESA and CESA from reduced water quality and lost or reduced quality habitat;
- Mineral resource impact of security risk to natural gas wells/pipelines in the event of levee failures and island inundations;
- Greenhouse gas emissions impact of reduction in availability of GHG offsets to the extent that new desalination facilities and increased groundwater pumping would use available offsets if required to mitigate for GHG impacts;
- Noise impact of increased groundwater pumping;
- Mineral resource impact of increased use of non-renewable natural gas to provide power to groundwater pumping facilities;
- Utilities impact of more water treatment facilities to treat poor water quality, for example from desalinized ocean water and treated groundwater.
- Hazardous materials impact of possible increase in nuclear waste if additional or expanded nuclear facilities are necessary to supply GHG-free electricity to desalination facilities and increased groundwater pumping;
- Biological impact from emissions and subsidence from increased groundwater pumping in areas where fully-protected and protected species occur;
- Biological impact of less water moving south that would be available for biological resources south of the Delta;

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