Chapter 5
Physical Environment

5.1 Water Supply and Water Management

Distribution of the State's water supplies varies geographically and seasonally. Water supplies also vary climatically through cycles of drought and flood. The CALFED Bay-Delta Program would increase the reliability of water supplies and reduce the mismatch between Bay-Delta water supplies and the current and projected beneficial uses that are dependent on the Bay-Delta system.

5.1 Water Supply and Water Management

5.1.1 SUMMARY

The primary water supply reliability objective of the CALFED Bay-Delta Program (Program) is to reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system. Water supplies for agricultural and urban uses from Bay-Delta sources could be reduced under the No Action Alternative if environmental water needs increase or if water project operations are modified to improve drinking water quality. Water supply reliability could be enhanced under the Preferred Program Alternative by increasing the ability to store and transport water, improving the conveyance of water through the Delta, improving the quality of Bay-Delta water supplies, managing demands through increasing conservation and recycling, facilitating water transfer markets, and managing environmental water needs through an EWA.

Preferred Program Alternative. Potential decreases in agricultural and urban water supplies from Bay-Delta sources could result from increased environmental water needs and drinking water quality requirements under the No Action Alternative. Relative to all foreseeable no action conditions, water supply reliability would be improved by several strategies included in the Preferred Program Alternative. Implementation of an EWA may allow for more efficient use of water for environmental purposes and decrease the conflict in uses of Bay-Delta water supplies. Optimizing the use of alternative water management tools, including water use efficiency measures, water recycling, and water transfers may improve the availability and economic utility of water supplies. Implementing water quality improvement actions may enhance the quality of source water supplies, thereby providing additional operational flexibility to meet water supply reliability and quality goals. Conveyance improvements may also increase the flexibility of water project operations and improve water supply reliability. Finally, new storage may provide improved water management capability and enhanced water supply reliability.

Potential long-term adverse impacts on specific regional agricultural and urban water supplies could result from increased water transfers. Areas with adequate water supplies could transfer portions of those supplies to areas with higher economic return from the use of water. Water transfers can affect third parties (those not directly involved in the transaction), local groundwater, environmental conditions, or other resource areas. Additional discussion on the potential impacts of water transfers on groundwater resources, agricultural social issues, and regional economics is included in Sections 5.4, 7.3, and 7.10, respectively. These chapters describe mitigation strategies to reduce third-party impacts associated with transfers. In addition, the objectives and criteria described in the Water Transfer Program Plan will protect against adverse third-party impacts associated with water transfers. (See Chapter 4 in the Water Transfer Program Plan.)

Conversion of Delta land use from agriculture to wetlands and marshes under the Ecosystem Restoration Program could result in increased water use and potential negative impacts on agricultural and urban water supply reliability. The combined beneficial effect on water supply and water management resources from actions under the Preferred Program Alternative, including the Water Quality Program, Water Use Efficiency Program, Water Transfer Program, conveyance improvements, and potential new water storage facilities, is expected to offset this potential loss of water supply, resulting in no significant adverse impacts.

Temporary local impacts on water supply reliability could occur during construction of the Program's proposed facilities. Potential temporary interruptions in water supply due to turbidity of water during levee work could negatively impact water supply and water management. This impact can be mitigated to a less-than-significant level.

Alternatives 1, 2, and 3. The potential adverse impacts on water supply reliability and mitigation strategies associated with Alternatives 1, 2, and 3 are largely the same as those described for the Preferred Program Alternative. The potential improved water management capability and enhanced water supply reliability could be greater under Alternative 3. Temporary local negative impacts on water supply reliability due to construction of Program facilities also could be greater under Alternative 3.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. Most potential negative consequences to water supply and water management are addressed through Program actions under the Preferred Program Alternative, as described above, and are not considered potentially significant adverse impacts. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation
Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts	Mitigation Strategies
Potential temporary local water supply interruptions due to turbidity of water during construction of Program facilities and habitat restoration activities (1).	1. Using best construction and drainage management practices to avoid transport of soils and sediments to waterways.

No potentially significant unavoidable impacts related to water supply and water management are associated with the Preferred Program Alternative.

5.1.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the area of controversy for this resource category.

Although the Ecosystem Restoration Program addresses ecological processes and stressors, such as temperature and introduced species, controversy exists over whether implementation of the Ecosystem Restoration Program in combination with an effective Water Management Strategy, including an EWA, will restore fisheries and simultaneously improve water supply reliability.

Significant controversy exists over the projected magnitude of future water demands and the appropriate role of Bay-Delta water supplies in meeting those demands.

California's increasing population will result in the need for improved water management to meet growing demands. Significant controversy exists over the projected magnitude of future water demands and the appropriate role of Bay-Delta water supplies in meeting those demands. The following sections discuss the sources of uncertainty contributing to this controversy and the potential for Program elements to address water supply and water management issues.

5.1.2.1 UNCERTAINTIES IN THE ASSESSMENT

The assessment methods used in this programmatic evaluation link estimates of future Delta water demands, the primary area of uncertainty related to water supply and water management, to Program actions. Future Delta water demands are influenced by, among other things, population growth, future land use changes, and future environmental water requirements. Uncertainty in future water demands is attributable to:

- Limited ability to forecast population growth, its geographic distribution, and changes in per capita water use due to socioeconomic factors and implementation of new water conservation measures.
- Limited ability to forecast agricultural land use changes (for example, shifts in cropping patterns, conversions to wetlands and marshes) and implementation of more efficient water management practices.
- Limited ability to forecast the ability of water users to implement other water management options such as new water recycling facilities or to acquire water through transfers.
- Limited ability to forecast the rate of recovery of the Bay-Delta ecosystem resulting from adaptively managed Program actions, leading to uncertainty in future environmental water requirements.

5.1.2.2 ADDRESSING UNCERTAINTY

The Program recognizes the importance of water supply reliability to regions potentially affected by Program actions. Although there are disagreements about the magnitude of future Delta water demands and the need for water supply facilities to meet these demands, the fact that water supply reliability is important to California is not an issue.

Water supply reliability evaluations rely on the development of assumptions and methodologies that may result in disagreements among technical experts and, therefore, constitute areas of controversy as used in CEQA. The use of different assumptions and methodologies may lead to conclusions that overestimate or underestimate the need for additional water supply facilities. Uncertainty in future Delta water demands is addressed in the assessment method through "bookending" the potential level of future demands and new storage facilities. This approach is described in Section 5.1.4.

New storage facilities are considered in this programmatic evaluation, together with aggressive implementation of water conservation, recycling, and a protective water transfer market. Each Program alternative is evaluated with and without new storage facilities. The total volume of new surface and groundwater storage considered in this evaluation ranges up to 6 MAF. Facility locations considered are in the Sacramento and San Joaquin Valleys and in the Delta. Implementation of new or expanded surface and/or groundwater storage will be predicated on complying with all environmental review and permitting requirements. Future site-specific evaluations, environmental review processes, and permit applications will be coordinated under CALFED's Integrated Storage Investigation.

5.1.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

This section discusses existing water supply and water management conditions in the Program study area. Existing conditions are characterized for each of the five regions defined within the study area. The regions used to describe water supply and water management are different from the regions used for analysis elsewhere in this document. The five Program regions described in Section 1.4.1 include: Delta, Bay, Sacramento River, San Joaquin River, and Other SWP and CVP Service Areas. As defined in Section 1.4.1, the San Joaquin River Region receives water supplies from Delta tributaries and Delta exports. Water supply and water management impacts on these supply sources are distinct and not readily aggregated. On the other hand, Delta water supplies exported to the SWP and CVP Service Areas within the San Joaquin River Region and outside of the Central Valley are more readily aggregated for this programmatic evaluation. For these reasons, the boundaries of San Joaquin River Region and the Other SWP and CVP Service Areas were modified for analysis of water supply and water management. In this section, the San Joaquin River Region includes only those areas receiving water supplies directly from the San Joaquin River and its tributaries. The Other SWP and CVP Service Areas region is redefined as South-of-Delta SWP and CVP Service Areas, and includes all areas south of the Delta that receive Delta exports from the state and federal water projects.

Distribution of the State's water supplies varies geographically and seasonally. Water supplies also vary climatically through cycles of drought and flood. California's water development has generally been in response to managing this variability. Figure 5.1-1 shows the location of some of the major surface water project facilities in the Program study area.

Average annual statewide precipitation is about 23 inches, corresponding to a water supply of nearly 200 MAF over California's land surface. About two-thirds of this precipitation is consumed through evaporation and transpiration by trees and other plants. The remaining one-third comprises the state's average annual runoff of about 71 MAF. Less than half this runoff is depleted by urban and agricultural use.

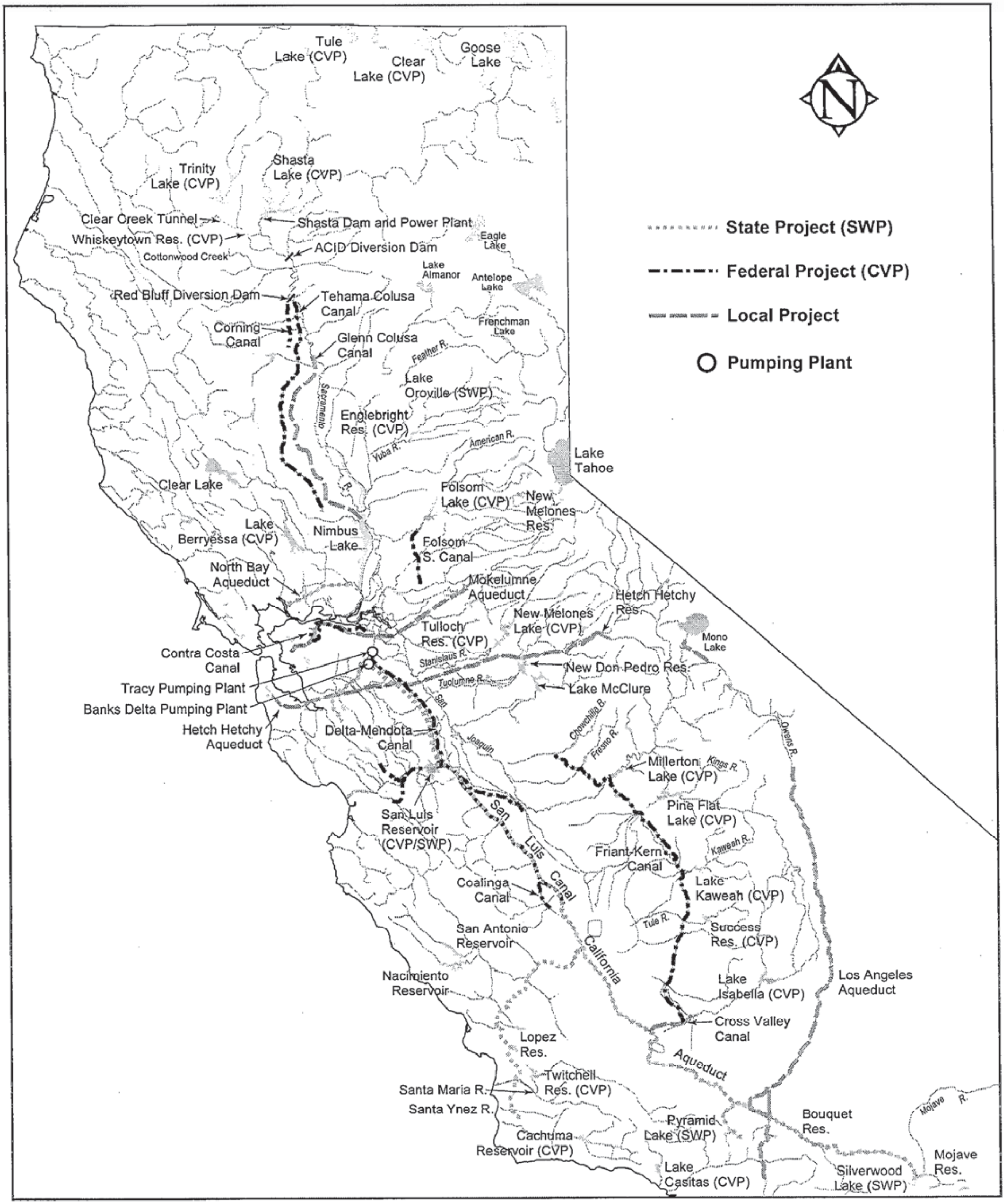


Figure 5.1-1   Surface Water Features Location Map

5.1.3.1 DELTA REGION

Several important water management facilities are located in the Delta. These include the CVP Pumping Plant at Tracy, the Delta Cross Channel (DCC) at Walnut Grove, the SWP Clifton Court Forebay (CCFB) and Banks Pumping Plant, the SWP North Bay Aqueduct (NBA) Pumping Plant, and the Contra Costa pumping plants at Rock Slough and Old River.

The CVP Tracy Pumping Plant has a maximum capacity of approximately 4,600 cfs, the nominal capacity of the Delta-Mendota Canal (DMC) at the pumping plant. The SWP Banks Pumping Plant supplies water for the South Bay Aqueduct (SBA) and the California Aqueduct, with an installed capacity of 10,300 cfs. Under current operational constraints, exports from Banks Pumping Plant are generally limited to a maximum of 6,680 cfs, except between December 15 and March 15, when exports can be increased by 33% of San Joaquin River flow (if greater than 1,000 cfs). The SWP also pumps water from Barker Slough into the NBA for use in the Bay Region. While the maximum pumping capacity at Barker Slough is 175 cfs, the average annual pumping rate is approximately 35 cfs.

CCWD recently completed construction of the Los Vaqueros Reservoir and a second pumping plant on Old River. These facilities will provide CCWD with access to improved water quality and emergency water supplies. Los Vaqueros will be refilled by diversions only when source water chloride concentration is less than 65 milligrams per liter (mg/L). Los Vaqueros water will be used for delivery during low Delta outflow periods, when chloride concentration at Rock Slough and Old River is greater than 65 mg/L.

Delta inflow from the tributary basins is allocated to supply in-Delta diversions for agricultural and municipal water use, provide minimum Delta outflow required to satisfy 1995 WQCP and CVPIA objectives, and allow Delta exports within the 1995 WQCP export/inflow ratio and the permitted pumping capacity. Inflow that exceeds these uses contributes to total Delta outflow. Some Delta exports are used for direct deliveries to satisfy water supply demands and some of the exports are stored in San Luis Reservoir (or other local water storage facilities) for later delivery.

Average annual in-Delta use, Banks and Tracy Delta exports, and total Delta outflow under simulated 1995-level (existing) conditions are summarized in Table 5.1-1. Water supply comparisons are made here and elsewhere in the document based upon a 73-year historical hydrologic period, a sequence of years often referred to as the "long-term" period. Similar comparisons are made using a subset of the long-term period—the dry and critical years. Over the long-term period, 28 years are classified as dry or critical by the Sacramento Valley 40-30-30 Index.

Table 5.1-1. Delta Water Supply and Water Management under Existing Conditions (MAP)

MANAGEMENT COMPONENT	LONG-TERM PERIOD	DRY AND CRITICAL YEARS	RANGE
In-Delta use	1.0	1.1	0.06-1.3
Banks and Tracy exports	5.6	4.6	3-8
Total Delta outflow	14.8	6.0	4-70

Long-term period average annual Delta inflow is about 22 MAF under existing conditions, with a range of less than 8 MAF to more than 74 MAF. Dry and critical year Delta inflow averages about 12 MAF annually under existing conditions.

5.1.3.2 BAY REGION

The most prominent water-related feature in the Bay Region is San Francisco Bay. The San Francisco Bay system includes the Suisun, San Pablo, and South Bays. The outlet of San Francisco Bay at Golden Gate Bridge is located 74 kilometers (km) from Chipps Island, the approximate location of the confluence of the Sacramento and San Joaquin Rivers and the beginning of Suisun Bay. To the north of Suisun Bay and east of Carquinez Strait lies the Suisun Marsh, an extensive mosaic of both tidally influenced and seasonal wetlands.

San Francisco Bay receives freshwater flow from the Sacramento and San Joaquin Rivers in the Delta Region. Delta outflow provides the Bay with ecological and water quality benefits. In addition to Delta outflow, San Francisco Bay receives freshwater inflow from several streams, including the Napa, Petaluma, and Guadalupe Rivers and the Alameda, Coyote, Walnut, and Sonoma Creeks. The average annual Bay inflow from these tributaries, excluding Delta outflow, is about 350 TAF. Inflow from these tributaries is highly seasonal, with more than 90% of the annual runoff occurring between November and April.

Levees were constructed to convert formerly flooded marshlands to arable islands. Valley lands were drained for farming and Central Valley streams were dammed for water supply. Hydraulic mining in the Sierra foothills washed large amounts of sediment into streams and channels leading to the Bay. Untreated municipal and industrial wastes were discharged directly into the Bay. All of these activities caused changes in the quantity and quality of water reaching the Bay.

Many streams in the Bay Region have been channelized through urban areas for flood protection, and most streams are intermittent. In most areas, urban water supplies are imported and stored locally in reservoirs. Activities in the watersheds of these reservoirs are restricted to protect public water supplies.

5.1.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region contains the entire drainage area of the Sacramento River and its tributaries and extends almost 300 miles from Collinsville in the Delta north to the Oregon border. The total land area within the region is 26,960 square miles. Average annual precipitation is 36 inches, and average annual runoff is approximately 22 MAF. The most intensive runoff occurs in the upper watershed of the Sacramento River above Lake Shasta and on the rivers originating on the west slope of the Sierra Nevada. These watersheds produce an annual average of 1 to more than 2 TAF of runoff per square mile.

The two major tributaries to the Sacramento River along its lower reach are the Feather River (which also includes flows from the Yuba River) and the American River. The combined flows of the Feather River and Sutter Bypass enter the river near Verona. The American River joins the Sacramento River north of downtown Sacramento. Smaller contributions are made by the Natomas Cross Canal, draining the area between the Bear River and American River drainages, and the Colusa Basin Drain, which drains the west side of the Sacramento Valley from about Willows south to Knights Landing.

The Sacramento River Region contributes the majority of Delta inflow. Unimpaired flow from the four major rivers in the Sacramento River Region (Sacramento, Feather, Yuba, and American Rivers) averaged 17.9 MAF and ranged from 5.1 to 37.7 MAF during the 1906-1996 period. Of this, the Sacramento River (at Red Bluff) averaged 8.4 MAF (including Trinity River imports, described below), the Feather River averaged 4.5 MAF, the Yuba River averaged 2.4 MAF, and the American River averaged 2.6 MAF.

Since 1900, numerous reservoirs have been constructed in or have affected this region. These include Shasta, Oroville, Trinity, and Folsom, as well as numerous smaller reservoirs. Total reservoir capacity in or affecting the Sacramento River Region is approximately 15 MAF. Historically, these reservoirs have been operated to provide agricultural and domestic water supplies, flood control capacity and, more recently, recreation and ecological flows.

The Sacramento, Feather, and American River systems are described in greater detail below. River sections most likely to be affected by the Program include the Sacramento River below Lake Shasta, the Feather River below Lake Oroville, and the American River below Folsom Lake.

Sacramento River

The Sacramento River watershed upstream of Lake Shasta has an area of about 6,420 square miles. Lake Shasta stores and releases flows of the Sacramento, Pit, and McCloud Rivers. Shasta Dam is a 602-foot-high concrete gravity structure providing a storage capacity of approximately 4.5 MAF. Water can be released from Lake Shasta through the powerhouse, the low-level or high-level river outlets, or the spillway.

The average annual inflow to Lake Shasta is about 5.9 MAF. Inflows generally increase from November through March, with peak flows generally occurring in March. As snowmelt is not a dominant component of Lake Shasta inflows, inflows generally decrease in April and May, and are less than 5,000 cfs from June through October. The flows in these summer and fall months are relatively constant (between 3,000 and 4,000 cfs) because the volcanic geology of the watershed provides a large groundwater component that sustains the streamflow.

Maximum storage occurs in April or May, following the months with highest runoff. The reservoir's springtime storage level is reduced in wet years to provide greater flood control space. Lake Shasta storage usually decreases from May through September, and usually increases from January through April. The seasonal storage and subsequent releases from Lake Shasta average about 1.5 MAF. Shasta also provides some year-to-year carryover storage in drought periods. Average annual Shasta carryover storage is 2.8 MAF and has varied from a maximum of 3.7 MAF in 1974 to a minimum of 630 TAF in 1977.

The Sacramento River watershed upstream of the Feather River is about 14,050 square miles. The annual runoff upstream of the Feather River is about 11 MAF. About half of this runoff is potentially controllable in Shasta and the other half is runoff from the downstream tributaries. The downstream tributaries have very limited reservoir storage; therefore, runoff follows the natural (unimpaired) pattern.

The Trinity River watershed upstream of Lewiston Lake has a drainage area of about 692 square miles and an average annual basin runoff of 1.2 MAF. The Trinity River Division of the CVP develops water supply for export to the Sacramento River Region. In addition to Lewiston Lake, the principal features of the Trinity Division are the 2.4-MAF Trinity Lake, Clear Creek Tunnel, Spring Creek Tunnel and Powerplant, and Whiskeytown Lake.

The maximum storage in Trinity Lake is currently limited between 1.8 MAF (end of October) and 2.1 MAF (end of March) to provide necessary flood control storage. An annual drawdown of 500-

800 TAF usually occurs during summer and fall. Annual average carryover storage is about 1.7 MAF and has varied from a maximum of 2.2 MAF in 1983 to a minimum of 240 TAF in 1977.

Whiskeytown Lake, located on Clear Creek, has a storage capacity of approximately 240 TAF. Although Whiskeytown Lake collects some natural inflow from Clear Creek, most of its inflow comes from Trinity River exports. Whiskeytown is operated with only limited seasonal storage fluctuations. Annual releases to Clear Creek of about 100 TAF provide in-stream flows and some downstream diversions. Some water supply diversions are made directly from Whiskeytown Lake. Most Trinity River exports and Clear Creek inflows are diverted through the Spring Creek Tunnel and Powerhouse to Keswick Reservoir.

Keswick Reservoir, a 159-foot-high concrete gravity structure, is located 8 miles downstream of Lake Shasta. With a storage capacity of approximately 25 TAF, Keswick is a regulating reservoir for releases from the Spring Creek and Shasta Powerhouses. Storage and elevation in Keswick Reservoir are maintained by concurrent operation of the powerhouses. The Keswick Powerhouse has a capacity of approximately 16,000 cfs.

Although in-stream flow requirements are specified downstream of Keswick Reservoir, they are generally less than 5,000 cfs and rarely control releases. In-stream flow requirements include the 1993 Biological Opinion for winter-run chinook salmon and the Sacramento River navigation control point (NCP). Additional summer and fall releases for temperature control between Keswick and Red Bluff were made beginning in 1991. These releases concluded in 1997 with the completion of the Shasta Dam Temperature Control Device. The regulated Keswick releases are much higher than unimpaired flows during the summer irrigation season.

The Red Bluff Diversion Dam (RBDD) is located on the Sacramento River just downstream of Red Bluff. Diversions are made to the Tehama-Colusa and Corning Canals from upstream of the RBDD, with a maximum annual diversion of about 600 TAF. Higher diversion rates to these canals are possible when the RBDD gates are closed; however, closure of the gates impacts passage of winter-run chinook salmon. Due to these concerns, the RBDD gates are closed only from May 15 through September 15. While the gates are open at the beginning and end of the irrigation season, diversions are limited to a pumping capacity of about 450 cfs. Several smaller diversions occur between Keswick and Red Bluff. Some water for the Tehama-Colusa Canal is obtained from Stony Creek (Black Butte Reservoir) when excess water is available.

The major diversion downstream of Red Bluff is the Glenn-Colusa Irrigation District's Glenn-Colusa Canal, located downstream of Hamilton City, with an annual diversion of about 800 TAF. Several additional diversions along the Sacramento River result in a combined annual diversion of about 1.9 MAF. Annual diversions for the entire Sacramento River Region above the Feather River mouth are approximately 3.3 MAF.

Feather River

The Feather River is a major tributary to the Sacramento River, with a drainage area of about 4,255 square miles. Originating in the volcanic formations of the Sierra Nevada, the Feather River flows southwest to Lake Oroville and is joined by the Yuba and Bear Rivers. The Yuba River joins the Feather River at the City of Marysville; the confluence with the Bear River is approximately 15 miles downstream of Marysville.

The average flow of the Feather River at Oroville is about 5,800 cfs. Both rainfall and snowmelt contribute to an unimpaired runoff that exceeds 2,000 cfs from January through June. Summer flow is sustained at about 1,000 cfs because of snowmelt and groundwater from the high-elevation watersheds. Upstream reservoirs contribute some seasonal storage that reduces runoff in spring and increases flow in summer and fall. Average annual unimpaired inflow to Lake Oroville is estimated at about 4.3 MAF. Due to several small upstream diversions, actual average annual inflow is about 4.0 MAF.

Lake Oroville has a storage capacity of approximately 3.5 MAF. Completed in 1968, the lake functions as the major storage facility for the SWP. Maximum storage at Oroville is achieved in the early summer months following spring runoff from snowmelt. The average annual storage diversion and release is approximately 1 MAF, with an average carryover storage of 2.2 MAF. Carryover storage was less than 1 MAF in 1977 and 1990.

Minimum flows in the Lower Feather River are established by a 1983 agreement between the DFG and DWR. The agreement provides for minimum flow standards between October and March for preservation of salmon spawning and rearing habitat. Current requirements are 1,700 cfs below Thermalito Afterbay from October to March and 1,000 cfs from April to September (some reductions are allowed in dry years). A maximum of 2,500 cfs is maintained in October and November to prevent spawning in overbank areas that might become dewatered. The flow requirements at Gridley range from 600 TAF in dry years to about 1 MAF in wet years.

In the past, substantial irrigation diversions were made from the Feather River in the vicinity of Oroville. These diversions are now made from the Thermalito complex. The maximum monthly diversions from Thermalito (approximately 150 TAF) are made during the May through August irrigation season. Annual Thermalito diversions are slightly less than 1 MAF.

The Yuba River drains a watershed of about 1,350 square miles of the western slope of the Sierra Nevada and is the major tributary to the Feather River. The average annual unimpaired runoff is about 2.3 MAF, with a range of 0.4 to 4.9 MAF. Several reservoirs have been constructed within the watershed. Englebright Dam, the lowermost dam, was completed in 1941. The major storage reservoir is New Bullards Bar on the North Fork, with a storage capacity of about 1 MAF and a watershed area of 490 square miles. More than 15 other reservoirs have a combined storage capacity of 400 TAF. A major portion of the Yuba watershed is unregulated, however, and very high flows are released from Englebright during major storms.

The major diversions from the Yuba River are made at or near Daguerre Dam by six water districts from three diversions. Several small unscreened diversions are downstream of Daguerre. Annual average diversions from the Yuba River are about 500 TAF. Yuba River minimum flows are maintained below Engelbright Reservoir.

The Bear River, the second largest tributary to the Feather River, has an average annual unimpaired runoff of about 270 TAF. Flows in the Bear River watershed are almost totally regulated by several storage and diversion facilities. The largest impoundment in the Bear River watershed is Camp Far West Reservoir, with a storage capacity of 100 TAF. Other small impoundments include Rollins Reservoir and Lake Combie, which store an additional 70 TAF. Approximately eleven Pacific Gas & Electric Company (PG&E) power plants with their forebays and afterbays also regulate Bear River flows.

As part of the hydroelectric project operations in the Bear River, water is exchanged with the Yuba River and American River basins. Water from the South Fork Yuba River is conveyed by the Drum Canal into the Drum Forebay on the Bear River. The average annual flow through the Drum Canal is about 370 TAF. Water from the North Fork of the American River, diverted through Lake Valley Canal, also flows into the Drum Forebay. Average annual flow through the Lake Valley Canal is about 12 TAF.

From the Drum Forebay, water is diverted to two locations. The first is Canyon Creek, where the water either supplies the Alta Powerhouse or flows back into the American River. Portions of the Alta Powerhouse discharge may be diverted to the Bear River. The second diversion from the Drum Forebay is to Drum Powerhouses 1 and 2. All discharge from these power plants flows into the Bear River.

American River

The American River is another major tributary of the Sacramento River, entering just north of Sacramento. The American River drains a watershed of about 1,900 square miles that covers the western Sierra Nevada and foothills with three major branches: the South Fork, Middle Fork, and North Fork. Maximum elevations are about 10,000 feet, and a substantial portion of the runoff results from snowmelt.

The 13 largest reservoirs on the American River have a total storage capacity of about 2 MAF. Folsom Lake was constructed in 1956 and is the largest reservoir on the American River, with a storage capacity of about 1 MAF. Nimbus Dam, a regulating reservoir constructed downstream of Folsom Dam and about 23 miles upstream of the mouth, provides diversions to the Folsom South Canal.

Average annual inflow to Folsom Lake is about 2.6 MAF. Average annual storage diversion and release is about 460 TAF. Average Folsom carryover storage is about 560 TAF. The required flood control storage is dependent on upstream storage. Additional flood control space has been provided in recent years to increase flood protection along the American River.

Because summer releases are made into the Lower American River from Folsom to meet local demands and Delta export, outflow, and water quality requirements, summer and fall flows are much higher than unimpaired flows. (On an annual average, actual flow is about the same as the unimpaired flow.) Average annual diversions, totaling about 400 TAF under 1995-level conditions, are made from Folsom Lake, Folsom South Canal, and the Lower American River. Annual diversions from Folsom Lake are about 210 TAF. Annual diversions from Folsom South Canal are about 70 TAF and Lower American River diversions are about 120 TAF. The seasonal diversion pattern is governed by municipal water supply uses along the American River. The two largest diversions are the San Juan Water District located in Folsom Lake and the City of Sacramento's Fairbairn Treatment Plant located about 7 miles upstream of the mouth of the American River.

In-stream flow requirements were established in the SWRCB's Decision- (D-) 893. The decision specifies 500 cfs during the fall spawning season and 250 cfs for the remainder of the year. Only during extreme droughts have American River flows been this low. DFG has determined that these flows are insufficient to maintain anadromous fishery resources. SWRCB's D-1400, following hearings from the proposed Auburn Dam, specified higher releases from Nimbus should the Auburn Dam be constructed. D-1400 flows are 1,250 cfs from October 15 to July 15, with 800 cfs for the remainder of the year. A 1990 court order (Hodge Decision) specified American River flow conditions that must be satisfied before allowing EBMUD to divert any water from the Folsom South Canal. The court-required flows for EBMUD diversions are 2,000 cfs from October 15 through February 28, 3,000 cfs from March 1 through June 30, and 1,750 cfs between July 1 and October 14.

Current Folsom operations use a relationship between storage and projected inflow to determine in-stream flow requirements. At relatively high storage and projected inflow values, in-stream flow requirements are set at the maximum Anadromous Fish Restoration Program (AFRP) monthly targets. As storage and projected inflow decreases, the in-stream flow requirements are reduced. This provides an adaptive balance between available water and in-stream flow benefits. During high flow periods, in-stream requirements are 2,500 cfs between July and February and 4,500 cfs between March and June. The maximum in-stream flow requirement is therefore about 2.3 MAF; however, the average in-stream flow requirement is about 1.5 MAF.

5.1.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region includes the Central Valley south of the watershed of the American River. It is generally drier than the Sacramento River Region, and flows into the Delta from the San Joaquin River are considerably lower than those into the Delta from the Sacramento River. The region is also subject to extreme variations in flow, as exemplified by flooding that occurred during January 1997.

The drainage area of the San Joaquin River above Vernalis is 13,356 square miles, including 2,100 square miles of drainage contributed by the James Bypass. Most of the inflow to the San Joaquin River region originates from the upper watershed tributary streams between the Mokelumne River and the San Joaquin River, on the west slope of the Sierra Nevada. Runoff intensity averages less than 1 TAF per square mile in this region. Inflows from the Merced, Tuolumne, and Stanislaus Rivers historically contribute over 60% of the flows in the San Joaquin River, as measured at Vernalis. Average annual precipitation in the lower reach of the river ranges from 10 to 12 inches per year.

The upper watershed of the San Joaquin River Region has historically been less developed than that of the Sacramento River Region, although the same general process of development has occurred, including mining, logging, housing construction, industrial development, and dam construction. As in the Sacramento River Region, the upper watershed contains major parks and wilderness areas. Most development has occurred in the lower foothills, near or below the snow line.

Annual average unimpaired runoff from the San Joaquin, Stanislaus, Tuolumne, and Merced Rivers is about 5.5 MAF. Numerous dams and diversions have been constructed on these rivers and other rivers in this system. Of the 5.5 MAF of unimpaired runoff, about 3.5 MAF is diverted from the major rivers of the San Joaquin system. An average of about 3 MAF annually reaches Vernalis and contributes to Delta inflows. The Upper San Joaquin, Stanislaus, Tuolumne, and Merced River systems are described in more detail below.

Upper San Joaquin River

The Upper San Joaquin River has average unimpaired flows of about 1.7 MAF, with a range of 360 TAF to 4.6 MAF, from an area of approximately 1,638 square miles. Historically, about 70% of the river's runoff has been diverted to the Friant-Kern and Madera Canals, primarily for agricultural uses. About

20% of historical water uses have been supplied from reservoir releases. Peak runoff caused by snowmelt occurs in May and June. Rainfall storms cause only moderate runoff from December through March. Late-summer and fall inflows are relatively low; the median flow is less than 100 TAF from September through February.

The Upper San Joaquin River, originating in the Sierra Nevada, is regulated by a series of small hydroelectric projects and Friant Dam which forms Millerton Lake. Millerton Lake was constructed by U.S. Bureau of Reclamation (Reclamation) in 1941. From Friant Dam, the Madera Canal conveys water north and the Friant-Kern Canal conveys water south to the Bakersfield area. These two canals divert most of the water entering Millerton Lake.

Several reservoirs upstream of Millerton Lake have a combined storage capacity of about 600 TAF. Millerton Lake stores runoff from the Upper San Joaquin River and has a storage capacity of approximately 520 TAF. Because most of the water entering Millerton Lake is diverted through the Madera Canal and from the Friant-Kern Canals, river releases from Friant Dam are typically small, although they may increase during storm events and when runoff is large enough to require spilling. Because most of the San Joaquin River flow is now diverted at Friant Dam, diversions for previous water users (exchange contractors) along the San Joaquin River are now supplied by water pumped at the Tracy Pumping Plant from the Delta into the DMC to the Mendota Pool.

Millerton Lake is typically drawn below 200 TAF in fall and reaches a maximum of about 400 TAF in summer. The lake provides limited annual carryover storage of about 180 TAF. This carryover storage generally provides only small releases the following year.

Monthly diversions from the Upper San Joaquin River generally peak in July, with a median diversion of approximately 225 TAF. The Friant-Kern and Madera Canals support the largest diversions in the Upper San Joaquin River. Some of the water diverted by these canals during wet years is used for groundwater recharge. Annual diversions range from about 200 TAF to more than 2 MAF in several years, with an average of about 1.2 MAF.

Below Friant Dam, median San Joaquin River flow is over 620 TAF annually. In most years, release flows peak during summer. Monthly flow below the dam ranges from about 5 TAF (10th percentile) to about 280 TAF (90th percentile). No in-stream flow requirements exist for the San Joaquin River between Friant Dam and the Merced River. Downstream riparian diversions at Gravelly Ford are estimated to require about 100 TAF per year.

Stanislaus River

The Upper Stanislaus River's drainage area is approximately 1,804 square miles. The average annual unimpaired runoff is about 1.1 MAF, with a range of 155 TAF to more than 2 MAF. Peak snowmelt runoff occurs between April and June. Rainfall runoff generally occurs between November and March. Late summer and fall unimpaired flows are relatively low; the median flow is less than 200 cfs from July through October. Runoff from the upper watershed generally is captured and released for irrigation diversions. Total annual flows on the Stanislaus River average approximately 1.2 MAF. Average annual flow near the mouth of the Stanislaus River is about 680 TAF.

The largest reservoir on the Stanislaus River is New Melones, which was completed by the Corps in 1978 and is operated by Reclamation. The reservoir was first filled in 1983 and remained at fairly high storage levels through 1986. The reservoir storage then declined from 1987 through 1991 during the drought. In wet years, when inflows are greater than beneficial uses, New Melones Reservoir storage increases to the flood control capacity. (The reservoir filled to capacity in 1993.) During summer months, storage releases from New Melones are needed to supply beneficial uses along the Stanislaus River.

Tulloch Reservoir has a storage capacity of about 70 TAF. Releases from Tulloch Powerhouse flow downstream to Goodwin Dam, where diversions are made into the Oakdale and South San Joaquin canals. More than 40 small pump diversions along the Stanislaus River supply irrigation water during spring and summer. Stockton-East Water District has a contract with Reclamation for 75 TAF per year of New Melones water to be delivered from Tulloch Reservoir through the Goodwin Tunnel/Farmington Canal system, when available.

Water allocation has been approximately 200 TAF for in-stream flow use and about 500 TAF for diversions. Additional releases for downstream water quality control have been made since 1982. Releases were made prior to 1982 for flood control purposes. Maximum monthly diversions are about 100 TAF during the irrigation season from May through August.

Salmon spawn in the 23-mile reach between Goodwin Dam and Riverbank, and rear in the entire Lower Stanislaus River. Current in-stream flow requirements vary from about 135 cfs (average in dry years) to about 415 cfs (average in wet years). Water quality releases during the irrigation months increase average flow by 200 cfs. DFG and the AFRP recommend additional spring flow for outmigration. The AFRP suggests an adaptive management framework, with releases that depend on available water supply. Because of water rights and contract obligations, additional in-stream flow requirements may be difficult to meet in some years.

Tuolumne River

The Tuolumne River has a watershed of about 1,900 square miles that drains the Sierra Nevada Mountains and foothills, including the north half of Yosemite National Park. The average annual unimpaired runoff of the Tuolumne River is about 1.8 MAF and ranges from 380 TAF to about 4.6 MAF. Peak snowmelt runoff occurs between April and June. Rainfall can cause substantial runoff from December through March. Late summer and fall inflows are relatively low; the median inflow is less than 50 TAF (800 cfs) from July through December.

Over 2.5 MAF of storage capacity has been constructed on this river. Water is impounded and regulated by several dams in the high Sierra for municipal water supply and power generation. The Hetch-Hetchy Reservoir (located in Yosemite National Park), with a capacity of about 360 TAF, was constructed by the City and County of San Francisco in 1923 for drinking water supply. Cherry Lake (260-TAF capacity) was completed in 1953 to increase the aqueduct yield.

Downstream of the San Francisco facilities, the Tuolumne River is impounded and regulated by New Don Pedro Reservoir. New Don Pedro Reservoir was completed in 1971 by the Turlock and Modesto Irrigation Districts to increase the reliability of water supply diversions. New Don Pedro Reservoir has a capacity of about 2 MAF and allows the diversion of about 900 TAF each year from La Grange Dam, located downstream of New Don Pedro Reservoir.

Annual Tuolumne River inflow to New Don Pedro Reservoir is about 1.5 MAF. Of this, about 900 TAF is used for diversions and 200 TAF is used for in-stream flows. The inflow to New Don Pedro Reservoir is affected by San Francisco's upstream reservoirs and diversions. Annual average storage releases are 420 TAF and range from 90 to 910 TAF. Average carryover storage is 1.2 MAF.

La Grange Dam is the upstream limit for anadromous fish on the Tuolumne River. Salmon spawn in the 25-mile reach between La Grange Dam and the town of Waterford, and rear in the entire Lower Tuolumne River. Based on historical records between 1970 and 1997, median monthly flow below La Grange Dam is about 230 cfs and ranges between 10 cfs (10th percentile) and 3,100 cfs (90th percentile).

Almost all diversions from the Tuolumne River below New Don Pedro Reservoir are made by the Modesto and Turlock Irrigation Districts. Maximum diversions generally peak in July with a median diversion of approximately 180 TAF. The combined annual diversions made by these two irrigation districts range from 440 TAF to about 1.1 MAF, with an average of about 900 TAF.

In-stream flow requirements for the New Don Pedro hydropower FERC license were revised in 1997. The flows are specified for the October-to-March salmon spawning and rearing season, the April and May outmigration pulse, and the summer steelhead rearing season. The salmon rearing flows vary from 80 to 300 cfs, with pulse flows of 500-3,000 cfs. The summertime steelhead rearing flows vary from 50 to 200 cfs.

Merced River

The Merced River has a watershed of about 1,275 square miles and drains the Sierra Nevada Mountains and foothills, including the southern half of Yosemite National Park (Yosemite Valley). The Merced River has average unimpaired flows of about 1 MAF, with a range of 150 TAF to more than 2 MAF. Peak snowmelt runoff occurs from April through July. Rainfall storms can cause substantial runoff from December through March. Late-summer and fall unimpaired flows are relatively low; the median flow is less than 100 cfs from August through October. The highest flows occur during winter, when rainfall storms require reservoir flood control releases. The unimpaired flows generally are captured and released for irrigation diversions. Summer flows at Stevinson are generally less than 50 cfs, and median flows during the October-to-March salmon spawning and rearing season are between 250 and 500 cfs.

Lake McClure is formed by New Exchequer Dam, which was completed by the Merced Irrigation District in 1967 to increase the reliability of water supply diversions from the Merced River. The storage capacity of Lake McClure is approximately 1 MAF. Annual diversions of about 600 TAF are made into the North Canal at the Merced Falls Dam and into the Main Canal at the Crocker-Huffman Dam. The Crocker-Huffman Dam near the town of Snelling is the upstream limit for anadromous fish on the Merced River. The Merced River Hatchery is located immediately below the Crocker-Huffman Dam. The available storage is utilized in the majority of years, with maximum storage levels achieved in May and June following the spring snowmelt season. Average carryover storage is 485 TAF. Annual storage releases average 350 TAF and range from about 150 to 550 TAF. Merced River inflow to Lake McClure is about 900 TAF. Of this, about 500 TAF is used for diversions and 400 TAF is used for in-stream flows.

Below the major Merced River diversions, average annual downstream flow is 430 TAF (590 cfs) and downstream riparian diversions are about 30 TAF. Maximum diversions occur in July and August, the peak irrigation months. At the mouth (near Stevinson), average annual flow is higher, about 500 TAF

(700 cfs), indicating that some of this flow is contributed by irrigation return flows along the Lower Merced River. Several diversions occur downstream of Crocker-Huffman Dam. Annual diversion range from about 200 to more than 650 TAF, with an average of about 550 TAF.

In-stream flow requirements for the New Exchequer and McSwain hydropower FERC license range from 35 TAF in dry years to about 50 TAF in wet years, with an average requirement of about 42 TAF (58 cfs). The Davis-Grunsky contract between DFG and Merced Irrigation District includes flow requirements of 200 cfs from November through March. DFG and the AFRP have suggested in-stream flows that depend on available runoff. DFG and the AFRP flows are specified for the October-to-March salmon spawning and rearing season, the April and May outmigration pulse period, and the summer steelhead rearing season. Salmon rearing flows (recommended by DFG) vary from 200 to 300 cfs, with pulse flows of 300-500 cfs and summer flows of 200-300 cfs. Additional flow for temperature control are recommended in April and May. The AFRP recommended considerably greater releases during years with higher runoff.

5.1.3.5 SOUTH-OF-DELTA SWP AND CVP SERVICE AREAS

The SWP includes 20 reservoirs and 662 miles of aqueduct. Conveyance facilities serving south-of-Delta service areas include the Coastal Branch Aqueduct (serving the Central Coast Region) and the California Aqueduct (serving the South Coast Region). The capacity of the California Aqueduct at the Delta is 10,300 cfs. South of the Tehachapi Mountains at the southern end of the Central Valley, the capacity of the aqueduct is 4,480 cfs. The major SWP reservoirs serving these areas include Pyramid Lake and Castaic Lake (which receive water via the West Branch of the California Aqueduct) and Silverwood Lake and Lake Perris (which receive water via the East Branch of the California Aqueduct). Of the initial project contracts for 4.2 MAF annual delivery, about 2.5 MAF was contracted by southern California, about 1.3 MAF by the San Joaquin Valley, and about 0.4 MAF by the Bay, Central Coast, and Feather River areas. These water supplies were contracted for by regional and local water agencies for anticipated future demand; the full 4.2 MAF of entitlement has not been requested to date. Since about 1980, southern California has received about 60% of its full entitlement, while the San Joaquin Valley has received nearly all of its entitlement. It has been estimated that SWP facilities have about a 65% chance of making full deliveries of requested water supplies at the 1995 level of demand.

Reclamation's CVP is the largest water storage and delivery system in California, covering 29 of the State's 58 counties. The CVP currently consists of 21 reservoirs capable of storing 12 million acre-feet of water, 11 power plants, 500 miles of major canals and aqueducts, and many other tunnels, conduits, power transmission line. The CVP irrigates about 3.25 million acres of farmland and supplies water to more than 2 million people through more than 250 long-term water contractors in its service area. Most of the CVP service area is inside the Central Valley. Outside the Central Valley, the service area includes part of Santa Clara County, northwest San Benito County, a small region along both sides of the Santa Cruz/Monterey County line, and northeastern Contra Costa County. About 90% of the south-of-Delta contractual delivery is for agricultural uses.

The CVP pumps water from the Delta at the Tracy Pumping Plant and conveys the water south via the DMC. Other key facilities south of the Delta include the San Luis Reservoir (shared with the SWP), the Contra Costa Canal, New Melones Dam, Friant Dam and the Friant-Kern Canal. In its south-of-Delta service area, the CVP includes the Delta, New Melones, San Felipe, San Luis and Friant Divisions. These areas hold approximately 5.8 MAF in total service contracts, including 1.4 MAF of Friant Division Class 2 supply available in wet years. Of the 5.8 MAF, 4.9 MAF is project water and 840 TAF is water right settlement water.

5.1.4 ASSESSMENT METHODS

5.1.4.1 TOOLS

Both qualitative and quantitative methods were used to assess the potential impacts of the Program alternatives on water supply and water management. In general, qualitative methods were used to assess impacts from implementation of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs. Qualitative methods also were used to assess the impacts of some aspects of the storage and conveyance features of the Program alternatives, including in-Delta storage. (See Section 2.1.2.) Because of the availability of appropriate models, quantitative methods were used to assess the impacts of other aspects of the storage and conveyance features of the Program alternatives.

DWRSIM is a planning model used to simulate the CVP and SWP systems of reservoir and conveyance facilities. The model calculates flows on a monthly time step, using a historical 73-year hydrologic sequence (water years 1922-94). Historical runoff patterns have been normalized to reflect 1995-level and 2020-level land use. This normalization process—or hydrology development process—results in hydrology inputs to DWRSIM that are representative of the water supply available to the CALFED study area under existing conditions (1995 level) and future conditions (2020 level). The No Action Alternative and all Program alternatives assume 2020-level conditions.

As part of the hydrology development process, the Sacramento River Region is divided into drainage and service areas from which water supplies and demands can be more easily evaluated. (San Joaquin River Region hydrology is based on maximum historical water use as determined by Reclamation.) These individual areas are called "depletion study areas." Three steps are conducted in sequence within the hydrology development process:

- Consumptive use studies evaluate water use by depletion area, using historical and projected agricultural and urban land use, evapotranspiration rates, precipitation rates, and soil moisture storage criteria. Projected agricultural and urban land use is based on DWR's Bulletin 160-98. Output from the consumptive use studies becomes input to the depletion analysis.

- Depletion analysis studies evaluate the effect of future water demands and future storage and diversion regulation on the historical flows of the river systems tributary to the Delta. Future depletion area outflows are computed by adjusting the historical outflow for any changes in water use occurring upstream.

- Preparing input to DWRSIM is the final step in the hydrology development process. Consumptive use and depletion analysis data are converted to local inflows and diversions for the control points in the DWRSIM network.

The hydrology development process imposes 25% or 50% deficiencies on full upstream CVP/SWP project demands during dry and critical water years. Upstream water demands that are not met through

CVP/SWP project deliveries are assumed to be met through locally derived water supplies. Details on the hydrology development process are documented in a July 1994 DWR memorandum report entitled "Summary of Hydrologies at the 1990, 1995, 2000, 2010, and 2020 Levels of Development for Use in DWRSIM Planning Studies."

A key outcome of the hydrology development process is that all upstream water demands are met through CVP/SWP project deliveries or through locally derived water supplies. Consequently, the modeling approach assumes that water supply reliability in the Sacramento and San Joaquin River Regions remains unchanged under all conditions—existing conditions, the No Action Alternative, and all Program alternatives.

Project Operations Modeling

DWRSIM is designed to simulate operation of the CVP and SWP systems for the purposes of water supply, flood control, recreation, in-stream flows, power generation and Delta water quality and outflow requirements. The model is used to analyze the potential effects of proposed new features, such as additional reservoir storage or Delta export conveyance, as well as any changes to criteria controlling project operations.

To evaluate the various Program alternatives using DWRSIM, new facilities and operational assumptions are assigned to the CVP and SWP. For this programmatic-level evaluation, impacts are evaluated and discussed relative to study regions rather than specific water projects.

Model results provide information on expected reservoir storage, river flow, Delta inflow, Delta outflow, exports, and water project deliveries. Project water deliveries are assumed to have priority access to available capacity of facilities. This analysis does not consider potential operational changes of non-project facilities with the Central Valley system. In addition to DWRSIM, electronic spreadsheet models and other analytical tools were used for the analyses. The monthly flows calculated by DWRSIM for the Sacramento and San Joaquin Rivers are used as input for Delta hydrodynamic and water quality modeling.

Bay-Delta Hydrodynamic and Water Quality Modeling

The hydrodynamic model, DSM2, simulates the channel flows, tidal effects, and water quality of the Bay-Delta estuary. For the purposes of this programmatic analysis, model simulations were conducted for a 16-year historical hydrologic sequence (water years 1976-91). This period was selected to cover a broad range of Delta inflows and exports and is generally representative of the 73-year historical hydrologic sequence used in DWRSIM.

A great number of variables must be simulated to describe flows in the Delta. The Delta is a network of interconnected channels. The water flowing in these channels is acted upon by a number of competing forces. Freshwater enters the Delta from tributary streams, including but not limited to the Sacramento, San Joaquin, Mokelumne, and Calaveras Rivers. During much of the year, these Delta inflows are largely controlled by upstream reservoir operations.

Another influence on the flow of water in Delta channels is tidal action. Tidal inflows move water into portions of the Delta where freshwater flows and channel geometry offer the least resistance. The relatively large freshwater inflows from the Sacramento River have the capacity to resist tidal inflows more than the smaller inflows from the San Joaquin River. Combined with pumping in the south Delta, saline Bay water tends to move further into the south Delta than it does into the north Delta. The pattern of flows is continually changing as a result of these competing forces, making it difficult to describe the dominant patterns.

Salinity is an indirect measure of hydrodynamic conditions in the Delta. Delta salinity is primarily a result of seawater intrusion, although upstream sources, such as agricultural drainage from the San Joaquin Valley, contribute to Delta salinity. X2 is a measure that describes Delta salinity resulting from hydrodynamic conditions. X2 is the distance upstream from the Golden Gate Bridge (in km) at which the mixing of freshwater from the Delta inflow and saltwater from the Bay results in a channel bottom salinity of two parts per thousand. Changes in these variables are used in this programmatic analysis to describe the effects of Program actions on hydrodynamic conditions in the Delta.

5.1.4.2 ADDRESSING UNCERTAINTY

The Program recognizes the need to address uncertainty in its assessment of Program alternatives. Project operations modeling and Delta hydrodynamic modeling rely on the formulation of reasonable assumptions to accurately reflect the consequences of present and future water management decisions. The use of different assumptions may lead to conclusions that overestimate or underestimate the impact or benefits of implementing the various Program elements. The modeling assumptions with the greatest uncertainty include future water demands and future environmental water requirements, as discussed in Section 5.1.2.

The Program has begun the formulation of a comprehensive water management strategy to determine the appropriate role of various water management tools in meeting Program objectives. Different combinations of tools may be appropriate depending on future population growth, land use changes, technological improvements, willingness to pay for improved water supply reliability, and environmental water requirements. These factors can affect the level of future demands on the Bay-Delta system. To aid in developing a water management strategy, the Program has undertaken an economic evaluation of water management alternatives. The Program is performing economic assessments to identify cost-effective combinations of strategies (for example, conservation, recycling, transfers, and new facilities) that meet the Program's water supply reliability objectives. This study effort will help to quantify the uncertainty and risk associated with alternative water management strategies.

At present, a high level of uncertainty is associated with future environmental water requirements. Through the development of an EWA, the Program intends to provide flexibility in achieving environmental benefits while reducing uncertainties associated with environmental water requirements. Flexible management of water operations could achieve fishery and ecosystem benefits more efficiently than a fully prescriptive regulatory approach. The Program believes that operations using an EWA can achieve substantial fish recovery while providing for continuous improvement in water supply reliability and water quality. A variety of potential approaches are available to define and operate an EWA. Although an EWA has significant potential, a number of major issues and details must be resolved before this approach can be fully implemented, These include:

- Determine which environmental protections would be provided through prescriptive standards and which would be provided through an EWA.

- Investigate various approaches for implementing an EWA.
- Developing accounting methodologies.
- Determine reliability of existing legal mechanisms to assure intended use of EWA water released for in-stream purposes.
- Determine how much existing surface and groundwater storage, water purchase contract water, and water generated from conservation and recycling projects will be needed by an EWA.

To fully describe potential consequences of program actions, the Program has incorporated a reasonable range of uncertainty into this programmatic analysis. This range of uncertainty was quantified by formulating two distinct bookend water management criteria assumption sets. These two sets of assumptions, referred to as Criteria A and B, serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in this programmatic analysis. The primary assumptions that differentiate the bookend assumption sets from each other and from existing conditions are Bay-Delta system water demands and various Delta water management criteria that regulate system operations. Figure 5.1-2 reflects the framework for evaluating the No Action Alternative and Program alternatives.

The range of water demands defined by these water management criteria assumption sets represents uncertainty in the future need for Bay-Delta water supplies due to population growth, land use changes, implementation of water use efficiency measures, and water marketing. Criterion A assumes current Bay-Delta system demands apply throughout the Program planning horizon. Under this assumption, any future increase in demands in the Program study area would be met by alternative supply or demand management options. In contrast, Criterion B assumes a future increase of about 10% in Bay-Delta system demands. SWP demands vary annually from 3.6 to 4.2 MAF and CVP demands are 3.5 MAF per year using this criterion.

The range of Delta water management criteria represents uncertainty related to future environmental water requirements. Under Criterion A, CVP and SWP facilities are operated to provide additional Delta protection above the existing conditions operation criteria. While specific assumptions regarding Delta water management criteria were made to complete the water simulation modeling, the Program's intention is to depict a general level of environmental protection. These assumptions should not be interpreted as specific predictions of future regulatory actions. Under Criterion B, existing Delta protective actions are assumed.

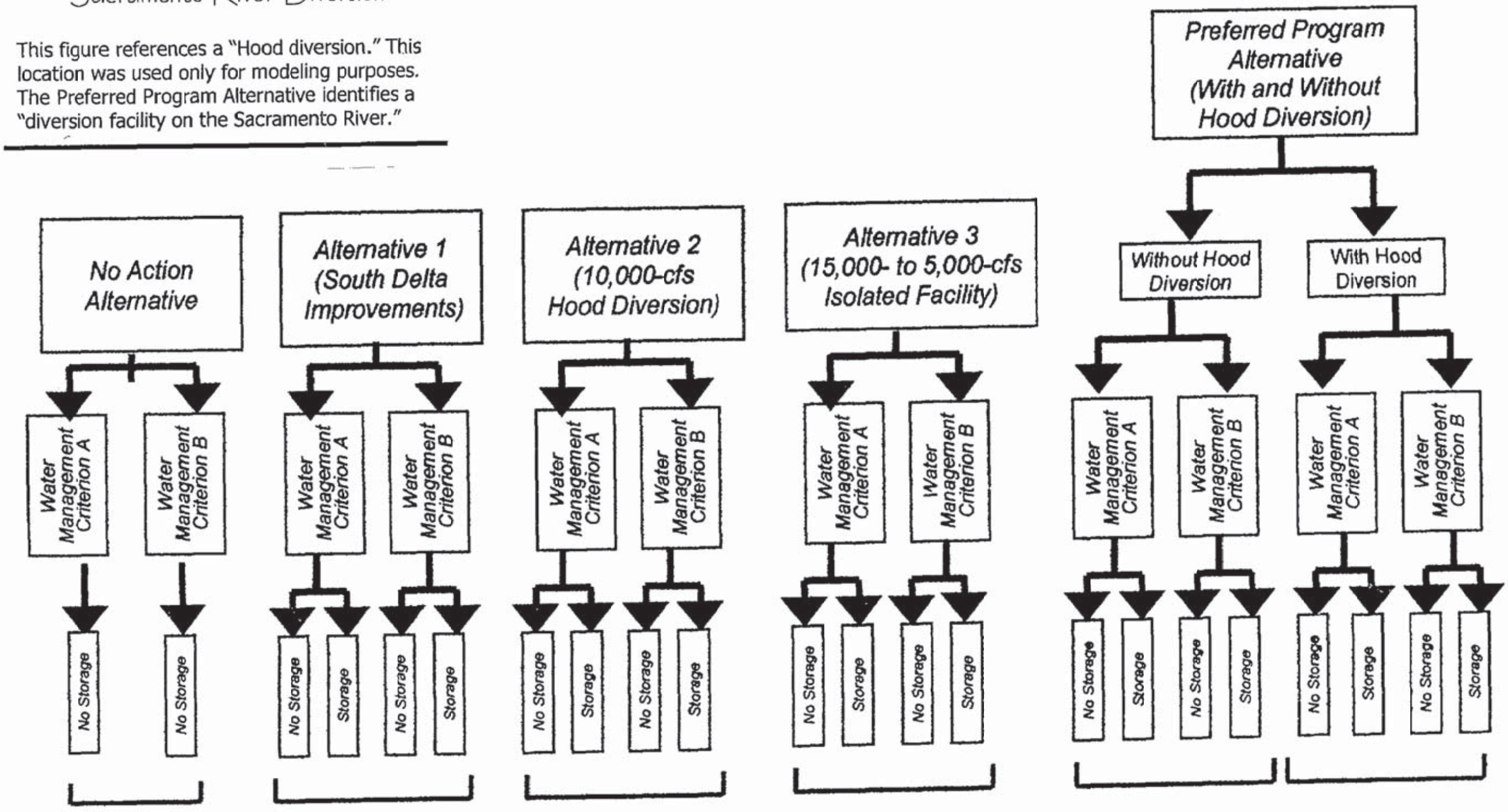
Ranges also were used to describe possible flow changes in the Trinity and American Rivers due to the Trinity River Flow Analysis Study and implementation of the EBMUD CVP contract. These activities could result in changes in the availability of water to meet Program objectives. The assumed ranges were included in the No Action Alternative assumptions to help decision makers better understand the potential consequences to the Program. No decisions have been made about the Trinity River flows or American River diversions. Both of these efforts are currently undergoing environmental review.

The CVPIA is included in the description of existing conditions and in the analyses of the No Action Alternative and Program alternatives in this programmatic evaluation. Section 3406 (b)(2) of the CVPIA mandates that the Secretary of Interior dedicate and manage 800 TAF of CVP yield for the primary purpose of implementing fish, wildlife, and habitat restoration measures. Considerable controversy has

Figure 5.1-2. Assessment Approach for the CALFED Programmatic EIS/EIR

Sacramento River Diversion

This figure references a "Hood diversion." This location was used only for modeling purposes. The Preferred Program Alternative identifies a "diversion facility on the Sacramento River."



surrounded interpretation and implementation of this provision. In November 1997, Interior issued its "Final Administrative Proposal on the Management of Section 3406(b)(2) Water," which described Interior's plan to comply with this provision. This Final Administrative Proposal provided the basis for the assumptions regarding implementation of CVPIA Section 3406 (b)(2) used in the analysis of alternatives included in this programmatic evaluation.

A legal challenge to Interior's interpretation of CVPIA Section 3406(b)(2) followed the release of the Final Administrative Proposal. The controversy centered on Interior's method of accounting for CVP yield for Section 3406 (b)(2) purposes. In response to a preliminary injunction issued by U.S. District Court Judge Oliver W. Wanger, Interior prepared and released the "Interim Decision on Implementation of Section 3406(b)(2) of the Central Valley Project Improvement Act" on July 14, 1999. This was followed by issuance of a "Final Decision on Implementation of Section 3406(b)(2) of the Central Valley Project Improvement Act" on October 6, 1999. The Final Decision describes the accounting methodology that Interior intends to use to determine the extent of restoration measures that will be implemented under CVPIA Section 3406 (b)(2). As described in the Final Decision, while Interior maintains broad discretion in determining what measures will be implemented, an annual accounting will be used to ensure that 800 TAF of CVP yield is dedicated to restoration actions each year.

In a March 2000 ruling that dissolved the preliminary injunction, Judge Wanger upheld Interior's method of accounting for CVP yield for the 1999-2000 water year in the Interim Decision, with some modification regarding flows in the American River. Plaintiffs have filed amended complaints, challenging the Final Decision, and have appealed Judge Wanger's order, dissolving the preliminary injunction on the Interim Decision. Moreover, the State of California currently is working with Interior to determine how SWP facilities will be operated during implementation of CVPIA Section 3406 (b)(2) restoration measures. For these reasons, it is unclear how CVPIA Section 3406(b)(2) ultimately will be interpreted. While general effects of CVPIA Section 3406 (b)(2) restoration actions are included in this programmatic evaluation, based on the November 1997 Final Administrative Proposal, some specific effects could vary in the future as the details of implementing CVPIA Section 3406 (b)(2) are determined. Final implementation of the CVPIA Section 3406(b)(2), however, does not present an insurmountable obstacle for this programmatic evaluation.

As described above, the No Action Alternative and the Program alternatives were evaluated with a range of operating assumptions to consider uncertainty in future Bay-Delta system water demands and environmental water requirements. The range of uncertainty is bounded by two distinct bookend water management criteria assumption sets (Criteria A and B). The provisions of Interior's November 1997 Final Administrative Proposal are included as operational assumptions in both of these bookend assumption sets. The Criterion A assumption set defines the highest environmental water requirements and lowest Delta exports considered in this analysis. Ecosystem protections provided in Criterion A exceed those included in the 1994 Bay-Delta Accord and the November 1997 Final Administrative Proposal interpretation of CVPIA Section 3406(b)(2). CALFED does not anticipate that future changes in interpretation of Section 3406(b)(2) will result in higher environmental water requirements or lower Delta export conditions than those described by the Criterion A assumption set. At the opposite end of the range of uncertainty, the Criterion B assumption set defines the lowest environmental water requirements and highest Delta exports considered in this analysis. Again, CALFED does not anticipate that a revised interpretation of Section 3406(b)(2) will result in a lower environmental water requirement or a higher Delta export condition than provided in the Criterion B assumption set. Some exceptions to these expected effects of CVPIA Section 3406(b)(2) could occur; some specific parameter may vary outside the ranges evaluated in this programmatic evaluation during some specific water-year type. However, these potential differences would be consistent for all alternatives and are not expected to significantly change the magnitude of projected impacts.

5.1.4.3 MODELING ASSUMPTIONS

A summary description of the Program alternative assumptions is provided in Table 5.1-2. This table also provides a description of Delta modifications and storage components associated with each alternative. These assumptions and Program alternative configurations are the foundation of the DWRSIM and DSM2 assessments, which provide quantitative information utilized by several resource areas for impact evaluations of the Program alternatives. In some instances, assumptions are required for modeling purposes that incorporate more detail than needed for this programmatic evaluation. An example of this level of detail is the specific location of storage and conveyance facilities. These detailed modeling assumptions, provided in Attachment A, describe the analytical processes employed in this evaluation; these assumptions are not intended to imply the outcome of future project-specific decisions.

Sacramento River Diversion

Tables and figures in Section 5.1 for the Preferred Program Alternative reference a "Hood diversion." This location was used only for modeling purposes. The Preferred Program Alternative identifies a "diversion facility on the Sacramento River."

5.1.4.4 APPROACH

The DWRSIM model was used to programmatically evaluate the effects of adding new facilities and changing existing facilities operating criteria on Central Valley flows, existing and new reservoir storage operations, Delta exports and outflow, and required water acquisition quantities. As described in Section 5.1.4.1, the hydrology development and modeling approach used in this evaluation includes the assumption that all upstream-of-Delta demands are met through CVP/SWP project deliveries or locally derived supplies. Projected water supply needs in these areas are deducted from Delta inflows. Consequently, water supply reliability remains unchanged under all Program alternatives for upstream-of-Delta areas.

The DWRSIM model was used to assess changes in water deliveries to South-of-Delta SWP and CVP water users resulting from Program implementation. For each Program alternative, water supply reliability was assessed relative to the degree and frequency at which the facilities (and associated operations criteria) are able to meet future water demands. These demands include municipal, industrial, agricultural, environmental, power production, aesthetic, and recreational water needs. Specific beneficiaries and willingness of beneficiaries to pay for new facilities will not be determined until later stages of the Program. For this analysis, SWP and CVP water users were used as surrogates for all potential water supply beneficiaries.

Assumptions regarding allocation of new storage capacity between agricultural, urban, and environmental beneficial uses are hypothetical and provided only for modeling purposes. Decisions about how to allocate potential benefits will be made based on several factors including the willingness of users to pay for new storage or conveyance facilities, operational opportunities and constraints associated with new storage or conveyance facilities, and environmental requirements associated with new storage or conveyance facilities.

Table 5.1-2. Summary of Modeling Assumptions

Alternative Configuration		Operation Criteria					Delta Modifications				Storage Components (Maximum Storage Volumes in MAF)						
		Baseline Operation Criteria	Water Management Criteria	South Delta Criteria	North Delta Hood Diversion	*Isolated Facility Criteria*	CVP-SWP Improvements	North Delta Channel	South Delta Modifications	*Isolated Conveyance/* Hood Facility (Conveyance Capacity in 1,000 cfs/Type)	Sacramento Valley Groundwater Storage	Upstream Surface Storage *Sacramento River Tributaries*	Upstream Surface Storage San Joaquin River Tributaries	San Joaquin Valley Groundwater Storage	South of Delta Aqueduct Surface Storage	DWRSIM Study	*DWRDSM2 Study*
Exist. Cond.		1														771	1EX
No Action		1	A													785	1A-A
		1	B													786	1A-B
Alternative 1		1	A	1			1		1,2,3							789	1C-A
		1	A	1			1		1,2,3		0.25	3.0	0.25	0.5	2.0	808	
		1	B	2			1		1,2,3							809	
		1	B	2			1		1,2,3		0.25	3.0	0.25	0.5	2.0	801	1C-BS
Alternative 2		1	A	1	1		1	1,4	1,2,3							790	2B-A
		1	A	1	1		1	1,4	1,2,3		0.25	3.0	0.25	0.5	2.0	810	
		1	B	2	2		1	1,4	1,2,3							811	
		1	B	2	2		1	1,4	1,2,3		0.25	3.0	0.25	0.5	2.0	803	2B-BS
Alternative 3	15K IF	1	A	2		1,3	1	4		15						804	3E-A
		1	A	2		1,3	1	4		15	0.25	3.0	0.25	0.5	2.0	812	
	5k IF	1	B	2		2	1	4	1,2,3	5						820	
		1	B	2		2	1	4	1,2,3	5	0.25	3.0	0.25	0.5	2.0	791	3B-BS
Preferred Program Alternative	w/o ~~Hood~~ Diversion	1	A	1			1		1,2,3							789	1C-A
		1	A	1			1		1,2,3		0.25	3.0	0.25	0.5	2.0	808	
		1	B	2			1		1,2,3							809	
		1	B	2			1		1,2,3		0.25	3.0	0.25	0.5	2.0	801	1C-BS
	w/ ~~Hood~~ Diversion	1	A	1	1		1	2	1,2,3							793	2P-A
		1	A	1	1		1	2	1,2,3		0.25	3.0	0.25	0.5	2.0	821	
		1	B	2	2		1	3,4	1,2,3							822	
		1	B	2	2		1	3,4	1,2,3		0.25	3.0	0.25	0.5	2.0	792	2P-BS

Please refer to the notes on the following page.

Table 5.1-2. Summary of Modeling Assumptions (continued)

OPERATION CRITERIA

Baseline Operation Criteria

1 1995-level hydrology and demands are assumed. South-of-Delta SWP demands vary between 3.5 MAF in drier years down to 2.6 MAF in wetter years based on local wetness indices. Annual south-of-Delta CVP demands are 3.4 MAF. CVP and SWP facilities are operated to meet the SWRCB May 1995 Water Quality Control Plan for the Bay-Delta (WQCP); the facilities are also operated to meet the CVPIA (b) (2) Delta actions. Trinity River minimum flows below Lewiston Dam are maintained at 340 TAF in all years.

Water Management Criteria

A 2020-level hydrology and 1995-level demands are assumed. CVP and SWP facilities are operated to meet additional prescriptive Delta actions above the baseline operation criteria. Trinity River minimum flows below Lewiston Dam are as defined per U.S. Bureau of Reclamation (Reclamation) Draft CVPIA PEIS. EBMUD American River diversions at Fairbairn are assumed as defined in the EBMUD Supplemental Water Supply Project (maximum 115 TAF per year).

B 2020-level hydrology and demands are assumed. SWP demands vary annually from 3.6 to 4.2 MAF. CVP demands are 3.5 MAF per year.

South Delta Criteria

1 Full and unlimited joint point of diversion (JPD) is assumed. Harvey O. Banks Delta Pumping Plant (Banks Pumping Plant) capacity is 10,300 cubic feet per second (cfs); actual pumping is constrained in accordance with 1981 U.S. Army Corps of Engineers (Corps) criteria.

2 Full and unlimited JPD is assumed. Banks Pumping Plant capacity is 10,300 cfs.

North Delta Criteria

1 Hood diversions are limited to: (a) 50% of south Delta exports; (b) 5,000 cfs in May; (c) 35% of Sacramento flow in March and June, and 15% in April and May. Rio Vista flow criteria of 3,000 cfs in July and August are maintained. Delta Cross Channel (DCC) gates are closed for all months, except in June for dry, critical, and below-normal water-year types.

2 Hood diversions are limited to: (a) 100% of the south-of-Delta exports, and (b) 5,000 cfs in May. Rio Vista flow criteria of 3,000 cfs are maintained. DCC gates are closed, except for July and August.

Isolated Facility Criteria

1 Isolated facility diversions are limited to 5,000 cfs in May. Minimum through-Delta conveyance is 1,000 cfs from October-March and July-September. Rio Vista flow criteria of 3,000 cfs are maintained. DCC gates are closed, except June (in dry, critical, and below-normal water years), and July and August (in all water years). The isolated facility conveyance is included in export restrictions.

2 Isolated facility diversions are limited to: (a) 5,000 cfs in May, and (b) 35% of Sacramento flow in March and June, and 15% in April-May. Minimum through-Delta conveyance is 1,000 cfs from October-March and July-September. Rio Vista flow criteria of 3,000 cfs are assumed. DCC gates are closed, except for July and August. The isolated facility conveyance is not included in export restrictions.

3 Level II Delta agriculture diversions are delivered from the Isolated Facility.

DELTA MODIFICATIONS

CVP and SWP Improvements

1 New fish screens operate at the Skinner Fish Facility and Tracy Pumping Plant intake. Interconnection between Tracy Pumping Plant and CCFB is assumed.

North Delta Modifications

1 A 10,000-cfs screened Hood intake is operational.

2 A 2,000-cfs screened Hood intake is operational.

3 A 4,000-cfs screened Hood intake is operational.

4 A 600-foot-wide alignment is assumed along the Mokelumne River from I-5 to the San Joaquin River.

South Delta Modifications

1 Increased permitted capacity of existing export pumps to physical capacity is assumed. A new CCFB intake structure is operational. An operable barrier (or equivalent) is installed at the head of Old River to maintain a positive flow down the San Joaquin River.

2 Flow and stage control structures (or equivalent) are installed on Middle River, Grant Line Canal, and Old River to control flow, stage, and south Delta salinity.

3 Channel enlargement along a 4.9-mile reach of Old River is assumed.

5.1.5 SIGNIFICANCE CRITERIA

The significance of effects of Program actions on water supply and water management is evaluated with respect to the Program primary water supply objective of reducing the mismatch between Bay-Delta water supplies and the current and projected beneficial uses dependent on the Bay-Delta system. The Program has refined its primary water supply reliability objective to include the following sub-objectives:

- Reduce diversion conflicts between water users and environmental needs during average and drought periods.
- Increase access to economically efficient water supplies during average and drought periods for all beneficial uses.
- Increase water system operational flexibility so it is better suited to respond to biological and hydrological variability and be more resilient to potential disasters.
- Improve water quality so available water supplies are suitable for more uses and reuses.

Alternatives that would increase conflicts between water users and environmental needs, reduce access to economically efficient water supplies for all beneficial uses, decrease system operational flexibility, or decrease water quality are deemed to result in a significant adverse impact on water supply.

5.1.6 NO ACTION ALTERNATIVE

To assess the consequences of the various Program alternatives on water supply and water management in the Program study area, a pre-implementation condition must be established. Typically, existing conditions provide an adequate basis for assessing the impacts of proposed projects. (See Section 5.1.3 for a description of existing conditions.) However, Program implementation is expected to occur over 30 or more years. Bay-Delta standards and management criteria, water management facilities, and other conditions are not expected to remain constant over this extended time period. The actual deviation between pre-implementation conditions and existing conditions is subject to a high degree of uncertainty. Section 5.1.2 elaborates on the uncertainties associated with the Program.

A 2020 No Action Alternative was defined to represent a reasonable range of uncertainty in the pre-implementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta water management criteria that regulate system operations. Further details on the bookend assumptions and other assumptions used in the evaluation of the No Action Alternative are presented in Section 5.1.4 and in Attachment A.

The programmatic comparisons presented in this section differentiate water supply and water management provided under the No Action Alternative and existing conditions for each of the five planning regions (described in Section 5.1.3). Water supply comparisons are made based upon a 73-year historical hydrologic period, a sequence of years often referred to as the "long-term" period. Similar comparisons are made using a subset of the long-term period—the dry and critical years.

Comparisons of water supply and water management characteristics under both No Action Alternative bookends were made with those same characteristics under existing conditions. For most parameters of interest, existing conditions fall between the two No Action Alternative bookends, within the range of uncertainty associated with the No Action Alternative. This trend applies to both the long-term period and dry and critical years. Specific comparisons of No Action Alternative and existing conditions water supply and water management characteristics for the Program's five planning regions are presented below.

5.1.6.1 DELTA REGION

Programmatic comparisons of Delta inflow and exports were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative.

The range of Delta inflows and exports predicted for the No Action Alternative generally bracket inflows under existing conditions. Over the long-term period, average annual Delta inflows could remain constant or decrease by as much as 330 TAF (-2%) under the No Action Alternative relative to existing conditions. Similarly, during dry and critical years, average annual Delta inflows could remain constant or decrease by as much as 280 TAF (-2%). Reductions in annual Delta inflows would result from greater upstream water use and smaller reservoir releases in response to export restrictions. The greatest average monthly percent reductions would occur during late spring and early summer, with deviations from existing conditions as high as -16% in June and July of dry and critical years.

The range of Banks and Tracy Delta exports predicted for the No Action Alternative generally bracket exports under the existing conditions. Figure 5.1-3 compares average monthly Delta exports for the long-term period. Similarly, Figure 5.1-4 compares average monthly Delta exports during dry and critical water-years.

Over the long-term period, annual Delta exports could decrease by as much as 570 TAF (-10%) or could increase by as much as 370 TAF (+7%) under the No Action Alternative compared to existing conditions. Reductions in annual Delta exports would result from more protective Delta water management criteria; increases in annual Delta exports would result from higher demands on the Bay-Delta system. The greatest average monthly percent reductions would occur during the spring, with deviations from existing conditions ranging from -20% to -60%. The greatest average monthly percent increases would occur during the winter, with deviations from existing conditions ranging from +10% to +20%.

During dry and critical years, annual Delta exports could decrease by as much as 610 TAF (-12%) or could increase by as much as 130 TAF (+3%) under the No Action Alternative compared to existing conditions. Higher Bay-Delta system demands have a relatively small impact on Delta exports during dry and critical years, as the system is generally supply-limited during droughts. The greatest average monthly percent reductions would occur during February through July, with deviations from existing conditions ranging from -20% to -50%. Similar to the long-term period, the greatest average monthly percent increases would occur during the winter, with deviations from existing conditions ranging from +5% to +10%.

Figure 5.1-3. Delta Exports at Banks and Tracy under the No Action Alternative and Existing Conditions for the Long-Term Period

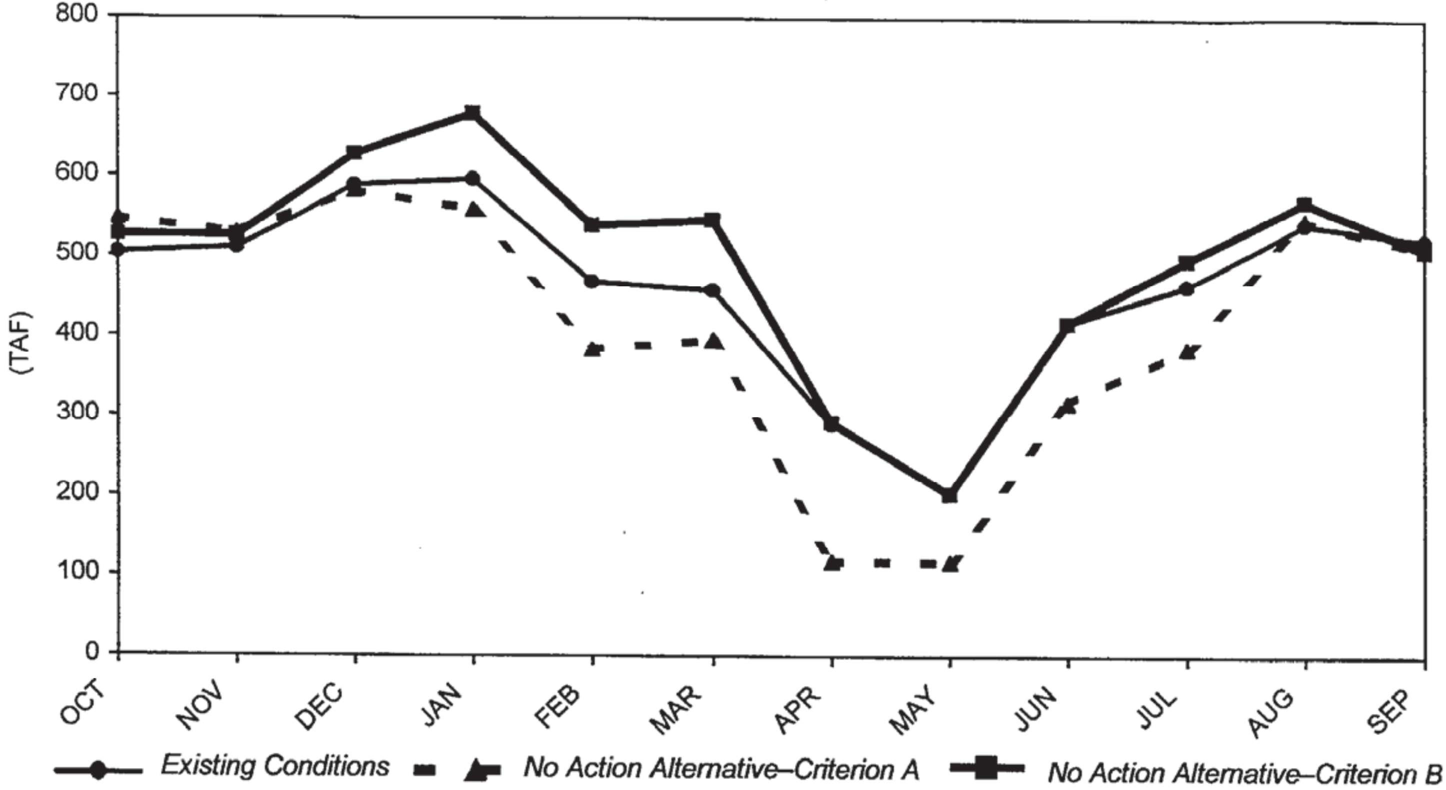
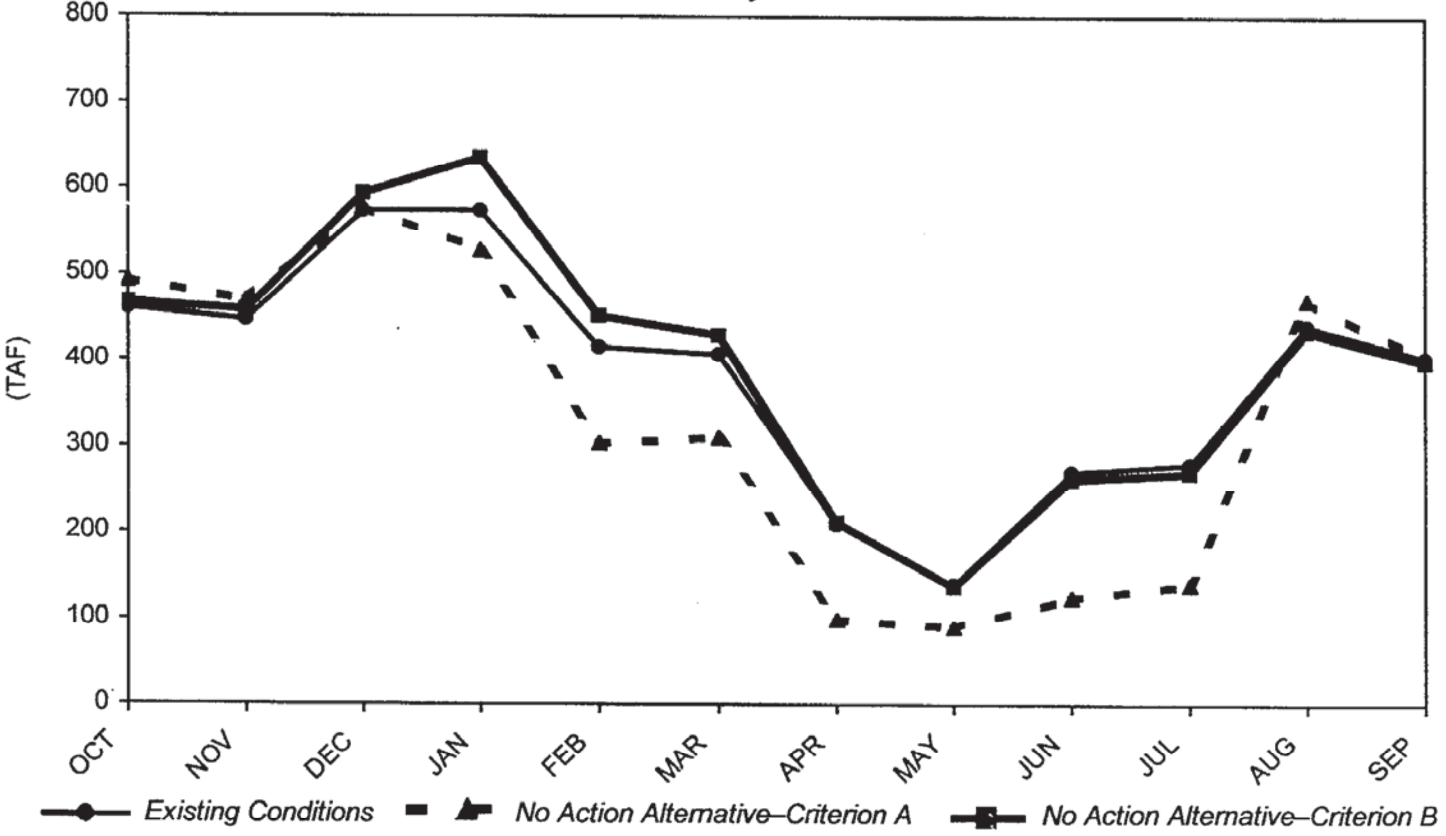


Figure 5.1-4. Delta Exports at Banks and Tracy under the No Action Alternative and Existing Conditions for Dry and Critical Years



5.1.6.2 BAY REGION

Programmatic comparisons of Delta outflow to San Francisco Bay were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative. Figures 5.1-5 and 5.1-6 present Delta outflow comparisons for the long-term period and dry and critical years, respectively.

Over the long-term period, annual Delta outflow could decrease by as much as 390 TAF (-3%) or could increase by as much as 230 TAF (+2%) under the No Action Alternative compared to existing conditions. Reductions in annual Delta outflow would result from higher demands on the Bay-Delta system; increases in annual Delta outflow would result from more protective Delta actions. The greatest average monthly percent reductions would occur during the fall months, with deviations from existing conditions as much as -8%. The greatest average monthly percent increases would occur during the spring months, with deviations from existing conditions as much as +9%.

During dry and critical years, annual Delta outflow could decrease by as much as 110 TAF (-2%) or could increase by as much as 330 TAF (+6%) under the No Action Alternative compared to existing conditions. Higher Bay-Delta system demands have a relatively small impact on Delta outflow during dry and critical years, as the system is generally supply-limited during droughts. The greatest average monthly percent reduction (-8%) would occur in January. The greatest average monthly percent increases would occur during the late winter and early spring, with deviations from existing conditions ranging from +5% to +11%.

5.1.6.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

This section provides a comparison of existing conditions and the No Action Alternative with respect to water supply and water management in the Sacramento and San Joaquin River Regions. The programmatic comparison focuses on water use and surface water storage.

Although this programmatic-level document evaluates potential impacts with respect to the five Program study areas, water management and supply impacts may vary within each region by river basin. To provide a foundation on which to evaluate region-specific No Action conditions, the river basins are differentiated and discussed accordingly. This section considers three river basins in the Sacramento River Region: Sacramento, Feather, and American. The Yuba River, another key river basin in the region, is considered part of the Feather River basin for purposes of this analysis. This section also considers four river basins in the San Joaquin River Region: Upper San Joaquin, Stanislaus, Tuolumne, and Merced. Although the Calaveras, Mokelumne, and Cosumnes Rivers enter the Lower San Joaquin River, they are not evaluated as part of the San Joaquin River Region water supply and water management section. Flows from these rivers are considered in the Delta outflow analysis.

Simulation results are presented in this section from a regional perspective, consistent with a programmatic-level evaluation. While changes in surface storage were estimated for the regions' larger facilities, results are aggregated for purposes of presentation. Facilities that were evaluated in the Sacramento River Region include Shasta, Oroville, and Folsom. Facilities that were evaluated in the San Joaquin River Region include New Melones, New Don Pedro, and McClure.

Figure 5.1-5. Delta Outflow under the No Action Alternative and Existing Conditions for the Long-Term Period

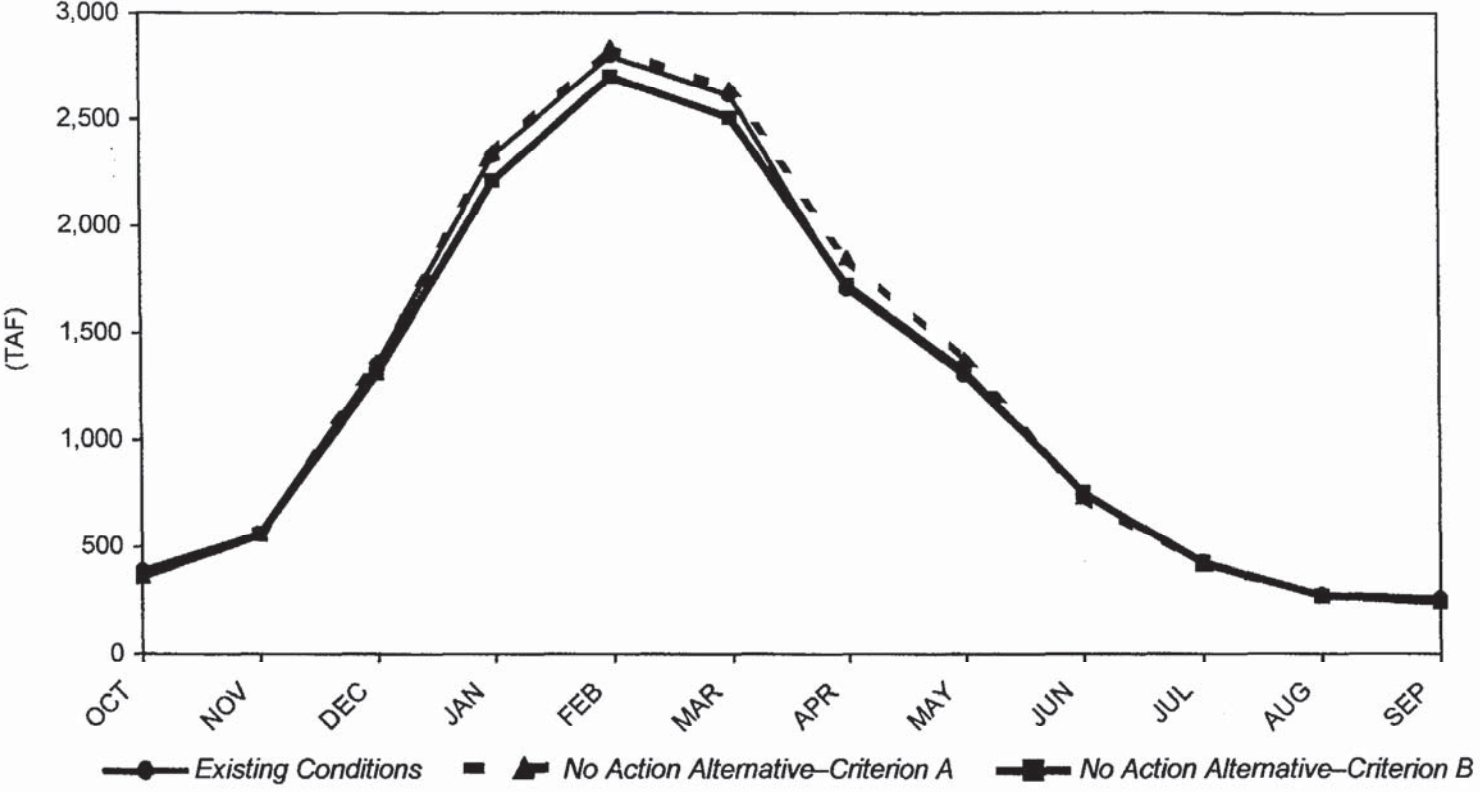
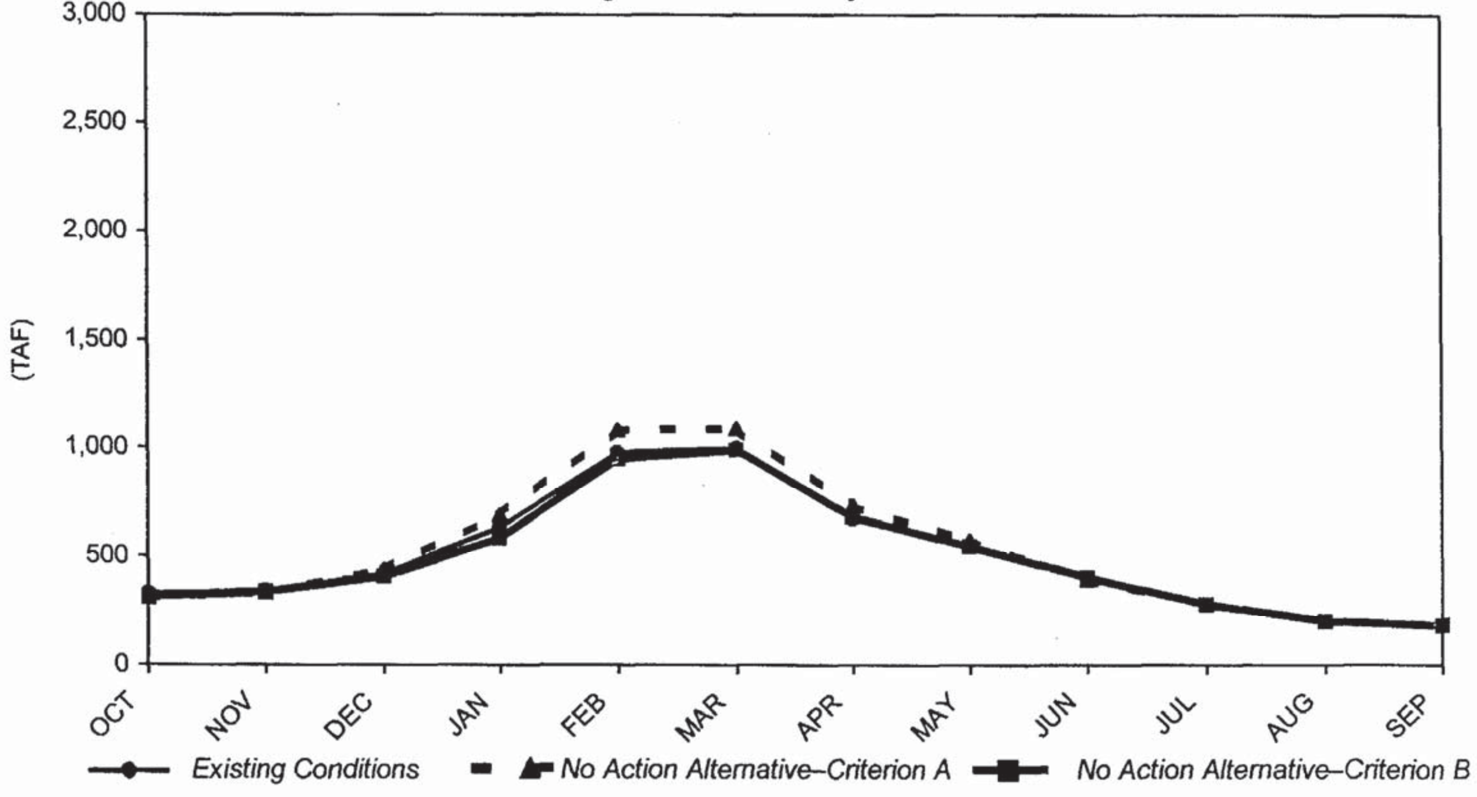


Figure 5.1-6. Delta Outflow under the No Action Alternative and Existing Conditions for Dry and Critical Years



Water Use

A depletion analysis was conducted to determine the effect of water demands and diversions on the flows of river systems tributary to the Delta. In this evaluation, upstream depletions and accretions do not vary between the No Action Alternative bookend water management criteria. All water demands in the Sacramento River and San Joaquin River Regions are met through CVP/SWP project deliveries and through locally derived water supplies under the No Action Alternative. For details related to the DWRSIM hydrology development process, refer to Section 5.1.4, "Assessment Methods."

Upstream water use assumed for the Sacramento River Region's No Action Alternative is based on 2020-level land use projections and long-term period historical inflow data. Water use is expected to increase in the Sacramento River Region under the No Action Alternative. Urban net water use was assumed to increase from 0.8 MAF under existing conditions to 1.1 MAF under the No Action Alternative. Agricultural net water use was assumed to decrease from 6.5 MAF under existing conditions to 6.4 MAF under the No Action Alternative. Average annual depletion of applied water is expected to increase in all three major river basins under the No Action Alternative. Annual depletions are expected to increase 140 TAF above existing conditions in the Sacramento River basin. Similarly, annual depletions are expected to increase 10 and 70 TAF above existing conditions in the Feather and American River basins, respectively.

Water use in the San Joaquin River Region is expected to decrease under the No Action Alternative based on an analysis of CVP demands conducted by the Bureau of Reclamation. Although urban net water use was assumed to increase from 0.4 MAF under existing conditions to 0.7 MAF under the No Action Alternative, agricultural net water use was assumed to decrease from 5.8 MAF under existing conditions to 5.3 MAF under the No Action Alternative. Average annual depletion of applied water is expected to decrease in all four major river basins under the No Action Alternative. Annual depletions are expected to decrease 25 TAF from existing conditions for the eastside San Joaquin Valley north of the Tuolumne River. Similarly, annual depletions are expected to decrease 27 TAF and 36 TAF from existing conditions between the Tuolumne and Merced Rivers and between the Merced and San Joaquin Rivers. Finally, annual depletions are expected to decrease 50 TAF from existing conditions for the DMC service area.

Local inflows and diversions developed for the depletion study areas were incorporated into the DWRSIM modeling analysis. Figures 5.1-7 and 5.1-8 compare accretions and depletions in the Sacramento River and San Joaquin River Regions under existing conditions and the No Action Alternative for both long-term and dry and critical periods, respectively. These figures show minor differences in regional accretions and depletions.

Surface Storage

DWRSIM was used to identify potential changes in surface storage volumes under existing conditions and the No Action Alternative. The three primary surface storage facilities in the Sacramento River Region—Shasta, Oroville, and Folsom—exhibited similar characteristics under existing conditions and the No Action Alternative. The three primary surface storage facilities in the San Joaquin River Region—New Melones, New Don Pedro, and McClure—also exhibited similar characteristics under existing conditions and the No Action Alternative. These results were observed for both long-term and dry and critical periods. Figures 5.1-9 and 5.1-10 show end-of September carryover storage exceedance for the primary

Figure 5.1-7. Sacramento River Basin Depletion under the No Action Alternative and Existing Conditions for the Long-Term Period and Dry and Critical Years

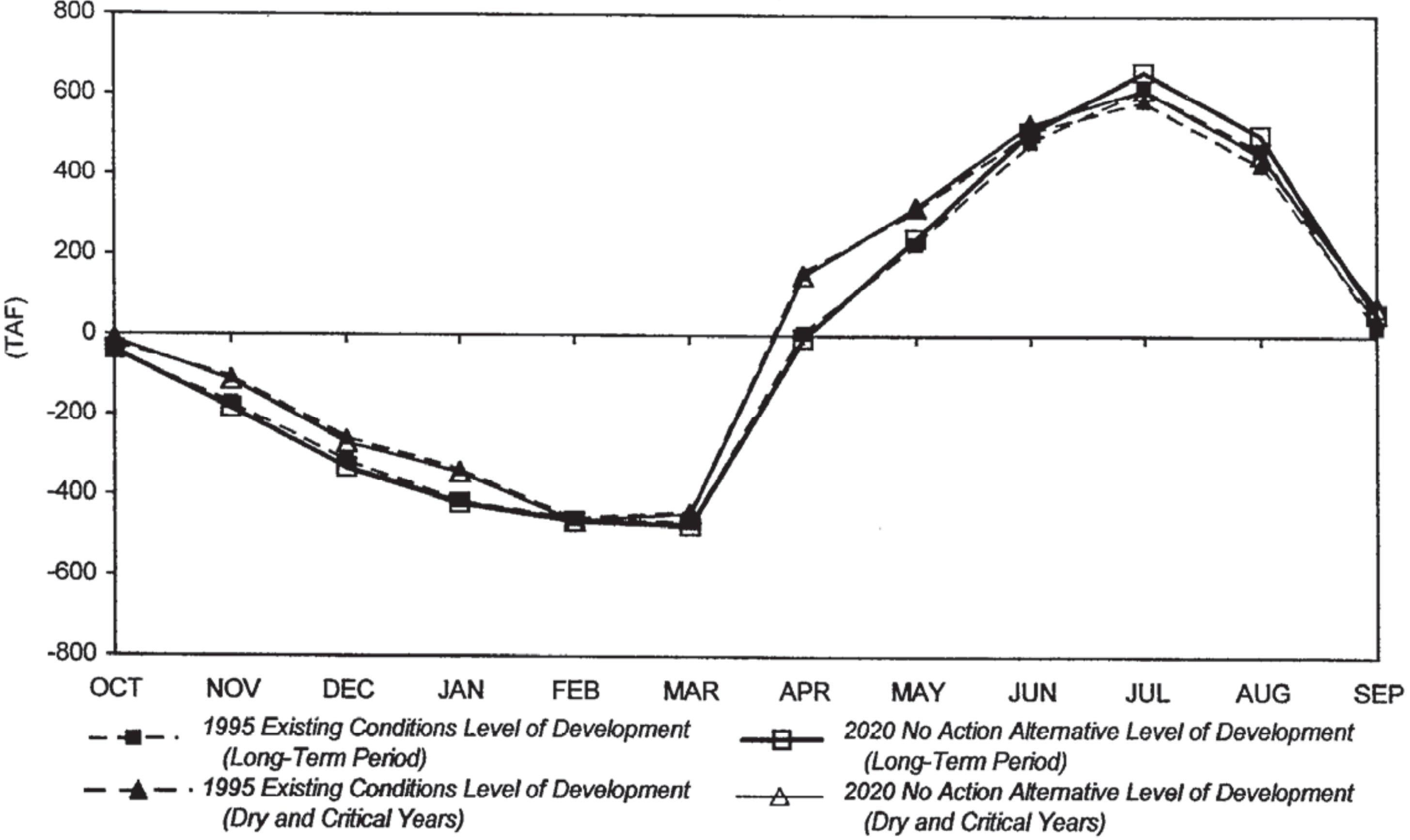


Figure 5.1-8. San Joaquin River Basin under the No Action Alternative and Existing Conditions for the Long-Term Period and Dry and Critical Years

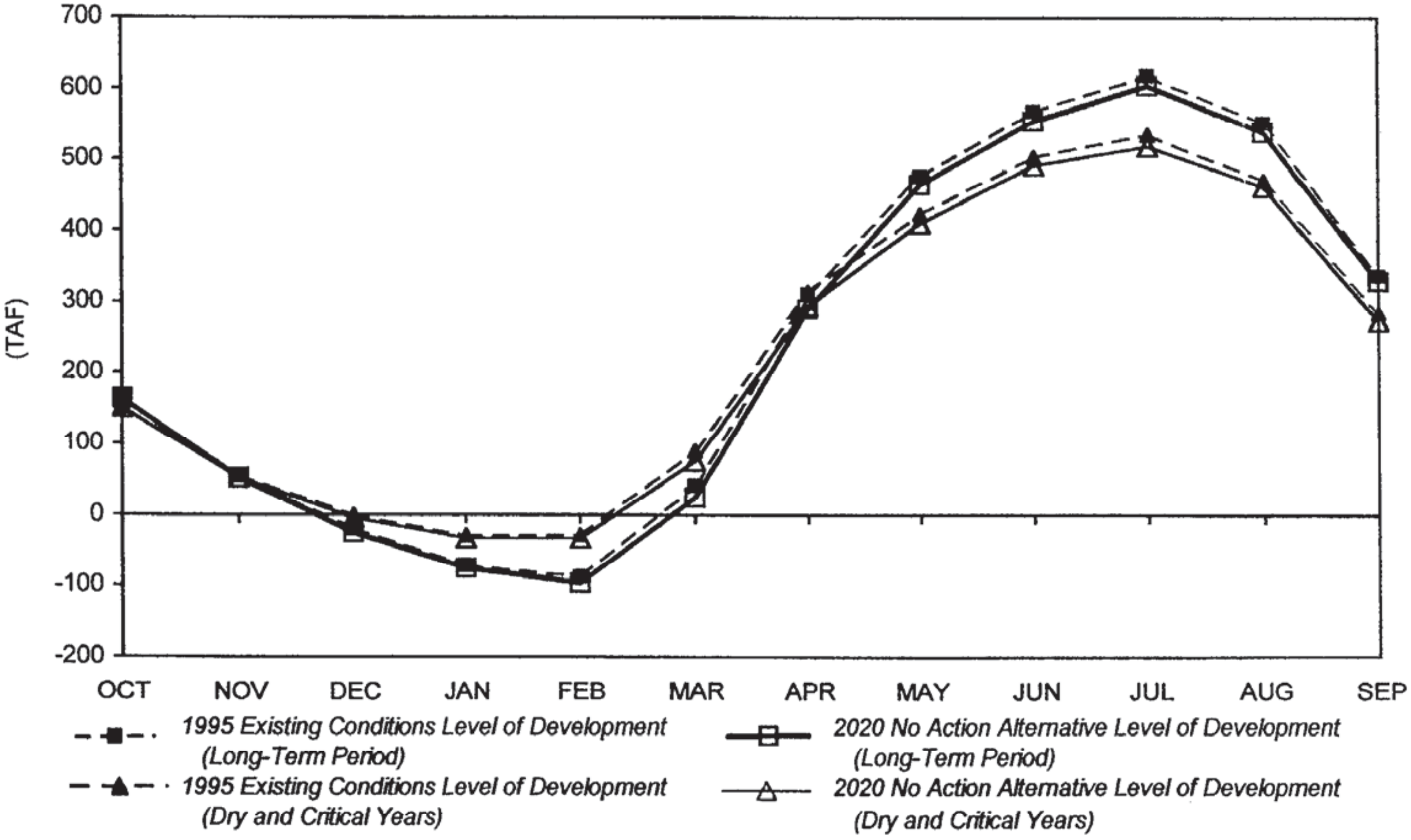


Figure 5.1-9. Carryover Storage for Existing Surface Reservoirs in the Sacramento River Region under the No Action Alternative and Existing Conditions

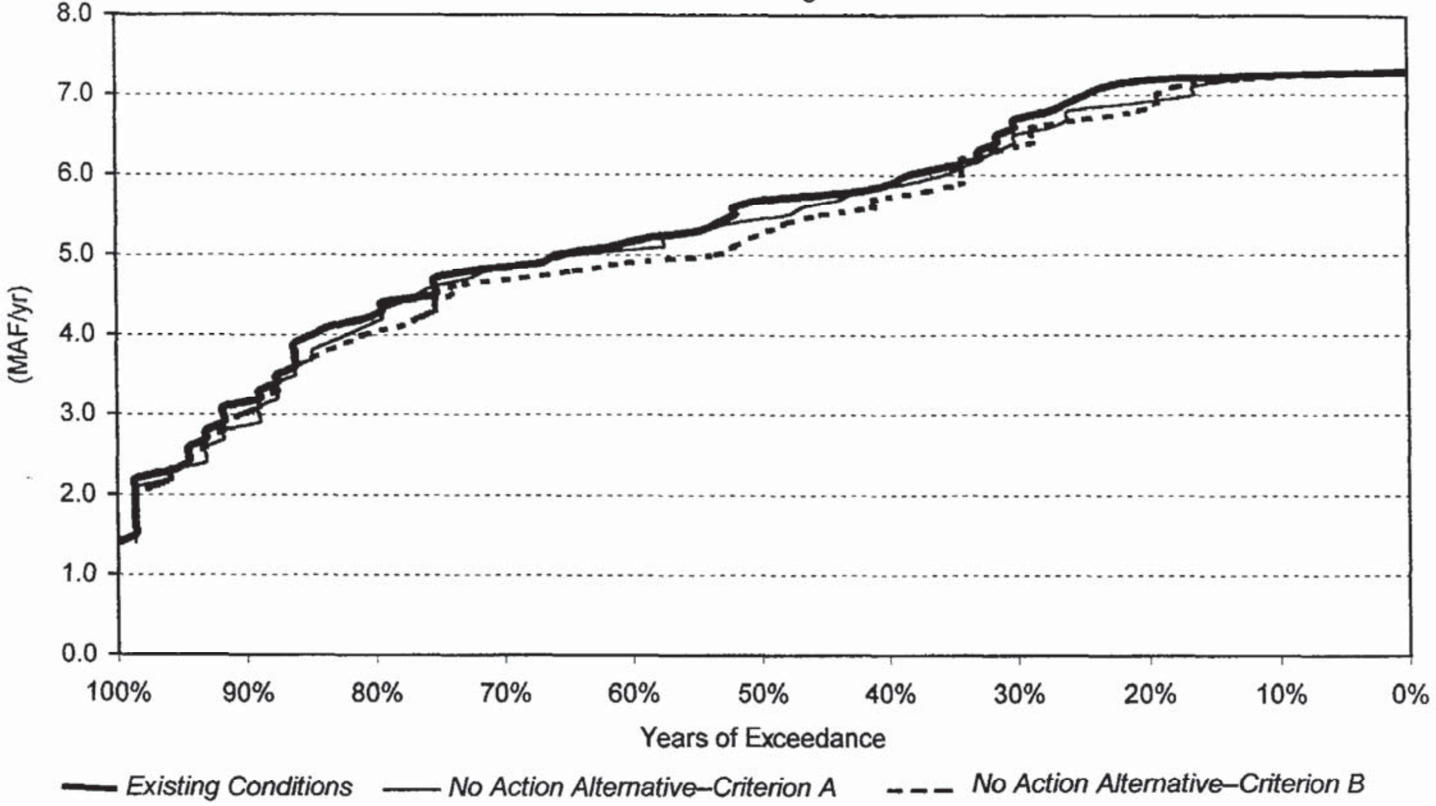
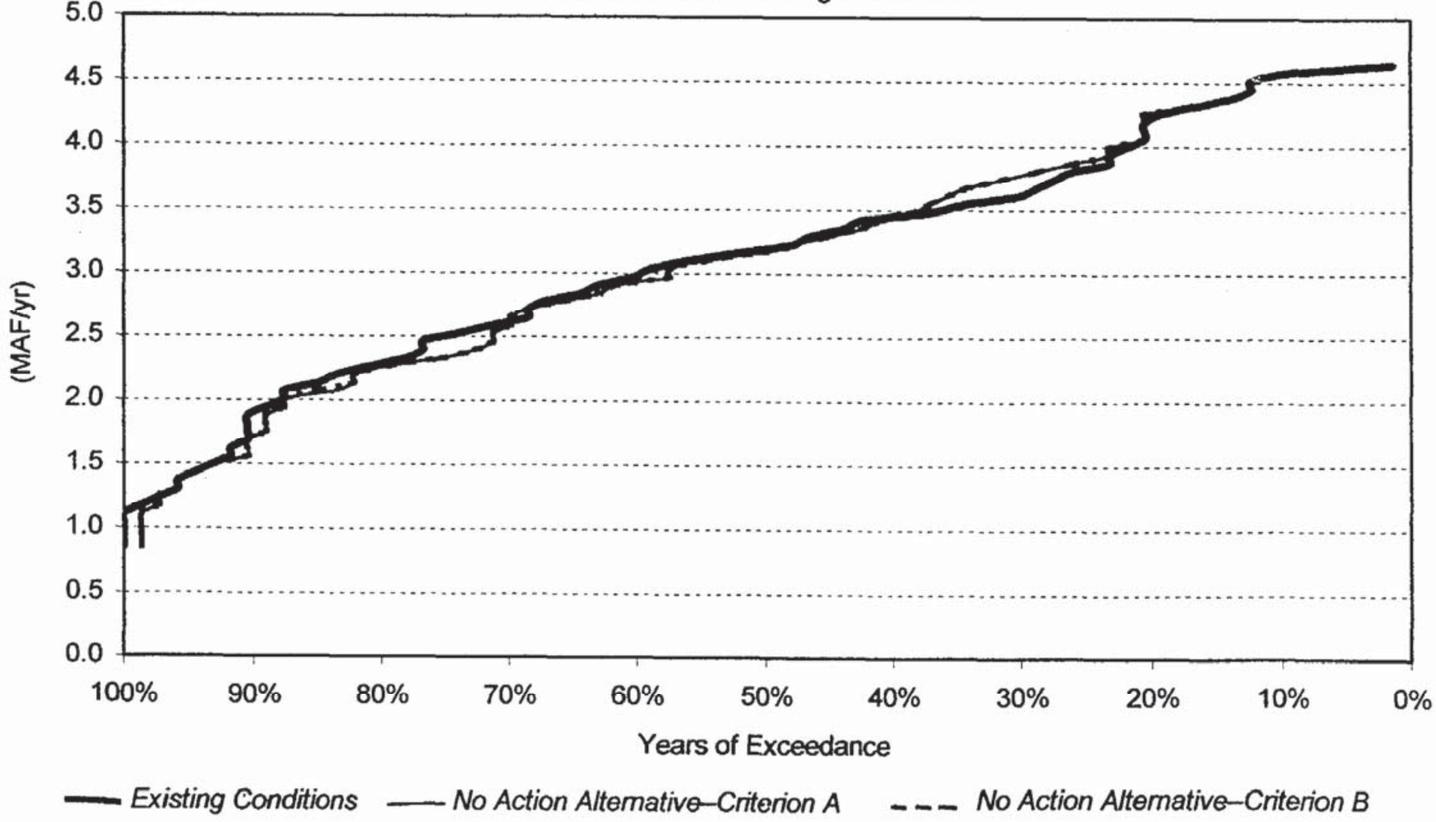


Figure 5.1-10. Carryover Storage for Existing Surface Reservoirs in the San Joaquin River Region under the No Action Alternative and Existing Conditions



surface facilities in the Sacramento River and San Joaquin River Regions, respectively. Carryover storage is defined as the reservoir storage volume at the end-of-September.

As shown in Figure 5.1-9, average Sacramento River Region long-term period carryover storage (similar to 50% exceedance) is about 5.5 MAF under existing conditions and ranges from 5.3 to 5.4 MAF under the No Action Alternative. Average dry and critical year storage (similar to 80% exceedance) is about 3.9 MAF under existing conditions and ranges from 3.8 to 3.9 MAF under the No Action Alternative. Carryover storage is expected to be lower under the No Action Alternative to meet higher Bay-Delta system demands or provide water supplies for additional protective Delta water management criteria.

As shown in Figure 5.1-10, average San Joaquin River Region long-term period carryover storage is about 3.2 MAF under existing conditions and 3.1 MAF under the No Action Alternative. Average dry and critical year storage is about 2.3 MAF under existing conditions and 2.2 MAF under the No Action Alternative.

5.1.6.4 SOUTH-OF-DELTA SWP AND CVP SERVICE AREAS

Programmatic comparisons of Delta deliveries to the South-of-Delta SWP and CVP Service Areas Service Areas were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative.

The range of average annual Delta deliveries predicted for the No Action Alternative generally bracket Delta deliveries under existing conditions. Figure 5.1-11 compares the reliability of average annual Delta deliveries under existing conditions with the expected range of delivery reliability expected under the No Action Alternative. The figure shows that, under existing conditions, average annual Delta deliveries are approximately 5.4 MAF for the long-term period (similar to 50% exceedance) and 4.5 MAF during dry and critical years (similar to 80% exceedance).

Under the No Action Alternative, average annual deliveries could range from 4.8 to 5.8 MAF for the long-term period. Higher deliveries would result from higher Bay-Delta system demands and would generally take place in above normal and wet years when unallocated flows are available for export in the Delta. Lower deliveries would result from additional protective Delta water management criteria. During dry and critical years, annual deliveries could decrease by as much as 610 TAF. Because the system is supply-constrained in dry and critical years, the higher demands considered in Criterion B would not result in significantly higher deliveries relative to existing conditions.

Under existing conditions, the Program assumes that the Diamond Valley Reservoir and the Coastal Aqueduct are not operating. Under Criterion B, the Program assumes these facilities are operational, resulting in some influence on demand patterns. However, the effects of the Diamond Valley Reservoir on Delta deliveries are expected to be minimal. Water supply reliability benefits from Diamond Valley Reservoir will be regional in scope. Although the facility is expected to increase regional operating flexibility during peak summer months, droughts, and emergencies, delivery of available Delta water supplies will still be necessary. Therefore, an increase in regional operating flexibility is expected to have little influence on SWP or CVP operations.

Figure 5.1-11. Average Annual Delta Deliveries under the No Action Alternative and Existing Conditions

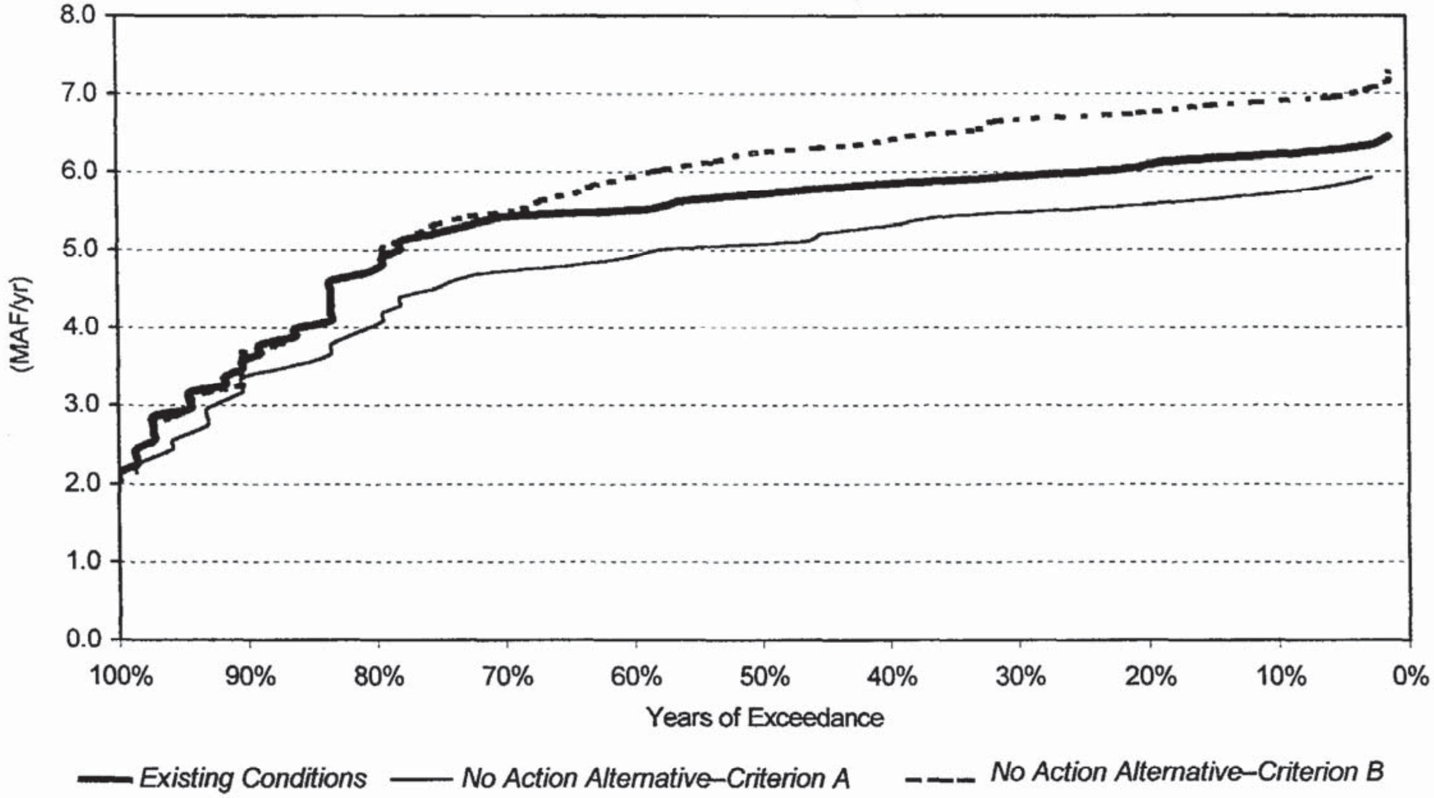
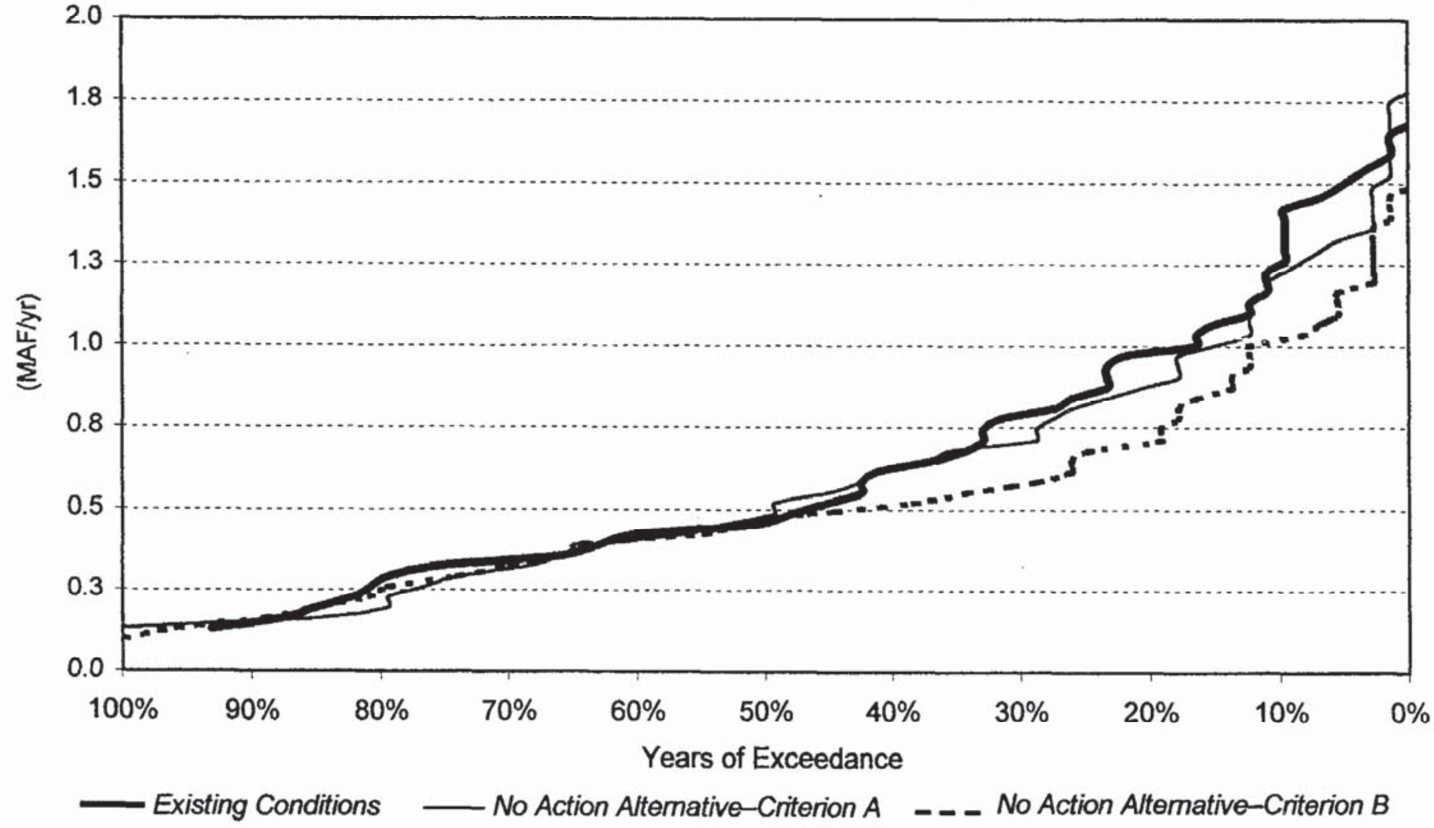


Figure 5.1-12. Carryover Storage for Existing Off-Aqueduct Reservoirs under the No Action Alternative and Existing Conditions



DWRSIM was also used to identify the potential changes in existing off-aqueduct operating storage volumes under existing conditions and the No Action Alternative. Figure 5.1-12 shows the estimated end-of-September carryover storage exceedance for San Luis Reservoir. As shown in the figure, average long-term period carryover storage (similar to 50% exceedance) is about 610 TAF under existing conditions and ranges from 520 to 580 TAF under the No Action Alternative. Average dry and critical year storage (similar to 80% exceedance) is about 300 TAF under existing conditions and ranges from 300 to 340 TAF under the No Action Alternative.

San Luis Reservoir typically fills in fall and winter months. During these months under existing conditions, storage volumes generally lie within the range of uncertainty associated with the No Action Alternative. This comparison is generally consistent for all water-year types.

San Luis Reservoir typically drains in spring and summer months. During these months, the No Action Alternative provides lower long-term average storage volumes relative to existing conditions. This deviation from existing conditions is due to more protective Delta water management criteria (under Criterion A) and higher deliveries (under Criterion B). During dry and critical years, Criterion B provides storage volumes similar to existing conditions.

5.1.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For water supply and water management, the environmental consequences of the Ecosystem Restoration, Levee System Integrity, Water Use Efficiency, and Water Transfer Program elements are similar under all Program alternatives and are described by study area in this section. The environmental consequences of the in-Delta storage component of the Storage element were evaluated qualitatively; are similar under all Program alternatives; and are described in Sections 5.1.7.1, 5.1.7.2, and 5.1.7.4. The environmental consequences of the Storage and Conveyance elements that vary among Program alternatives, are described in Section 5.1.8. General effects of the Water Quality and Watershed Program elements common to all study areas are summarized below.

The primary water quality constraints on use of water from the Delta for municipal, industrial, and agricultural purposes are salinity, bromide, dissolved organic carbon (DOC), and pathogens (microbes that are potential human health hazards). Improved water quality could increase the amount of water available for some beneficial uses. Improved water quality could provide improved operational flexibility by increasing the windows of opportunity for diversions from the Delta. Additional opportunities for diversions would allow temporal shifting of exports to decrease impacts on Delta fisheries while maintaining or improving water supply reliability. It is expected that the effects of the Water Quality Program on water supply and water management would be beneficial.

The various possible watershed projects proposed under the Watershed Program could alter flow regimes through the Delta and into the Bay. For example, vegetation and habitat restoration projects may increase retention of surface water in the watershed. Effects on water supply of these flow changes should be small and beneficial. Additional effects of the Watershed Program in the Sacramento River and San Joaquin River Regions are discussed below.

5.1.7.1 DELTA REGION

Ecosystem Restoration Program

The Ecosystem Restoration Program would result in additional water use in the Delta due to new flow targets and conversion of land use from agriculture to wetlands and marshes. Water users in the Delta have water rights that would not be altered by the Ecosystem Restoration Program.

Levee System Integrity Program

Improving levee system integrity would reduce the risk of levee failure that could disrupt the diversion of water from the Delta. Levee failures due to high water levels would most likely occur during winter or spring, when dependence on Delta exports is low. However, failures due to seismic events could happen anytime of the year. Disruption of Delta pumping could significantly affect water supplies in areas that receive Delta water exports.

Levee rehabilitation would involve large-scale construction operations affecting considerable areas of land and water. Construction activities in or immediately adjacent to waterways could temporarily increase local water turbidity and, depending on the source of the material used for levee construction, could cause the release of nutrients, natural organic matter, and other toxic substances into the water. The significance of the impacts on water supply sources would depend on the scale and rate of construction activities. These impacts are expected to be mitigable.

Water Use Efficiency Program

Water use efficiency could allow water to be maintained in storage for a longer period of time during dry periods, and would help reduce the amount of water that is presently diverted for beneficial uses. Increasing water use efficiency also could affect the area's water use by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. The Water Use Efficiency Program would increase water supply reliability during very low-flow periods, resulting in a beneficial effect on water supply and water management.

The effects of water use efficiency would be similar to those of reduced water demand within a given area. However, the Water Use Efficiency Program would not necessarily equate to reduced water demand from a statewide perspective. Specifically, reduced demand would not be directly proportional to reduced Delta exports. Reduced water demand would simply increase available supply for consumption in another region of the state. This effect would be largely contingent on the water-year type and delivery timing. For instance, if urban demand in the South Coast Region were reduced during a dry or critical water year, demands elsewhere in the state would be such that the foregone South Coast deliveries could be allocated to agriculture or urban consumption anywhere in the CVP and SWP service areas.

Water Transfer Program

Water transfers can result in more efficient distribution of water resources among water users during low-flow periods, increasing the reliability of supplies in the Delta during water supply shortages. The Delta environment is included as a potential beneficiary of water transfers either directly through environmental water transfers or indirectly by timing transfers to provide ecosystem benefits. These would be beneficial effects. Management of the EWA may magnify the effects of this program.

Storage

In-Delta storage (see Section 2.1.2 for description) could provide improved operational flexibility for managing Delta Region diversions and agricultural drainage, Delta exports, and Delta outflow. Releases from in-Delta storage could improve access to water supplies for Delta Region water users and Delta ecosystem benefit. Releases from in-Delta storage also could be used to dilute Delta Region agricultural drainage, resulting in improved Delta water quality and access to water supplies for other uses. Appropriate operational rules would be required to ensure that diversions to in-Delta storage do not adversely affect access to water supplies for Delta Region water users.

5.1.7.2 BAY REGION

Ecosystem Restoration Program

The indirect impacts of the Ecosystem Restoration Program on the Bay Region could include improved water quality at Rock Slough during low-flow periods and reduced deliveries through CCFB. These are expected to be small and have no significant impacts for Bay Region water users.

Under the Ecosystem Restoration Program, the acreage of shallow water aquatic habitat and saline emergent wetlands will be increased adjacent to Suisun Bay and Marsh, San Pablo Bay, the Napa and Petaluma Rivers, and Sonoma Creek. Some of the proposed lands for conversion are currently used for agriculture. These changes would have a small effect on the Bay Region's water use.

Levee System Integrity Program

A Suisun Marsh levee component would benefit surface water supply and water management issues. Some sediment loading may happen because of the levee rehabilitation but should be minimal since the construction material would be taken from the interior side of the levee. Channel geometry may be altered at a small level when levee rehabilitation takes place on exterior slopes. Channel depth may increase as levees are standardized to a uniform height and structure, but no alterations to channel hydraulics are expected. Water quality in the western Suisun Marsh would be protected with levee rehabilitation, providing a beneficial effect.

The Levee System Integrity Program is not discussed for regions other than the Delta and Bay Regions because its effects primarily are confined to these regions.

Water Use Efficiency Program

Water use efficiency could allow water to be maintained in storage for a longer period of time during dry periods, and would help reduce the amount of water that is presently diverted for beneficial uses. Increasing water use efficiency also could affect the area's water use by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. The Water Use Efficiency Program would increase water supply reliability during very low-flow periods, resulting in a beneficial effect on water supply and water management.

The effects of water use efficiency would be similar to those of reduced water demand within a given area. However, the Water Use Efficiency Program would not necessarily equate to reduced water demand from a statewide perspective. Specifically, reduced demand would not be directly proportional to reduced Delta exports. Reduced water demand would simply increase available supply for consumption in another region of the state. This effect would be largely contingent on the water-year type and delivery timing. For instance, if urban demand in the Bay Region were reduced during a dry or critical water-year, demands elsewhere in the state would be such that the foregone Bay Region deliveries could be allocated to agriculture or urban consumption anywhere in the CVP and SWP service areas.

Increased water use efficiency could result in reduced water demands during dry periods and increased opportunities for storing water for future use. However, water saved through conservation measures is anticipated to be used locally to offset current or future unmet demands. During periods of low-flow, improved efficiency measures would allow reduced supplies to meet more demands, with potentially less impacts on the users. Increased levels of wastewater recycling can further improve the Bay Region water supply reliability, by generating a water supply that is nominally affected by drought conditions. Water use efficiency could marginally reduce the volume of wastewater generated, but is not expected to cause local reductions in water supplies to water users who supplement their water supplies with recycled water. The effects of the Water Use Efficiency Program in the Bay are expected to be beneficial to water supply and water management.

Water Transfer Program

Increased ability to transfer water could result in more voluntary and beneficial redistribution of water resources among water users. The degree to which redistribution would occur cannot be estimated accurately at the programmatic level. Management of the EWA may magnify the impacts of this program.

Water transfers would affect water supply in the Bay Region, primarily through changes to river flow upstream of the Delta. Increased water transfers change the timing of diversions and alter the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. Water transfers from areas upstream of the Delta to areas south of the Delta would affect Bay water supplies since it would be necessary to modify Delta water diversion schedules, possibly augmenting water delivery opportunities. This would cause negligible impacts for Bay water users.

Storage

In-Delta storage (see Section 2.1.2 for description) could provide improved operational flexibility for managing Bay Region diversions, Delta Region drainage, Delta exports, and Delta outflow. Releases from in-Delta storage could improve access to water supplies for Bay Region water users. Releases from in-Delta storage also could be used to dilute Delta Region drainage, resulting in improved Delta water quality and access to water supplies for other uses. Operational flexibility and potential water supply management benefits would be improved if the in-Delta storage facilities include direct conveyance to Bay Region diversion facilities. Appropriate operational rules would be required to ensure that diversions to in-Delta storage do not adversely affect access to water supplies for Bay Region water users.

5.1.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would result in beneficial effects on water supply within both Central Valley rivers and the Delta. During dry and below-normal water-year types, flows would be increased to meet minimum flow targets. This could result in long-term beneficial effects on hydraulic characteristics and channel water quality within the Sacramento River and San Joaquin River Regions. Short-term adverse impacts could be created by increased sediment loading during construction activities. Conversion of cultivated land to wetlands could increase water use. Also, reductions in channel velocities in some Delta reaches that are widened to encourage meanders could result in increases in water temperature during drier water-year types. Ecosystem restoration would increase the use of in-stream flows for environmental purposes but reduce water supplies available for diversion from rivers and the Delta.

Water Use Efficiency Program

Water use efficiency could allow water to be maintained in storage for a longer period of time during dry periods, and would help reduce the amount of water that is presently diverted for beneficial uses. Increasing water use efficiency also could affect the area's water use by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. The Water Use Efficiency Program would increase water supply reliability during very low-flow periods, resulting in a beneficial effect on water supply and water management.

The effects of water use efficiency would be similar to those of reduced water demand within a given area. However, the Water Use Efficiency Program would not necessarily equate to reduced water demand from a statewide perspective. Specifically, reduced demand would not be directly proportional to reduced Delta exports. Reduced water demand would simply increase available supply for consumption in another region of the state. This effect would be largely contingent on the water-year type and delivery timing. For instance, if urban demand in the South Coast Region were reduced during a dry or critical water-year, demands elsewhere in the state would be such that the foregone South Coast deliveries could be allocated to agriculture or urban consumption anywhere in the CVP and SWP service areas.

Additionally, water use efficiency improvements may allow for modifications in the timing and amount of reservoir releases for agricultural or urban uses. Timing changes also could benefit fish and aquatic ecosystems by making supplies available when needed by these resources.

Water Transfer Program

Increased ability to transfer water from the Sacramento River and San Joaquin River Regions to other areas could result in more voluntary and beneficial redistribution of water resources among water users. The degree to which redistribution would occur cannot be estimated accurately at the programmatic level. Management of the EWA may magnify the impacts of this program.

Potential long-term adverse effects on specific regional agricultural and urban water supplies could result from increased water transfers. Areas with adequate water supplies could transfer portions of those supplies to areas with higher economic return from the use of water. Water transfers can affect third parties (those not directly involved in the transaction), local groundwater, environmental conditions, or other resource areas. Additional discussion on the potential impacts of water transfers on groundwater resources, agricultural social issues, and regional economics is included in Sections 5.4, 7.3, and 7.10, respectively. These sections describe mitigation strategies to reduce third-party impacts associated with water transfers. In addition, the actions described in the Water Transfer Program Plan, in conjunction with existing requirements, will protect against adverse third-party impacts associated with water transfers. (See Chapter 4 in the Water Transfer Program Plan.)

Watershed Program

Potential watershed projects could alter flow regimes in the upper watersheds as well as downstream, thus affecting water supply. Depending on the size and scale of the projects, effects could range from very limited quantity and temporal changes in flows to more pronounced regional alterations in flow regimes. Vegetation and habitat restoration projects may increase the retention of surface water in the watershed, resulting in less variable runoff (reduced peak flows and increased base flows in streams).

Alteration of forest management and timber harvest practices could change total runoff quantities if implemented over large areas. Reduced clear-cutting and overall reductions in logging could substantially reduce runoff from the forested areas. Maintained or reforested tree stands would increase evapotranspiration, interception, and infiltration of precipitation, all of which reduce surface runoff. In areas where snowmelt plays an important role in the flow regime, reducing the effects of timber harvesting would increase shading, which tends to reduce direct evaporation of snow pack and maintains the snow pack longer. Range improvement activities could increase vegetation cover and re-establish riparian habitat, both of which would tend to increase water retention in watersheds. The net effect of all of these potentially offsetting activities on water supply is unknown, but the relative impacts on water supply in the Program's study area are expected to be small.

5.1.7.4 SOUTH-OF-DELTA SWP AND CVP SERVICE AREAS

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program could affect water supply within South-of-Delta SWP and CVP Service Areas. Meeting Delta flow targets could reduce water supply available for exports and/or affect water exports timing. Opportunities to purchase water through water transfers could be reduced, resulting in negative effects on water supply.

Water Use Efficiency Program

Water use efficiency could allow water to be maintained in storage for a longer period of time during dry periods, and would help reduce the amount of water that is presently diverted for beneficial uses. Increasing water use efficiency also could affect the area's water use by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. The Water Use Efficiency Program would increase water supply reliability during very low-flow periods, resulting in a beneficial effect on water supply and water management.

The effects of water use efficiency would be similar to those of reduced water demand within a given area. However, the Water Use Efficiency Program would not necessarily equate to reduced water demand from a statewide perspective. Specifically, reduced demand would not be directly proportional to reduced Delta exports. Reduced water demand would simply increase available supply for consumption in another region of the state. This effect would be largely contingent on the water-year type and delivery timing. For instance, if urban demand in the South Coast Region were reduced during a dry or critical water-year, demands elsewhere in the state would be such that the foregone South Coast deliveries could be allocated to agriculture or urban consumption anywhere in the CVP and SWP service areas.

Water use efficiency has the potential to supplement water supply reliability and subsequent environmental benefits. However, the potential may not exist for water use efficiency to completely replace the water supply reliability and water management flexibility of other water management tools.

Water Transfer Program

The increased ability to transfer water from the Sacramento River and San Joaquin River Regions to South-of-Delta SWP and CVP Service Areas could result in more voluntary and beneficial redistribution of water resources among water users. The degree to which redistribution would occur cannot be estimated accurately at this programmatic level. The Water Transfer Program is expected to benefit water users in the South-of-Delta SWP and CVP Service Areas. Management of the EWA may magnify the effects of this program.

Storage

In-Delta storage (see Section 2.1.2 for description) could provide improved operational flexibility for managing Delta Region drainage, Delta exports, and Delta outflow. Releases from in-Delta storage could improve access to water supplies for South-of-Delta SWP and CVP Service Areas water users. Releases from in-Delta storage also could be used to dilute Delta Region agricultural drainage, resulting in improved Delta water quality and access to water supplies for other uses. Operational flexibility and potential water supply management benefits would be improved if the in-Delta storage facilities include direct conveyance to South-of-Delta SWP and CVP Service Areas Delta export facilities.

5.1.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For water supply and water management, the Storage and Conveyance elements result in environmental consequences that differ among the alternatives, as described below.

The programmatic comparisons presented in this section differentiate water supply and water management provided under the Program alternatives and No Action Alternative. These comparisons are made in consideration of assumptions regarding future water management actions effecting the Bay-Delta system. The water management criteria includes ranges of water demands and protective Delta water management criteria. The range of water demands represents uncertainty in the future need for Bay-Delta water supplies due to uncertainty in projections of population, land use, implementation of water use efficiency measures, and the effects of water marketing. The range of protective Delta water management criteria represents uncertainty related to future actions required to assure recovery of the Bay-Delta ecosystem.

To properly document and evaluate the results, impact ranges were methodically quantified. Impact ranges were estimated for key parameters representative of each Program study area. For instance, the range of impacts associated with the No Action Alternative is detailed for each evaluation. In addition, ranges were developed for potential changes associated with implementation of each respective Program alternative. Where applicable, a range of impacts for each alternative was developed under Criteria A and B without new storage as well as Criteria A and B with new storage. This provides an indication of a given parameter's sensitivity to the protective Delta water management criteria assumption sets. Lastly, a range of changes associated with new storage relative to each alternative is described where appropriate. Each range is presented for both the long-term period and dry and critical years.

5.1.8.1 ALTERNATIVE 1

Some improvements to water supply and water management would be realized from improved export pumping capacity under Alternative 1. Greater water supply and water management benefits may be obtained if additional storage facilities are constructed.

Delta Region

Programmatic comparisons of Delta inflows and exports were made between Alternative 1 and the No Action Alternative using DWRSIM modeling results. Both bookend water management criteria assumption sets (Criteria A and B) were used to define the range of uncertainty associated with each alternative. Delta inflow comparisons are based on the peak average monthly value, which typically occurs in February. The maximum deviation between Program alternatives typically occurs in this month. Delta export comparisons are based on peak and minimum monthly average values, as well as average annual values.

Average monthly Delta inflow is largely unaffected under Alternative 1 relative to the No Action Alternative. Over the long-term period, Delta inflow normally peaks in February. Average February flow is approximately 190 TAF under the No Action Alternative and is generally about the same under Alternative 1. The differences in Delta inflow are largest from April through October. This effect is more pronounced during dry and critical years. Additional storage as well as water management assumptions have no appreciable impacts on Delta inflow.

The pattern of long-term average Delta exports would be modified somewhat by Alternative 1, with greater exports occurring August through January relative to the No Action Alternative. Figure 5.1-13 compares average monthly south-of-Delta exports for the long-term period. Similarly, Figure 5.1-14 compares average monthly south-of-Delta exports during dry and critical years. The range of average annual Delta exports under Alternative 1 for both hydrologic periods are compared to the No Action Alternative in Figure 5.1-15.

Combined exports from Banks and Tracy Pumping Plants peak in late winter months, with monthly long-term period values ranging from 560 to 680 TAF under the No Action Alternative and from 540 to 760 TAF under Alternative 1. Delta exports, at minimum values in spring months, change little under Alternative 1. Monthly long-term period exports range from 120 to 200 TAF under the No Action Alternative and range from 120 to 210 TAF under Alternative 1. On an annual basis, without additional storage, Alternative 1 increases long-term period Delta exports by an additional 270-390 TAF over the No Action Alternative. With additional storage, Alternative 1 increases annual Delta exports about 580-800 TAF over the No Action Alternative. Therefore, annual long-term export increases of 310-410 TAF are directly related to additional storage under Alternative 1.

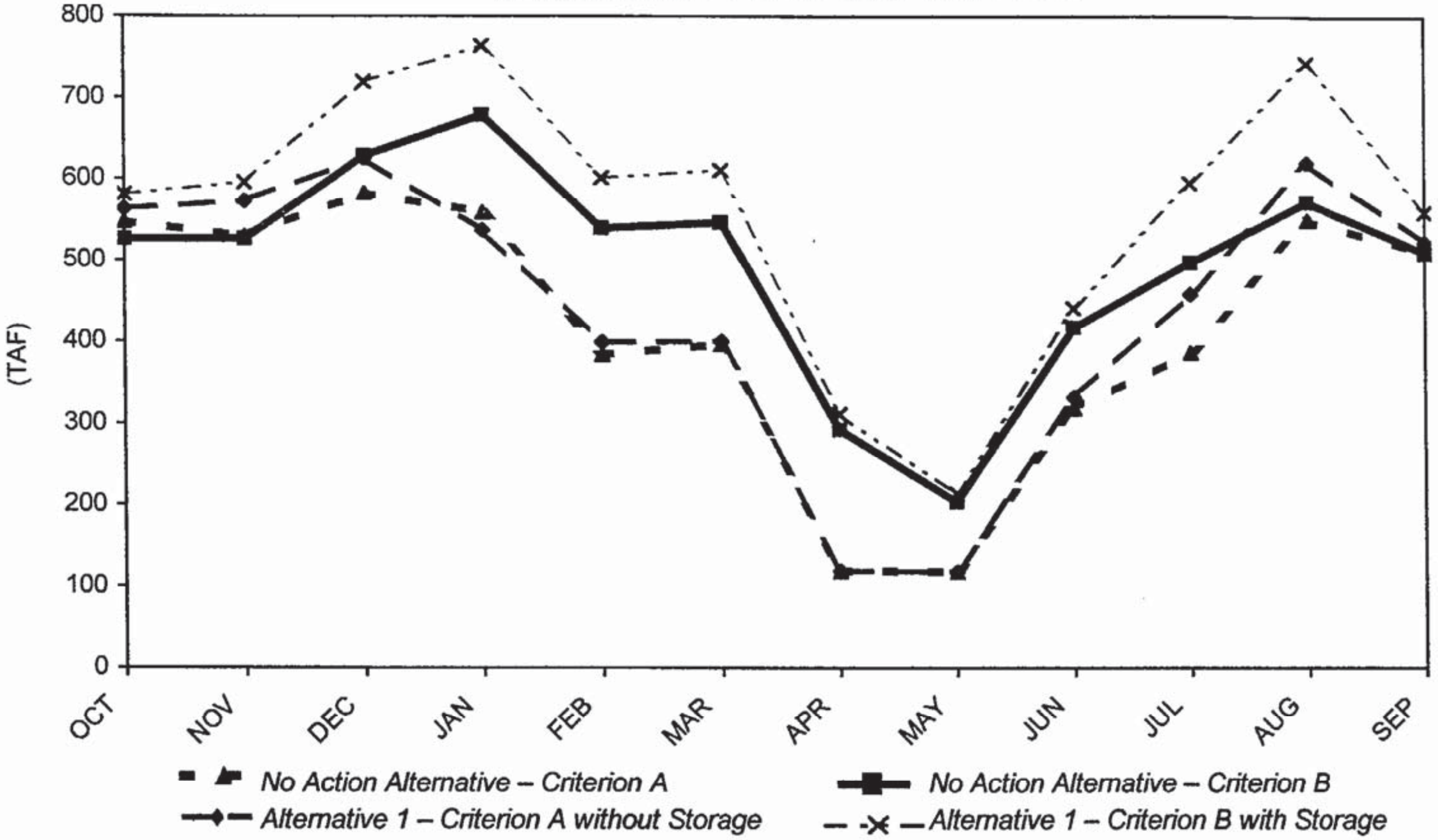
Alternative 1 has a similar influence on dry and critical year Delta exports. Under the No Action Alternative, monthly Delta exports range from 530 to 640 TAF in the peak winter months and from 90 to 140 TAF during the spring months. Under Alternative 1, monthly dry and critical year exports range from 530 to 720 TAF in the peak winter months and from 90 to 140 TAF during the spring months. On an annual basis, without additional storage, Alternative 1 increases dry and critical year Delta exports by an additional 30-190 TAF over the No Action Alternative. With additional storage, Alternative 1 increases annual Delta exports by 180-640 TAF over the No Action Alternative. Therefore, annual dry and critical year export increases of 150-450 TAF are directly related to additional storage under Alternative 1.

Bay Region

Programmatic comparisons of Delta outflow to San Francisco Bay were made between Alternative 1 and the No Action Alternative using DWRSIM modeling results. Figures 5.1-16 and 5.1-17 present monthly average Delta outflow comparisons for the long-term period and dry and critical years, respectively.

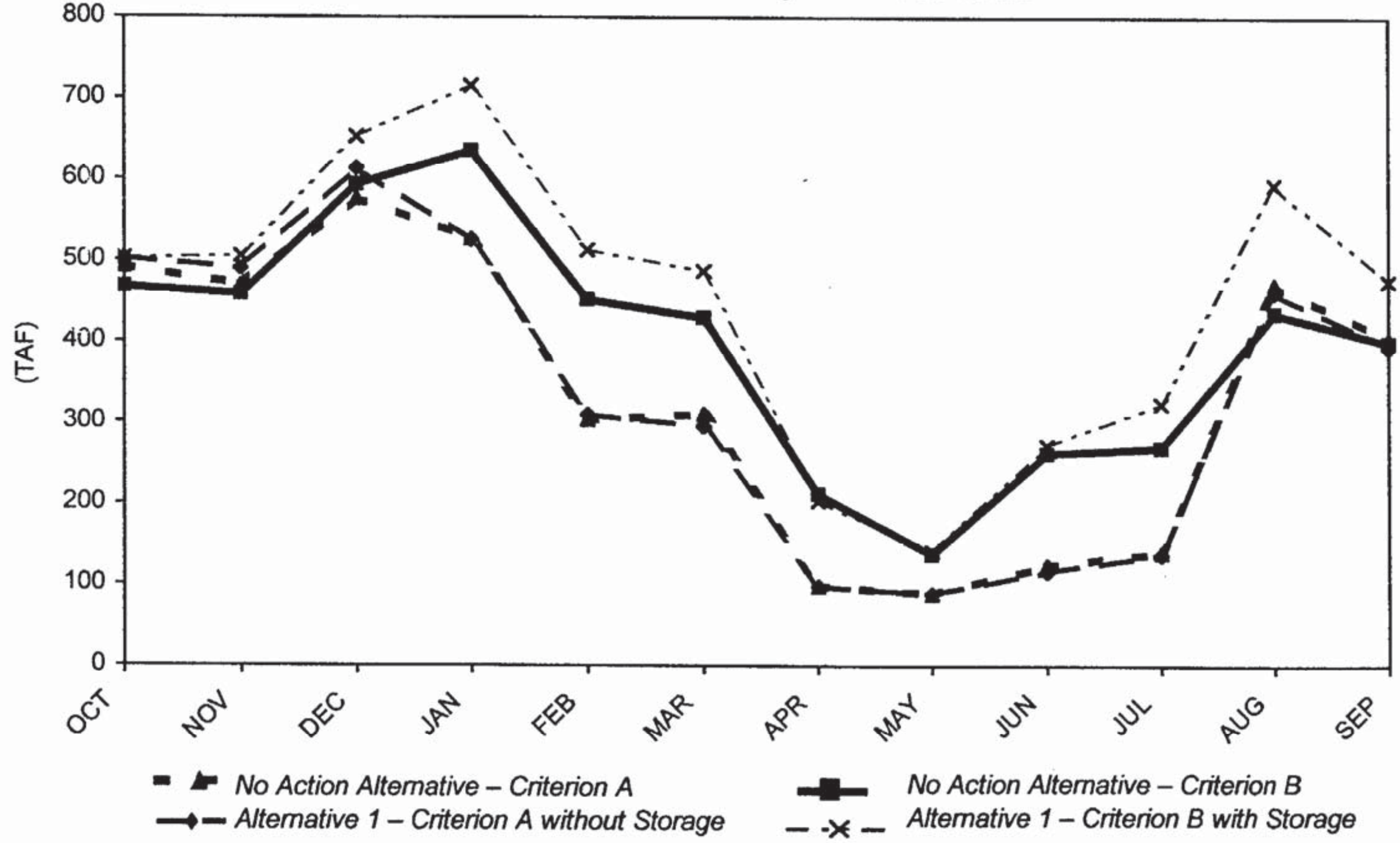
Delta outflow is typically lower under Alternative 1 than under the No Action Alternative during November through March. Percentage differences are typically small, however. Over the long-term period, Delta outflow normally peaks in February. Average February outflow ranges from 2.7 to 2.8 MAF under the No Action Alternative and ranges from 2.6 to 2.8 MAF under Alternative 1. The differences in Delta outflow are smaller from April through October. Ecosystem Restoration Program flows provide some additional May outflow under Alternative 1. On an annual basis, without additional storage, Alternative 1 could decrease average long-term period Delta outflows by as much as 80 TAF or could increase Delta outflow by 30 TAF compared to the No Action Alternative. With additional storage,

Figure 5.1-13. Delta Exports at Banks and Tracy under Alternative 1 for the Long-Term Period



Revised from June 1999 draft

Figure 5.1-14. Delta Exports at Banks and Tracy under Alternative 1 for Dry and Critical Years



Revised from June 1999 draft

Figure 5.1-15. Average Annual Delta Exports at Banks and Tracy under Alternative 1 for the Long-Term Period and Dry and Critical Years

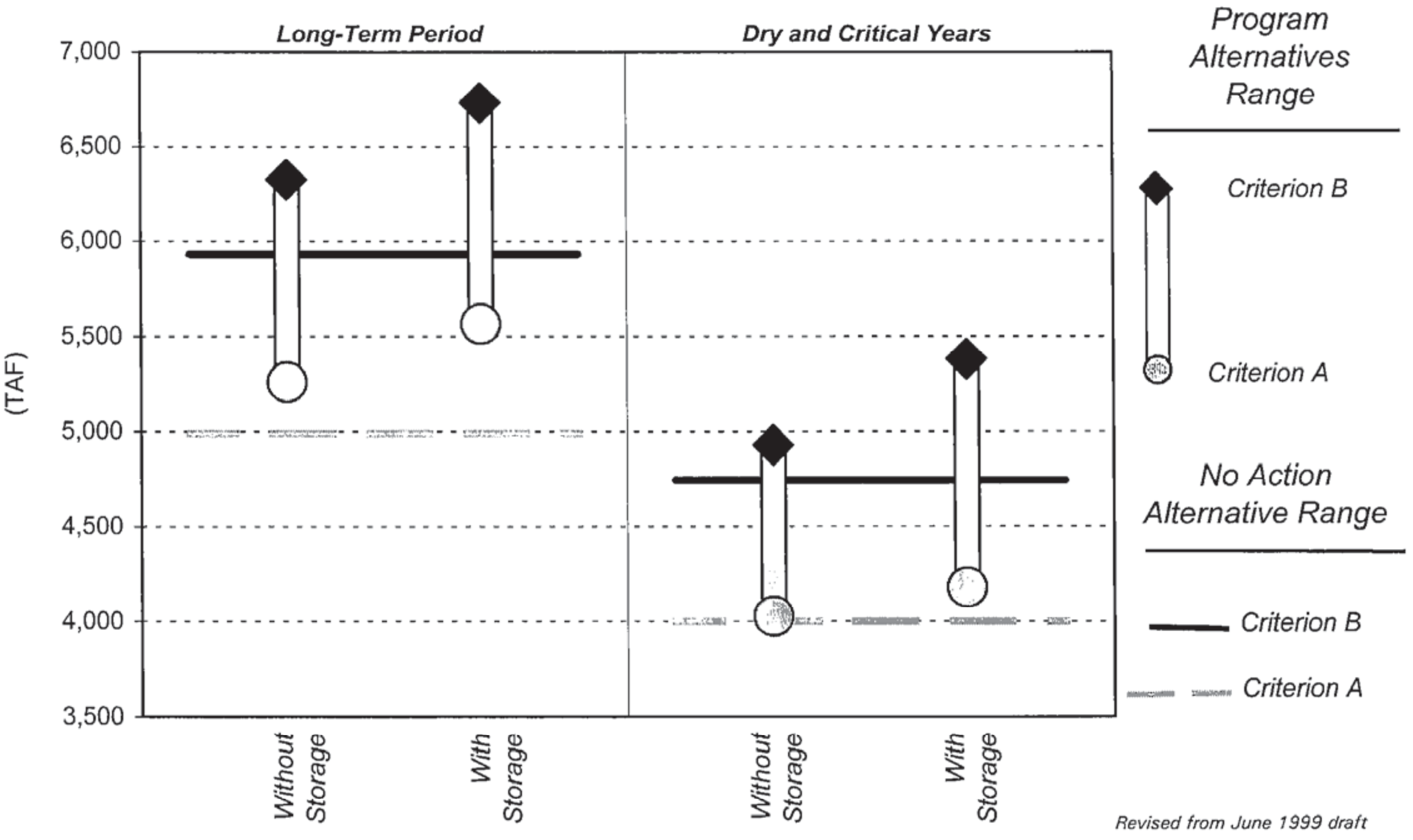


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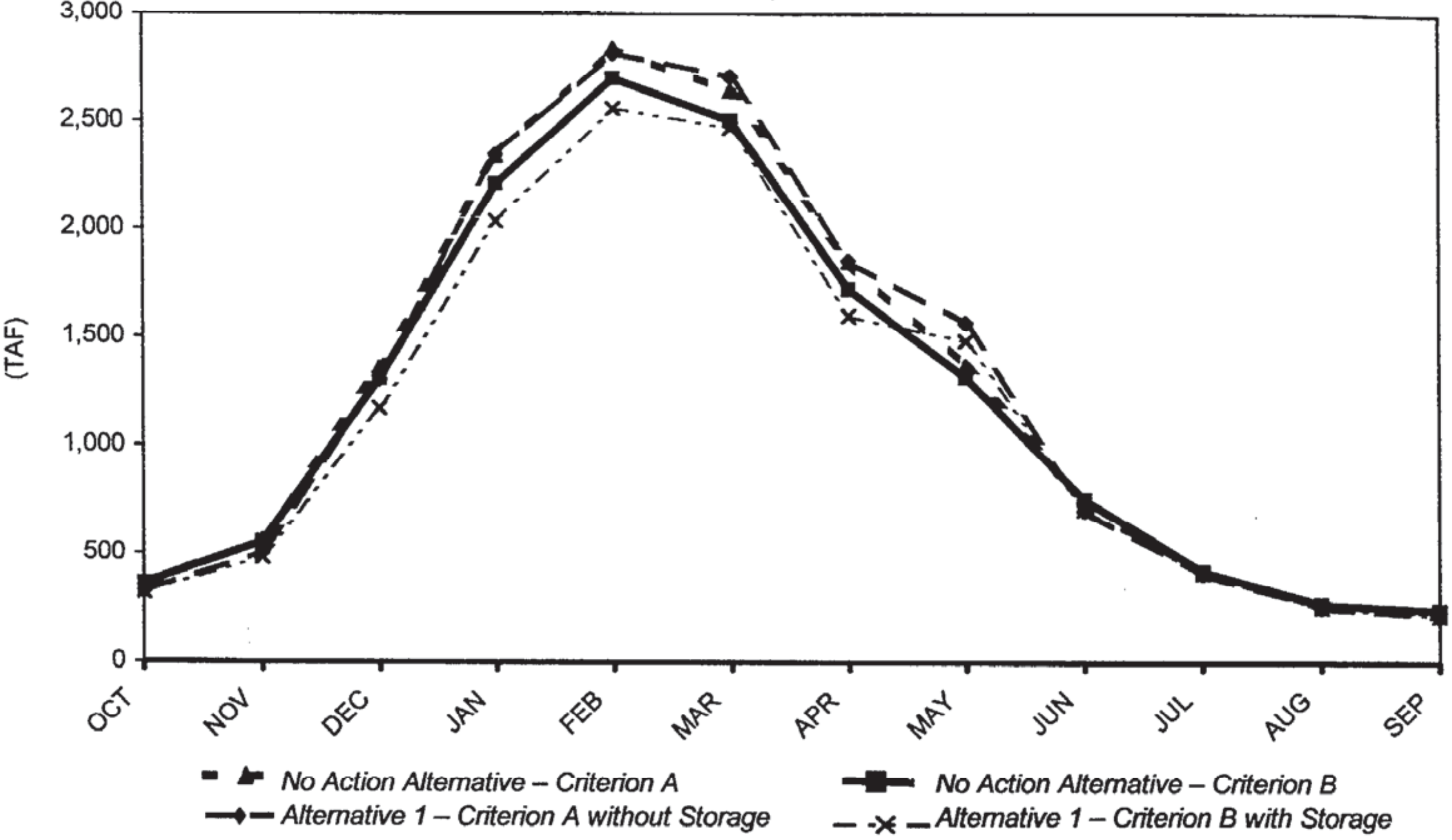
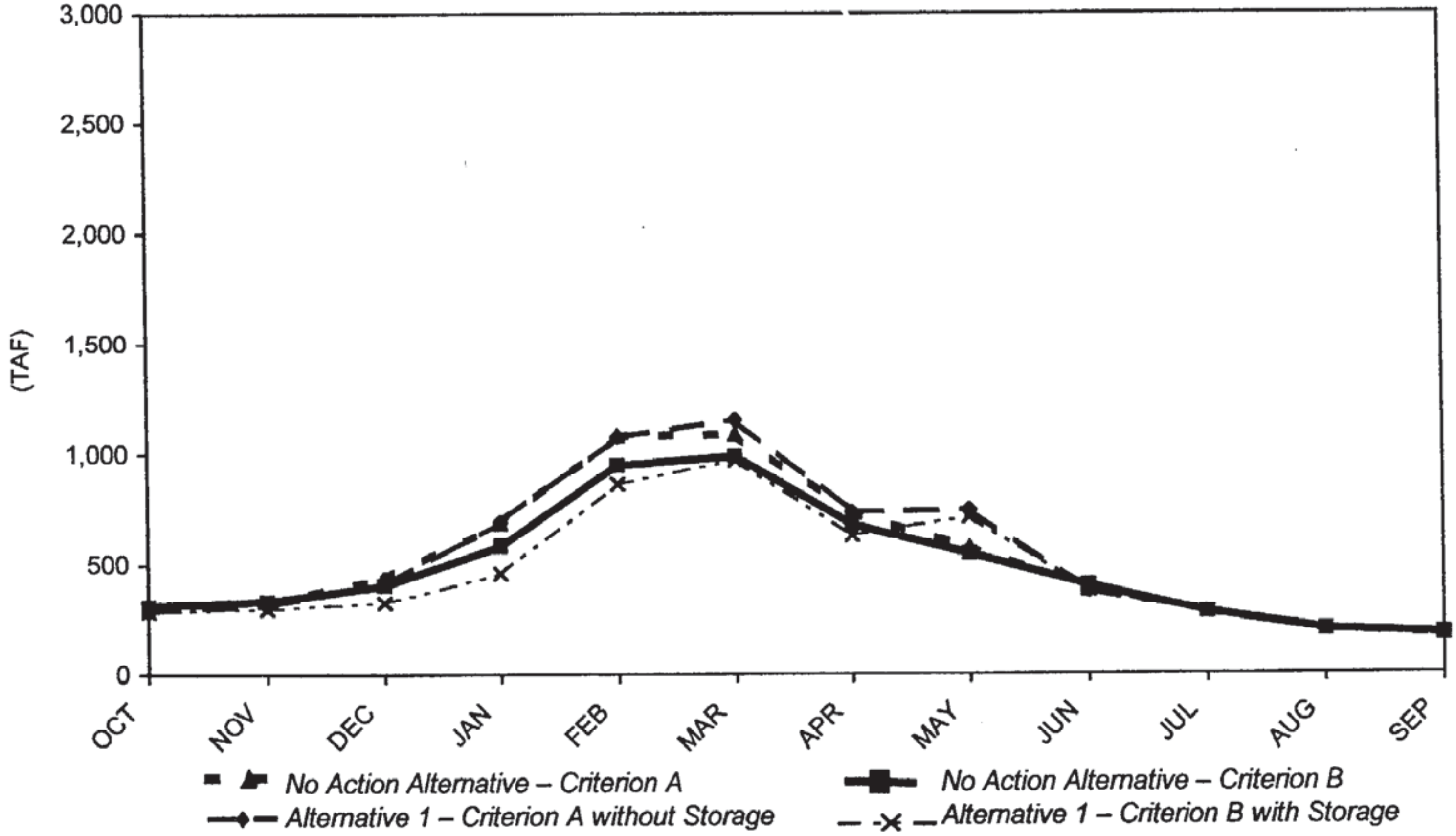
Figure 5.1-16. Delta Outflow under Alternative 1 for the Long-Term Period



Revised from June 1999 draft

Figure 5.1-17. Delta Outflow under Alternative 1 for Dry and Critical Years



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Alternative 1 decreases average annual Delta outflows about 350-660 TAF. Therefore, annual long-term Delta outflow decreases of 370-580 TAF are directly related to additional storage under Alternative 1.

During dry and critical years, February outflows range from 950 TAF to 1.1 MAF under the No Action Alternative and range from 860 TAF to 1.1 MAF under Alternative 1. On an annual basis, without additional storage, Alternative 1 increases average dry and critical year Delta outflows up to 160 TAF over the No Action Alternative. With additional storage, Alternative 1 could decrease average dry and critical year outflows by 260 TAF or could increase outflows by 90 TAF relative to the No Action Alternative. Therefore, annual dry and critical year Delta outflow decreases of 70-310 TAF are directly related to additional storage under Alternative 1.

Sacramento River and San Joaquin River Regions

This section provides a comparison of Alternative 1 and the No Action Alternative with respect to water supply and water management in the Sacramento River and San Joaquin River Regions using DWRSIM modeling results. The programmatic comparison focuses on existing storage, new storage, and Ecosystem Restoration Program acquisitions.

Alternative 1 does not change the water supply reliability in the Sacramento River and San Joaquin River Regions relative to the No Action Alternative. All water demands in the Sacramento River and San Joaquin River Regions are met through CVP/SWP project deliveries and through locally derived water supplies. Refer to Section 5.1.4, "Assessment Methods," for details related to the DWRSIM hydrology development process. However, as discussed later in this section, surface water acquisitions through the Ecosystem Restoration Program could reallocate supplies from willing sellers to in-stream uses.

Existing Storage. End-of-September carryover storage in the major Sacramento River Region surface storage facilities (Shasta, Oroville, and Folsom) was evaluated for Alternative 1 and the No Action Alternative. Figure 5.1-18 depicts the ranges of long-term period and dry and critical year carryover storage for Alternative 1 and the No Action Alternative.

Under the No Action Alternative, average carryover storage in Sacramento River Region reservoirs ranges from 5.3 to 5.4 MAF for the long-term period, and from 3.8 to 3.9 MAF for dry and critical years. Alternative 1 long-term period carryover storage ranges from 5.1 to 5.5 MAF, while dry and critical year carryover storage ranges from 3.6 to 4.0 MAF.

In the absence of new storage facilities, implementation of Alternative 1 has little impact on carryover storage under Criterion A water management assumptions. Alternative 1 results in a moderate reduction in carryover storage under Criterion B water management assumptions. Without new storage, the reduction in average long-term carryover storage under Alternative 1 may vary from 100 to 190 TAF. The same trend is demonstrated for dry and critical years with the reduction in average carryover storage varying from 20 to 170 TAF.

With new storage facilities, implementation of Alternative 1 under Criterion A assumptions reduces long-term and dry and critical year carryover storage in existing facilities from on the order of 120 TAF relative to the No Action Alternative. Under Criterion B assumptions, Alternative 1 increases carryover storage from on the order of 260 TAF.

Figure 5.1-18. Carryover Storage for Existing Surface Reservoirs in the Sacramento River Region under Alternative 1 for the Long-Term Period and Dry and Critical Years

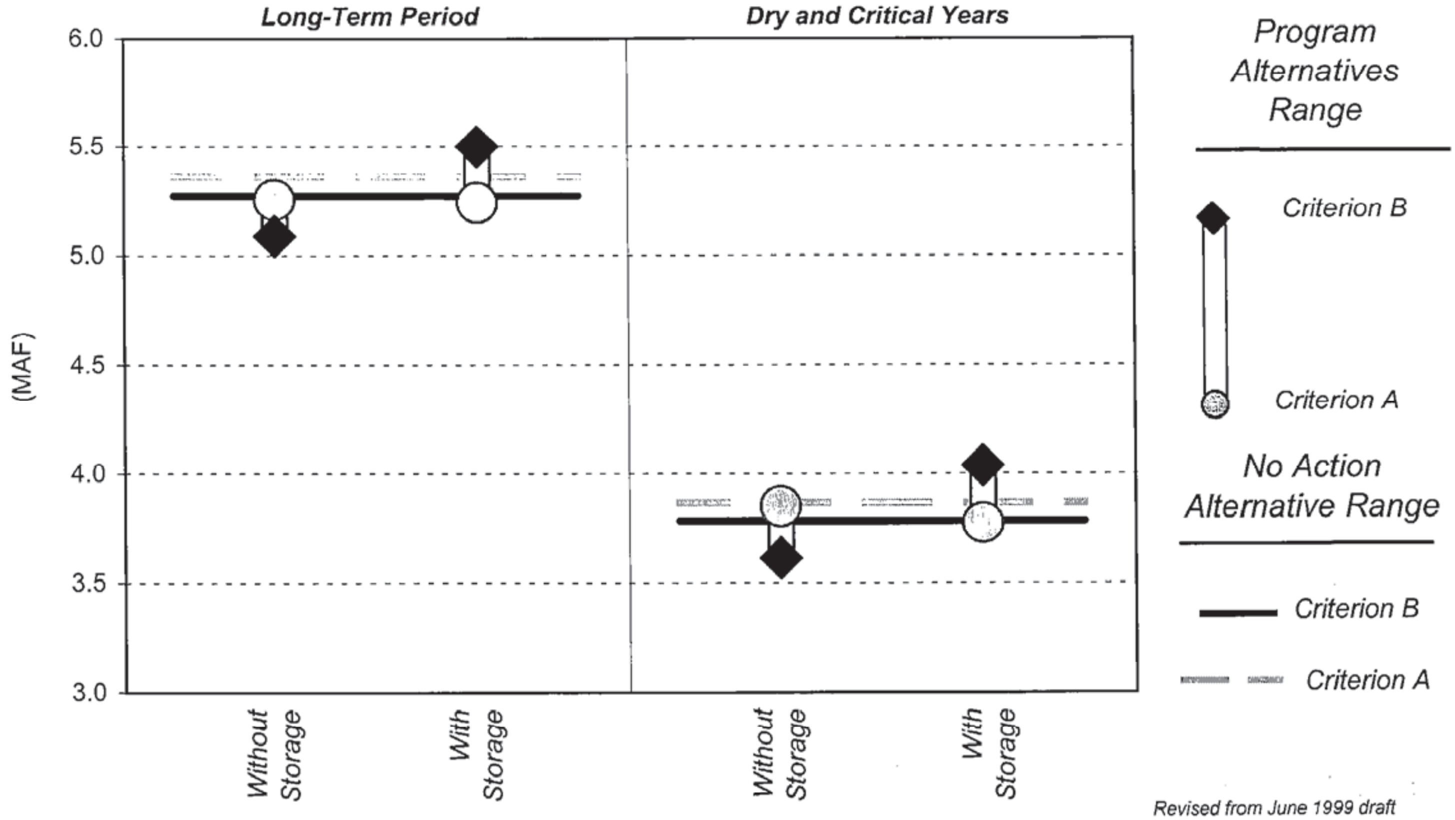

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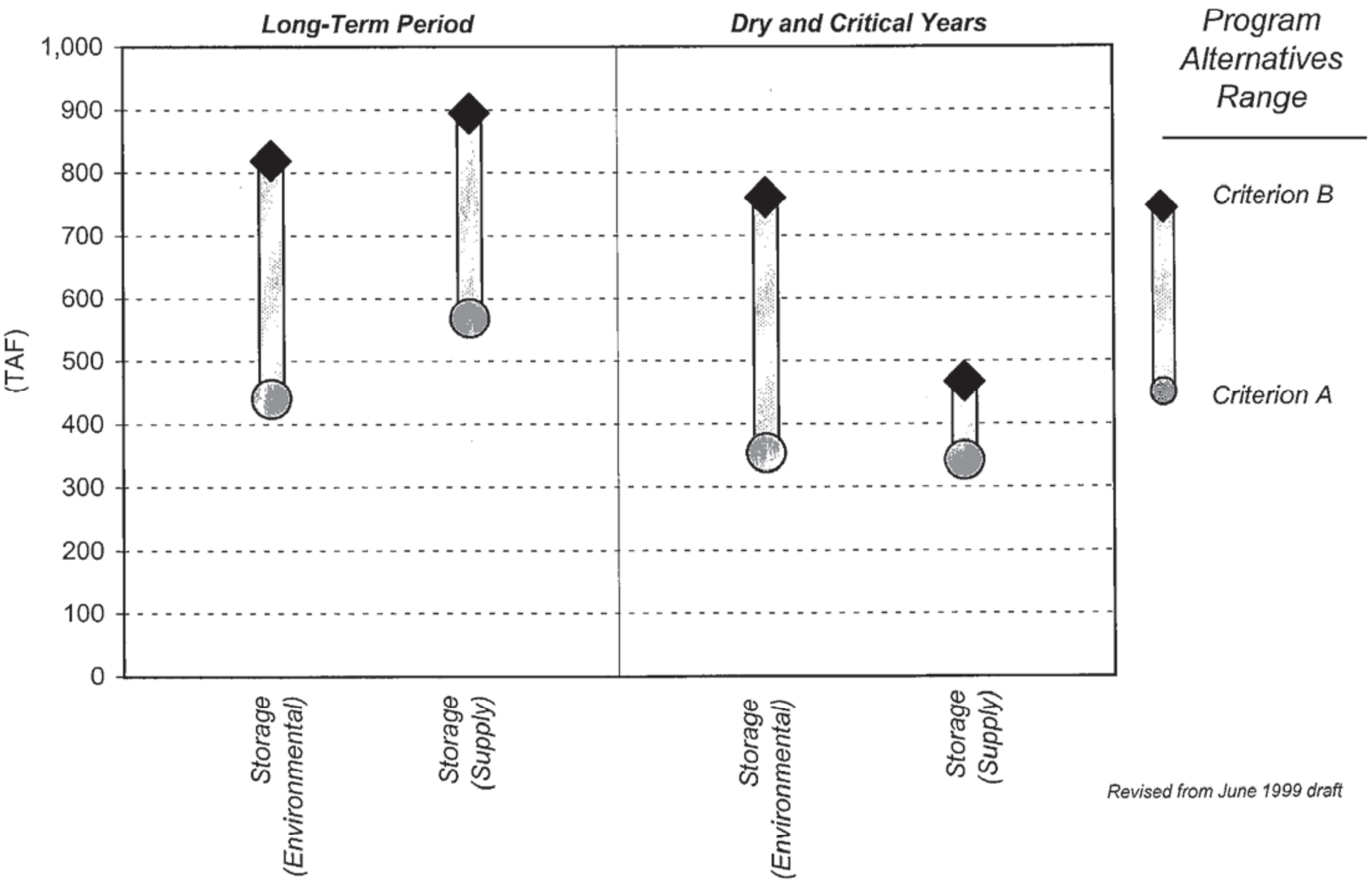
Figure 5.1-19. Carryover Storage for New Surface Reservoirs in the Sacramento River Region under Alternative 1 for the Long-Term Period and Dry and Critical Years



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End-of-September carryover storage in the major San Joaquin River Region surface facilities (New Melones, New Don Pedro, and McClure) was also evaluated for Alternative 1 and the No Action Alternative. Implementation of Alternative 1 has no measurable effect on system carryover storage. Similarly, no variation is evident based on water management criteria or implementation of additional storage facilities.

New Storage. New Sacramento River and San Joaquin River Region surface storage facilities were evaluated under Alternative 1. This evaluation distinguished between storage for water supply and storage for environmental enhancement.

Figure 5.1-19 presents Sacramento River Region surface storage comparisons for the long-term period and dry and critical years. Peak storage in the new facilities generally occurs in early summer under all hydrologic conditions. For the long-term period, peak water supply storage ranges from 750 TAF to 1.3 MAF, while dry and critical year peak storage typically ranges from 480 to 850 TAF. Carryover storage ranges from 570 to 890 TAF for the long-term period, and from 340 to 470 TAF for dry and critical years. Criterion A water management assumptions consistently result in lower water supply storage. For the long-term period, peak Sacramento River Region environmental storage ranges from 510 to 910 TAF, while dry and critical year peak storage typically ranges from 440 to 870 TAF. Carryover storage ranges from 440 to 820 TAF for the long-term period, and from 350 to 760 TAF for dry and critical years. Criterion A water management assumptions consistently result in lower environmental storage.

New Sacramento River Region groundwater storage facilities also were evaluated under Alternative 1. These facilities are assumed to have a maximum capacity of 250 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from this groundwater storage are assumed to be made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 43 to 45 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

In this evaluation, new San Joaquin River Region surface storage facilities were dedicated to providing water for Ecosystem Restoration Program flow targets. Peak average annual storage tends to occur in late spring and is approximately 240-250 TAF for the long-term period and 220-240 TAF for dry and critical years. Carryover storage ranges from 200 to 220 TAF for the long-term period and dry and critical years. Criterion B water management assumptions consistently resulted in lower storage.

Ecosystem Restoration Program Acquisition. All Program alternatives include Ecosystem Restoration Program flow targets described in Attachment A for the Sacramento River and San Joaquin River Regions. In the Sacramento River Region, surface water would be acquired from willing sellers on the Sacramento, Feather, Yuba, and American Rivers for in-stream purposes. Similarly, in the San Joaquin River Region, water would be acquired from willing sellers on the Stanislaus, Tuolumne, and Merced Rivers. It is assumed that water would be acquired from water right holders on these rivers and may result in short-term fallowing. The acquired water would be stored during the period of a contract year by reoperating upstream reservoirs and released in a manner to increase flow toward the in-stream flow targets on these rivers.

The modeling analysis provides the Ecosystem Restoration Program acquisition flows through "add water" and does not reoperate existing reservoirs. Since the Ecosystem Restoration Program flow targets are in the spring, reservoir operations are likely to accommodate the release pattern for additional in-stream flows. In effect, the acquisition of water would involve a shift in the release pattern from storage reservoirs, combined with a reduction in the diversion of the released water.

Under the Ecosystem Restoration Program, release of acquired water would flow through the Delta and increase Delta outflow. The acquired water would not be exported by the CVP or SWP. However, the projects would receive some incidental benefit toward meeting Delta water quality and outflow requirements, since the increase in Delta outflow resulting from release of acquired water would reduce salinity intrusion into the Delta.

Table 5.1-3 shows water acquisition quantities under Alternative 1 estimated to meet proposed Ecosystem Restoration Program flow targets. For locations in the Sacramento River Region, flow targets vary with the Sacramento Valley 40-30-30 water-year index. For locations in the San Joaquin River Region, flow targets vary with the San Joaquin Valley 60-20-20 water-year index.

Table 5.1-3. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions without New Storage under Alternative 1 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	90	20	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	50	80	50-60	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	80-90	10	0	0
Additional Delta flows [a]	0	110-140	180-210	220-250	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	30	40	30	50
Merced River [b]	0	10	30	20	40
Total acquisitions	**0**	**310-370**	**510-550**	**390-440**	**170**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

Fewer water acquisitions are required to meet Ecosystem Restoration Program flow targets when Sacramento River and San Joaquin River Regions surface storage is included in Alternative 1. New storage also could be operated to provide Ecosystem Restoration Program flows for other tributaries by exchange agreements. These types of arrangement are not reflected in this analysis. Table 5.1-4 shows the water acquisitions quantities estimated to meet the proposed Ecosystem Restoration Program flow targets under Alternative 1 with new storage.

South-of-Delta SWP and CVP Service Areas

Programmatic comparisons of deliveries to the South-of-Delta SWP and CVP Service Areas were made between Alternative 1 and the No Action Alternative using DWRSIM modeling results. This section also evaluates storage in existing and new off-aqueduct facilities.

Table 5.1-4. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions with New Storage under Alternative 1 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	20-50	0-10	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	40	70	40	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	0-30	0	0	0
Additional Delta flows [a]	0	50-60	110-120	160-200	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	10	20-30	10	30
Merced River [b]	0	0	0	0	10
Total acquisitions	**0**	**130-190**	**300-360**	**260-320**	**120**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

Delta Deliveries. The range of annual Delta deliveries under the No Action Alternative was compared to the range of deliveries expected under Alternative 1. Deliveries are generally higher under Alternative 1 with implementation of new storage facilities and Criterion B water management assumptions.

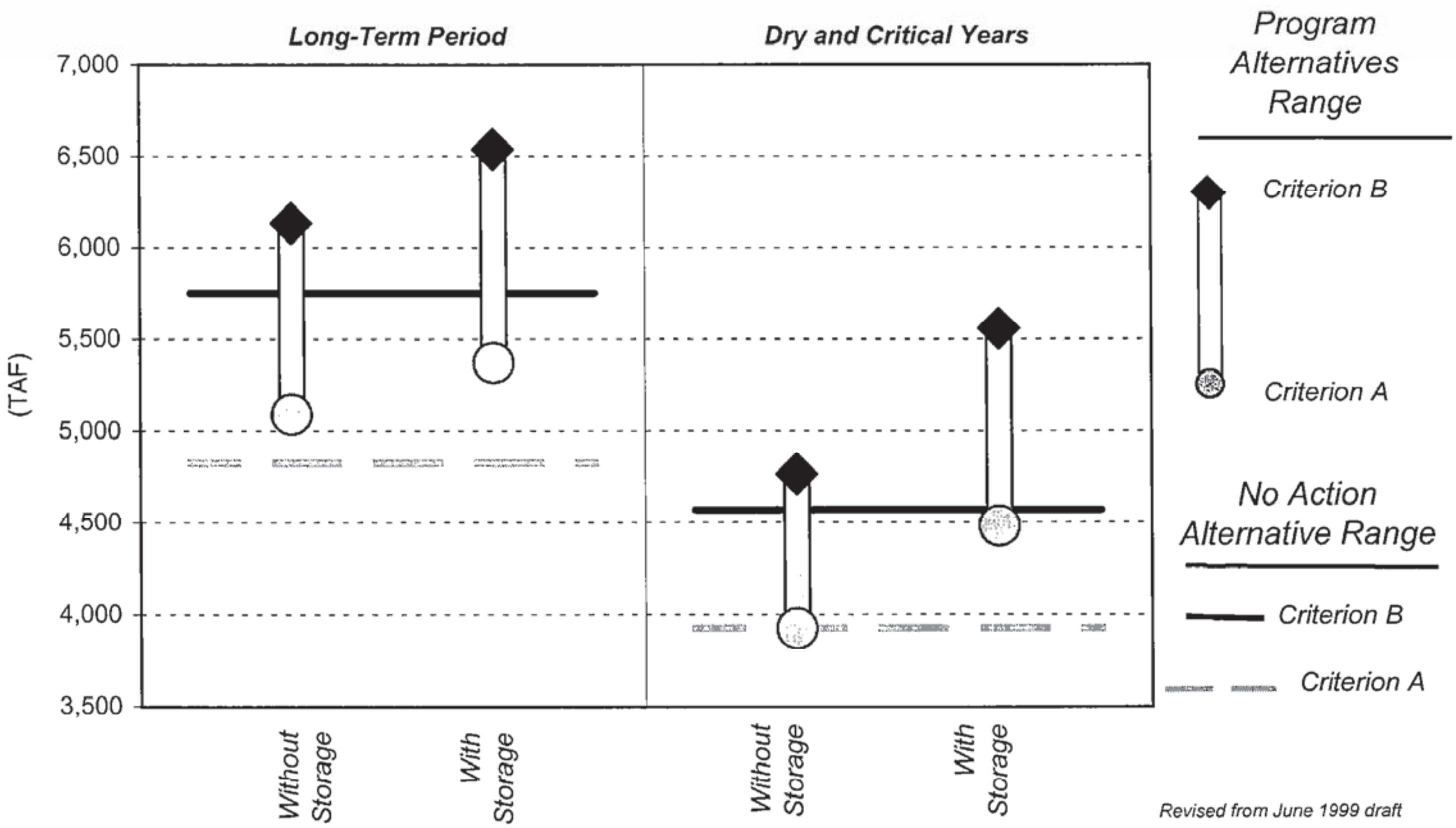
Under Alternative 1, the range of average annual deliveries over the long-term period is from 5.1 to 6.5 MAF. The low end of this range assumes no new storage facilities and Criterion A water management assumptions; the high end of this range assumes new storage facilities and Criterion B water management assumptions. The No Action Alternative results in a long-term average annual delivery range of 4.8-5.8 MAF. During dry and critical years, Alternative 1 average annual deliveries range between 3.9 and 5.6 MAF and the No Action Alternative deliveries range between 3.9 and 4.6 MAF.

Without additional storage facilities, Alternative 1 would increase long-term average annual deliveries by 270-380 TAF relative to the No Action Alternative. Dry and critical year deliveries would increase by up to 190 TAF under Alternative 1. Implementation of Alternative 1 in conjunction with new surface storage would increase long-term average annual deliveries by 550-790 TAF. In dry and critical years, Alternative 1 would increase deliveries by 560-990 TAF. Therefore, annual long-term Delta delivery increases of 400-410 TAF are directly related to additional storage under Alternative 1. The range of average annual long-term and dry and critical water-year Delta deliveries for Alternative 1 compared to the No Action Alternative is depicted in Figure 5.1-20.

Existing Off-Aqueduct Storage Facilities. San Luis Reservoir is the primary existing off-aqueduct storage facility serving the South-of-Delta SWP and CVP Service Areas. San Luis Reservoir carryover storage and reservoir releases were evaluated under Alternative 1 and the No Action Alternative.

With no additional storage, Alternative 1 increases San Luis Reservoir carryover storage by 40-140 TAF for long term and by 60-100 TAF for dry and critical years (above the No Action Alternative). If additional storage is implemented, Alternative 1 increases long-term carryover storage by 210-270 TAF and dry and critical carryover storage by 160-170 TAF above the No Action Alternative. Therefore, a long-term average carryover storage increase of 130-170 TAF is directly attributed to additional storage under Alternative 1. The average carryover storage increase of 40-70 TAF for dry and critical years is

Figure 5.1-20. Average Annual Delta Deliveries under Alternative 1 for the Long-Term Period and Dry and Critical Years



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directly related to additional storage under Alternative 1. Figure 5.1-21 presents carryover storage comparisons for the long-term period and dry and critical years.

The broadest range in monthly average storage releases from San Luis Reservoir generally occurs in summer months for both water management criteria under all hydrologic conditions. The smallest long-term summer releases are generally associated with Criterion A water management in the absence of new storage facilities, while the greatest summer releases are associated with Criterion B water management in conjunction with additional storage capacity. The broadest range of long-term monthly average reservoir releases under Alternative 1 is approximately 190-340 TAF. Under the No Action Alternative, long-term peak average monthly summer releases range from 260 to 300 TAF. Winter releases are similar under Alternative 1 and the No Action Alternative.

New Off-Aqueduct Storage Facilities. Carryover storage and releases associated with new off-aqueduct surface storage facilities were evaluated under Alternative 1. Such facilities would serve South-of-Delta SWP and CVP Service Areas similar to San Luis Reservoir.

Over the long-term period, carryover storage in new off-aqueduct surface storage facilities ranges from 770 to 800 TAF under Alternative 1. For dry and critical years, carryover storage ranges from 330 to 390 TAF. Water management Criterion A provides higher carryover storage in wetter water-years while water management Criterion B provides higher carryover storage in drier water-years. The higher demands under Criterion B results in lower carryover storage in wetter water-years and more protective Delta actions under Criterion A results in lower carryover storage in drier water-years. Figure 5.1-22 presents carryover storage comparisons for the long-term period and dry and critical years.

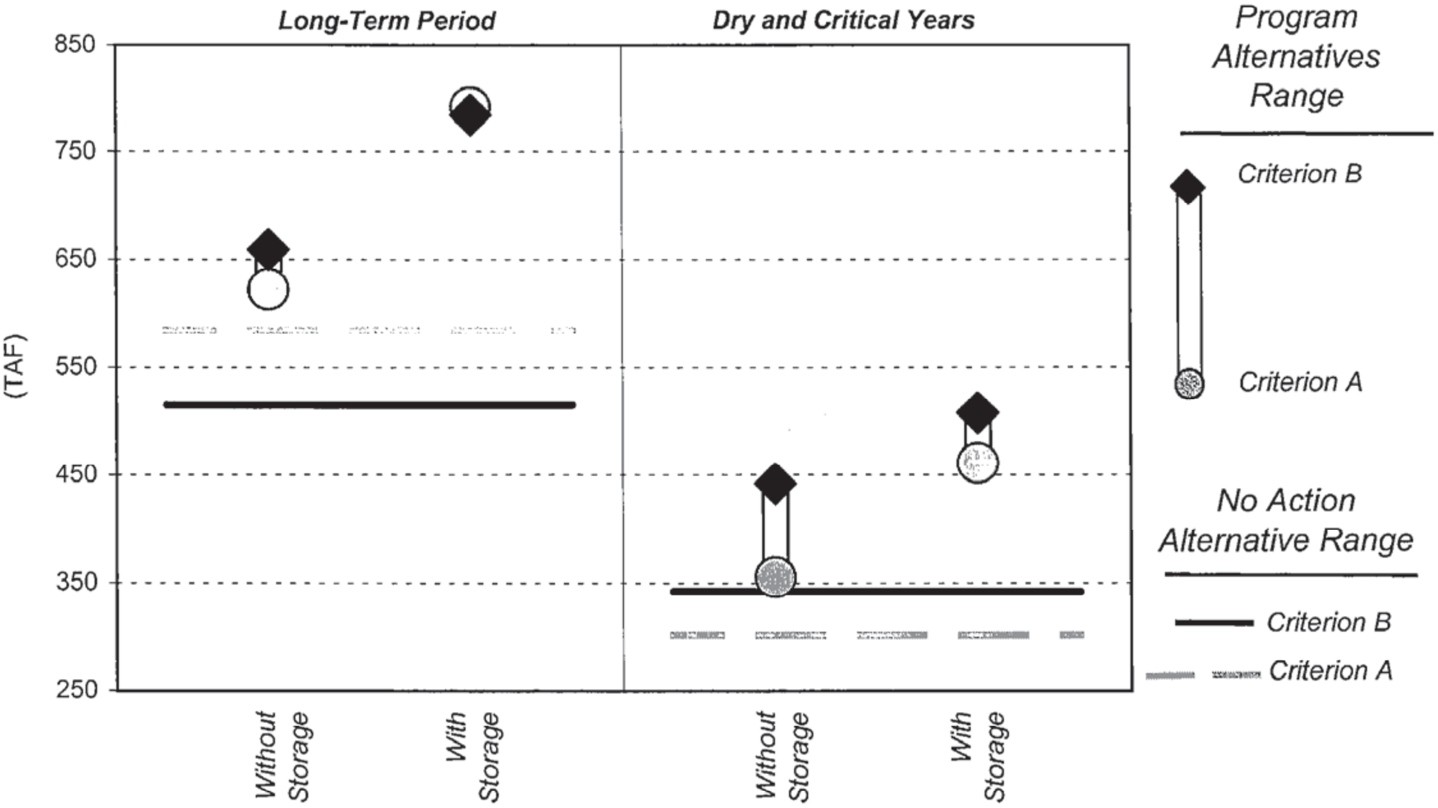
Releases from new off-aqueduct surface storage facilities generally occur from spring to late summer under Alternative 1. Peak releases typically occur in midsummer for all hydrologic conditions. The peak monthly release is approximately 160 TAF for the long-term period and ranges from 180 to 190 TAF for dry and critical years. In dry and critical years, monthly average releases tend to be similar under both water management criteria. Over the long-term period, Criterion A water management results in early spring peak releases while Criterion B results in late spring peak releases. Reduced Delta exports associated with Criterion A create more reliance on off-aqueduct storage releases to meet spring demands.

New off-aqueduct groundwater storage facilities also were evaluated under Alternative 1. These facilities are assumed to have a maximum capacity of 500 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from this groundwater storage are assumed to be made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 60 to 90 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

5.1.8.2 ALTERNATIVE 2

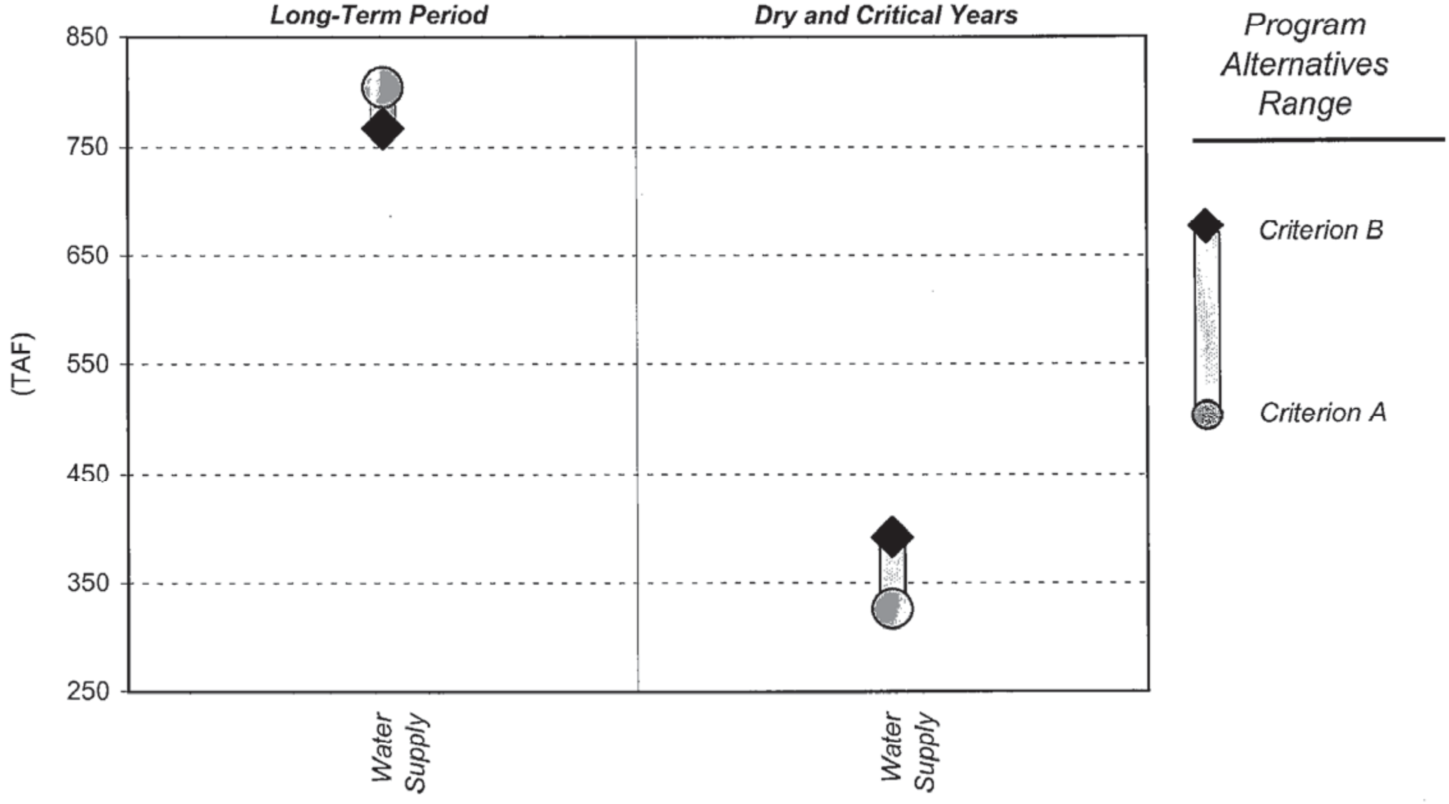
Some improvements to water supply and water management would be realized from improved export pumping capacity under Alternative 2. Greater water supply and water management benefits may be obtained if additional storage facilities are constructed.

Figure 5.1-21. Carryover Storage for Existing Off-Aqueduct Reservoirs under Alternative 1 for the Long-Term Period and Dry and Critical Years



Revised from June 1999 draft

Figure 5.1-22. Carryover Storage for New Off-Aqueduct Reservoirs under Alternative 1 for the Long-Term Period and Dry and Critical Years



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Delta Region

Programmatic comparisons of Delta inflows and exports were made between Alternative 2 and the No Action Alternative using DWRSIM modeling results. Both bookend water management criteria (assumption sets Criteria A and B) were used to define the range of uncertainty associated with each alternative.

Average monthly Delta inflow is typically lower under Alternative 2 than under the No Action Alternative. Over the long-term period, Delta inflow normally peaks in February. Average February flow is approximately 190 TAF under the No Action Alternative and ranges from 160 to 180 TAF under Alternative 2. For dry and critical years, peak monthly flow ranges from 60 to 70 TAF under both the No Action Alternative and under Alternative 2. Additional storage slightly reduces total Delta inflow for the long-term average and dry and critical years.

The pattern of long-term average Delta exports would be modified somewhat by Alternative 2, with greater exports occurring August through January relative to the No Action Alternative. Figure 5.1-23 compares average monthly south-of-Delta exports for the long-term period. Similarly, Figure 5.1-24 compares average monthly south-of-Delta exports during dry and critical years. The range of average annual Delta exports under Alternative 2 for both hydrologic periods are compared to the No Action Alternative in Figure 5.1-25.

Combined exports from Banks and Tracy Pumping Plants peak in late winter months, with long-term period values ranging from 560 to 680 TAF under the No Action Alternative and from 540 to 760 TAF under Alternative 2. Delta exports, at minimum values in spring months, change little under Alternative 2. Long-term period exports range from 120 to 200 TAF under the No Action Alternative and range from 120 to 210 TAF under Alternative 2. On an annual basis, without additional storage, Alternative 2 increases long-term period Delta exports by an additional 230-410 TAF over the No Action Alternative. With additional storage, Alternative 2 increases annual Delta exports by 460-800 TAF over the No Action Alternative. Therefore, annual export increases of 230-390 TAF are directly related to additional storage under Alternative 2.

Alternative 2 has a similar influence on dry and critical year Delta exports. Under the No Action Alternative, Delta exports range from 530 to 640 TAF in the peak winter months and from 90 to 140 TAF during the spring months. Under Alternative 2, dry and critical year exports range from 520 to 710 TAF in the peak winter months and from 90 to 140 TAF during the spring months. On an annual basis, without additional storage, Alternative 2 increases dry and critical year Delta exports by an additional 30-200 TAF over the No Action Alternative. With additional storage, Alternative 2 increases annual Delta exports by 130 to 650 TAF over the No Action Alternative. Therefore, annual dry and critical year export increases of 100-450 TAF are directly related to additional storage under Alternative 2.

Under Alternative 2, diversions from the Sacramento River near Hood to the Mokelumne River system occur throughout the year. Details regarding the diversion facility near Hood assumptions are presented in Section 5.1.4 and Attachment A. In general, the pattern of diversions peak in the early winter and midsummer months with lower diversions in the spring. Figure 5.1-26 compares average monthly diversions near Hood for the long-term period. Similarly, Figure 5.1-27 compares average monthly diversions near Hood during dry and critical years.

Figure 5.1-23. Delta Exports at Banks and Tracy under Alternative 2 for the Long-Term Period

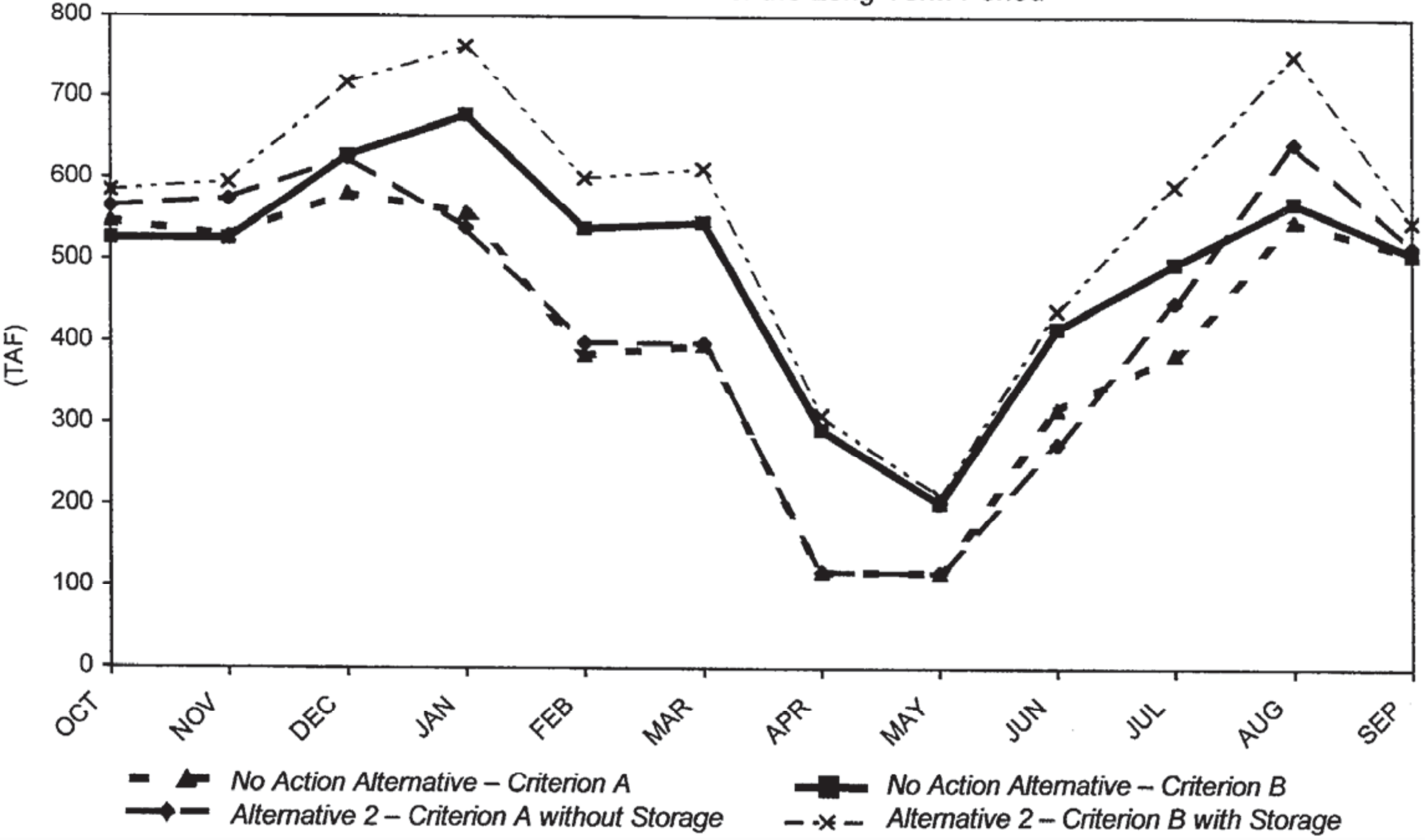

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Figure 5.1-24. Delta Exports at Banks and Tracy under Alternative 2 for Dry and Critical Years

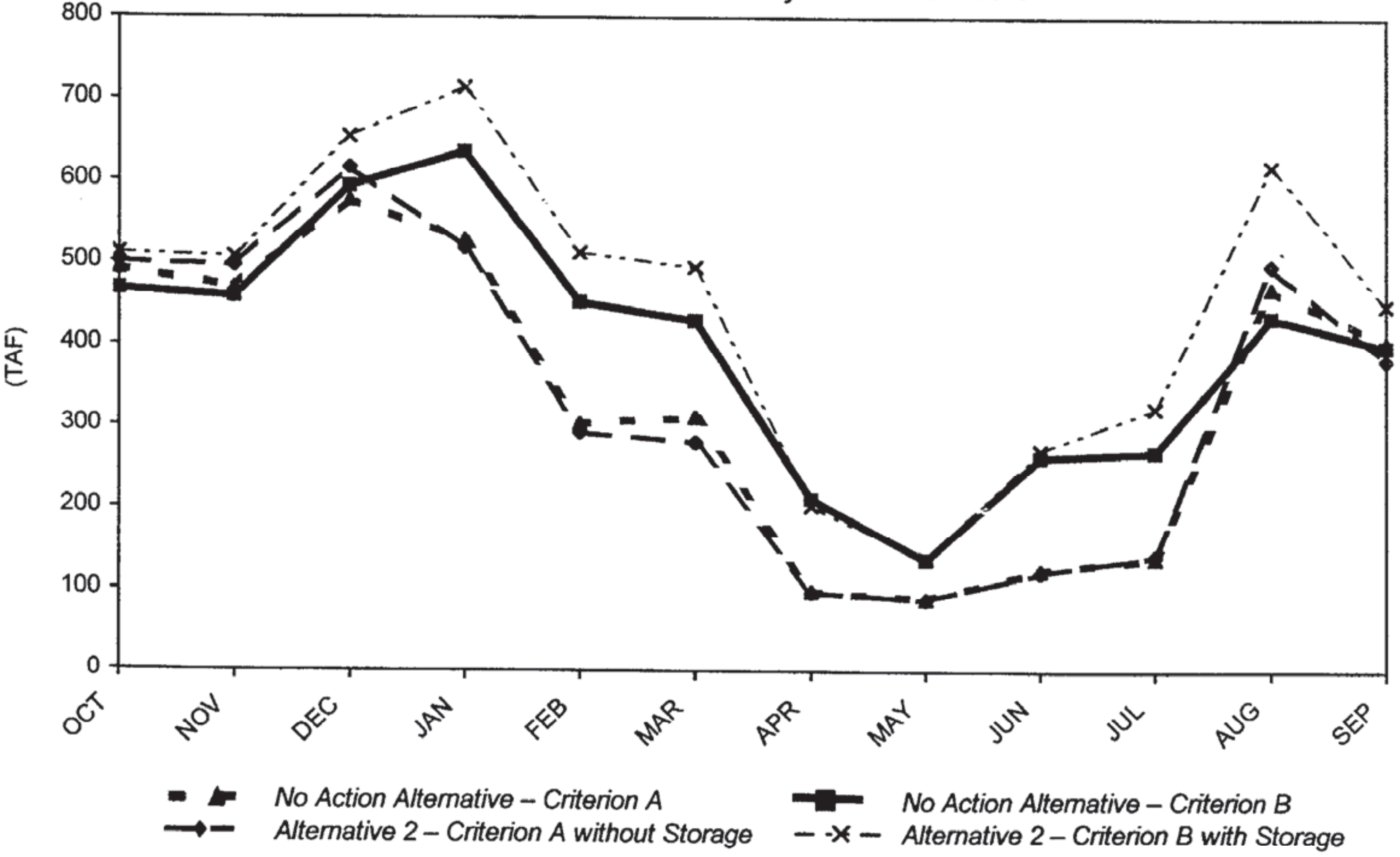

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Figure 5.1-25. Average Annual Delta Exports at Banks and Tracy under Alternative 2 for the Long-Term Period and Dry and Critical Years

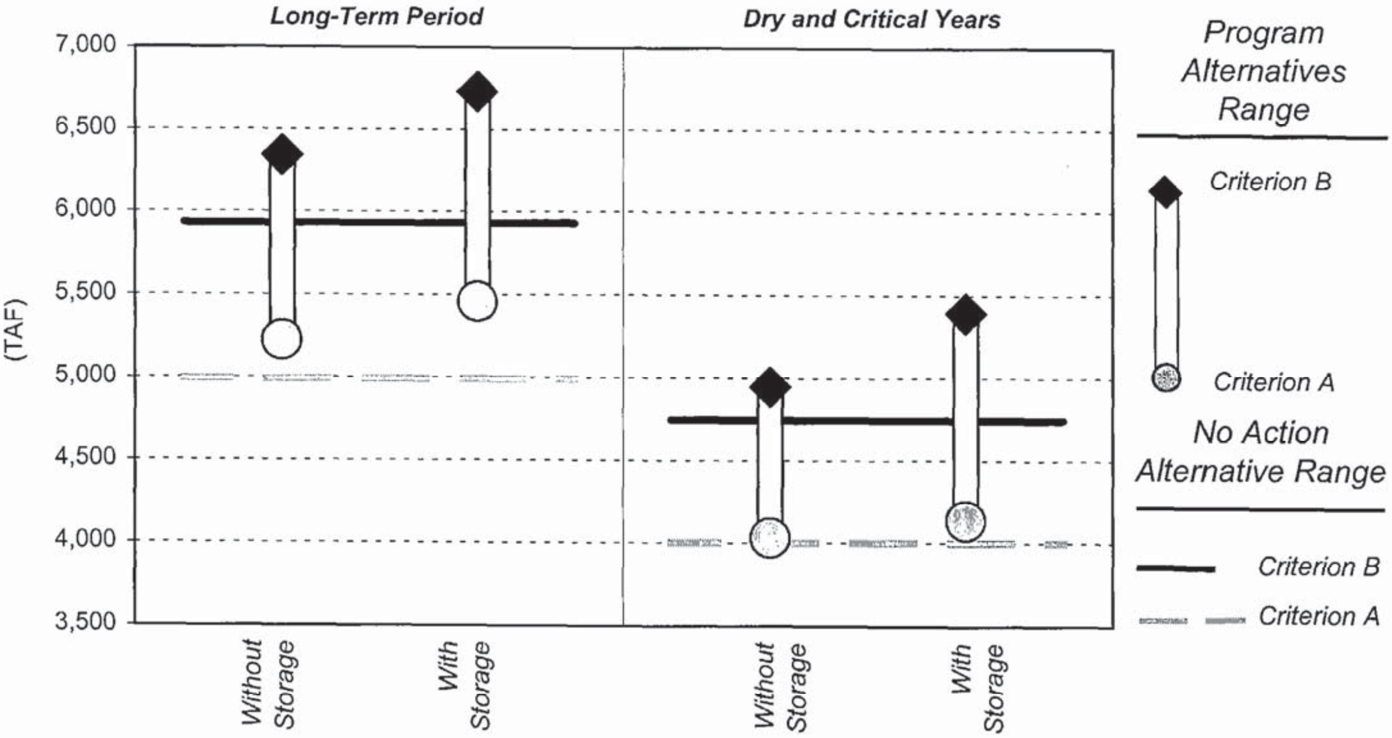

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Figure 5.1-26. Hood Diversions under Alternative 2 for the Long-Term Period

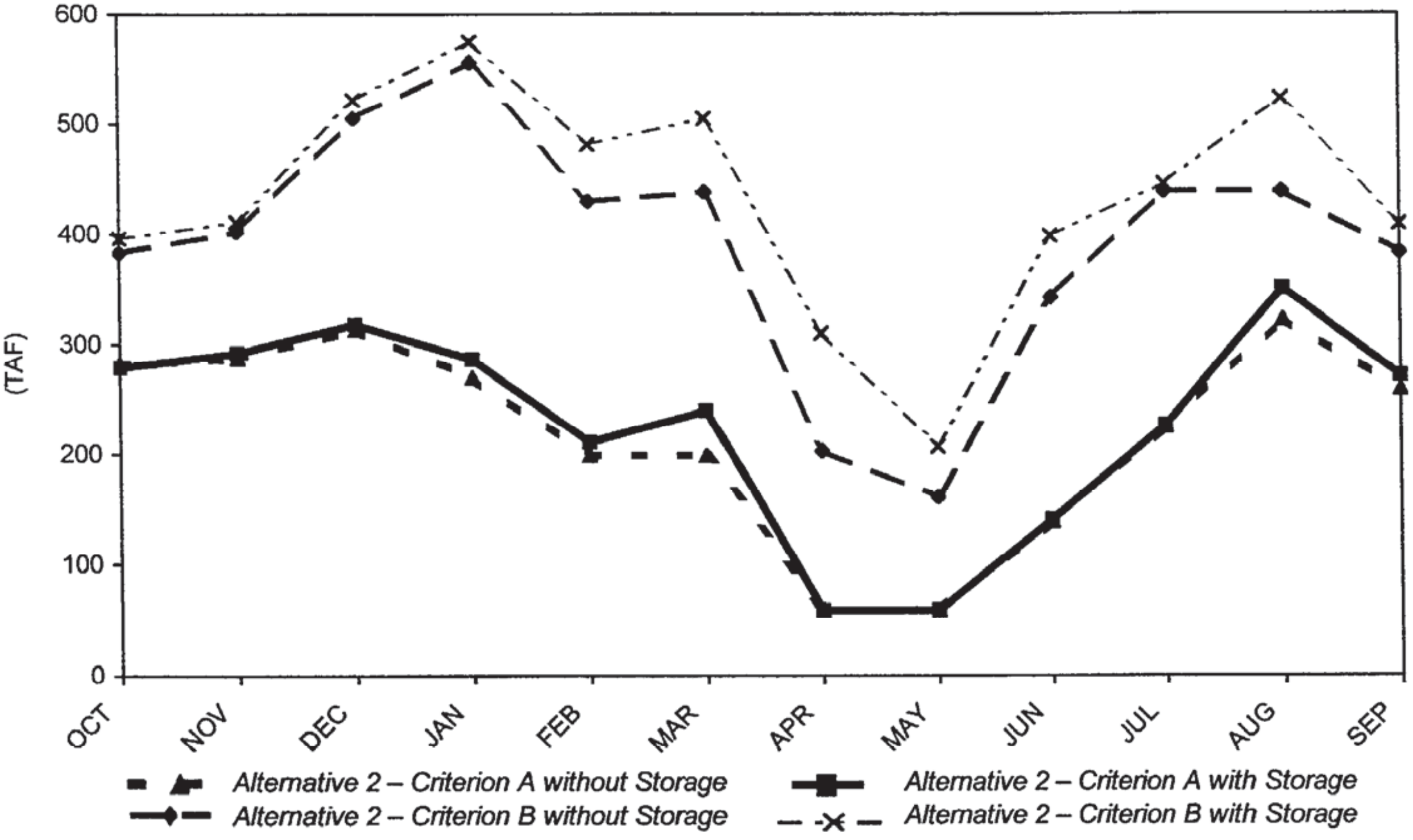
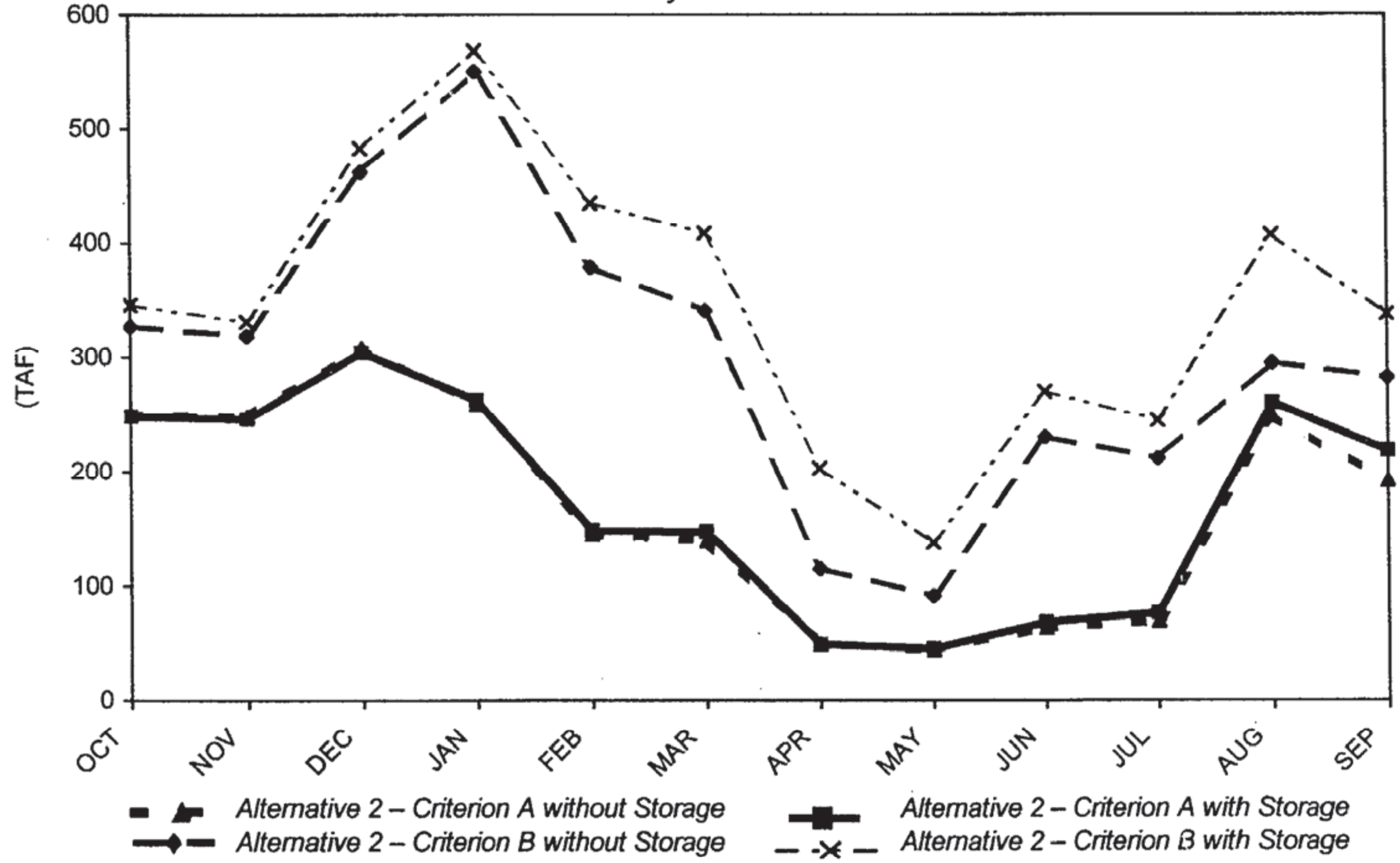


Figure 5.1-27. Hood Diversions under Alternative 2 for Dry and Critical Years



Average monthly diversions near Hood are typically greatest in winter, with long-term diversions ranging from 270 and 580 TAF. Lower average monthly diversions occur during spring due to more restrictive operation criteria, with long-term diversions ranging from 60 to 210 TAF. For dry and critical water-years, diversions range from 260 to 570 TAF in peak winter months and from 40 to 140 TAF in spring months.

Under Alternative 2 without additional storage, the average annual long-term period diversions near Hood range between 2.6 and 4.7 MAF. For dry and critical years, the average annual diversions range from 2.0 to 3.6 MAF. When additional system storage is applied to Alternative 2, the annual long-term diversions near Hood average from 2.7 to 5.2 MAF. For dry and critical years, annual diversions near Hood average between 2.1 and 4.2 MAF. Additional diversions near Hood directly attributable to additional storage range on average from 120 to 500 TAF and from 60 to 570 TAF annually, for the long-term period and dry and critical years, respectively.

Bay Region

Programmatic comparisons of Delta outflow to San Francisco Bay were made between Alternative 2 and the No Action Alternative using DWRSIM modeling results. Figures 5.1-28 and 5.1-29 present monthly average Delta outflow comparisons for the long-term period and dry and critical years, respectively.

Delta outflow is typically lower under Alternative 2 than under the No Action Alternative during November through March. Percentage differences are typically small, however. Over the long-term period, Delta outflow normally peaks in February. Average February outflow ranges from 2.7 to 2.8 MAF under the No Action Alternative and ranges from 2.6 to 2.8 MAF under Alternative 2. The differences in Delta outflow are smaller from April through October. Ecosystem Restoration Program flows provide some additional May outflow under Alternative 2. On an annual basis, without additional storage, Alternative 2 modifies average long-term period Delta outflow by (-90) to 60 TAF compared to the No Action Alternative. With additional storage, Alternative 2 decreases average annual Delta outflows by 270-660 TAF. Therefore, annual Delta outflow decreases of 330 to 570 TAF are directly related to additional storage under Alternative 2.

During dry and critical years, February outflows range from 950 TAF to 1.1 MAF under the No Action Alternative, and from 870 TAF to 1.1 MAF under Alternative 2. On an annual basis, without additional storage, Alternative 2 increases average dry and critical year Delta outflows by as much as 210 TAF over the No Action Alternative. With additional storage, Alternative 2 modifies average dry and critical year outflow from -260 to 210 TAF relative to the No Action Alternative. Therefore, annual Delta outflow decreases up to 300 TAF are directly related to additional storage under Alternative 2.

Sacramento River and San Joaquin River Regions

This section provides a comparison of Alternative 2 and the No Action Alternative with respect to water supply and water management in the Sacramento River and San Joaquin River Regions using DWRSIM modeling results. The programmatic comparison focuses on existing storage, new storage, and Ecosystem Restoration Program acquisitions.

Figure 5.1-28. Delta Outflow under Alternative 2
for the Long-Term Period

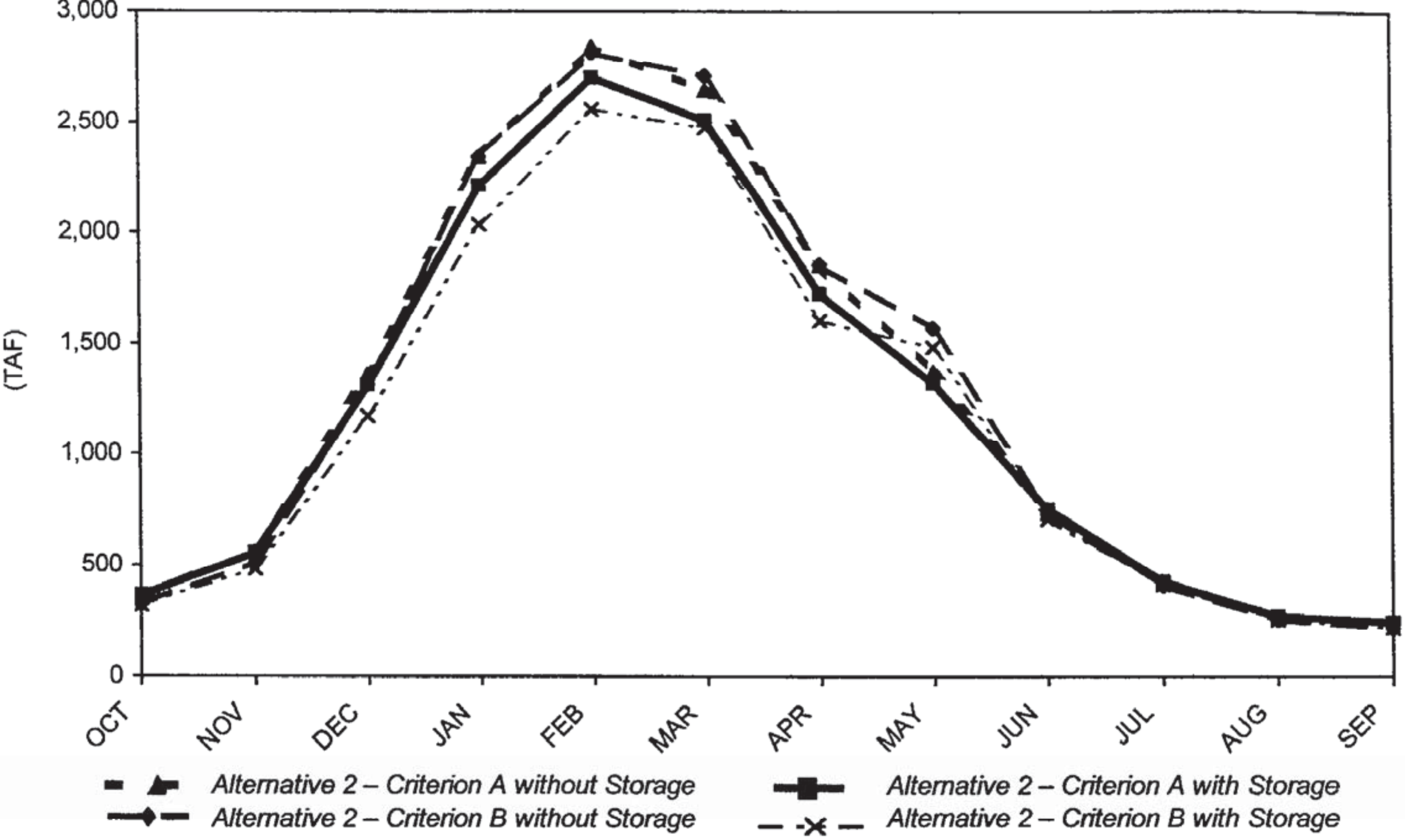
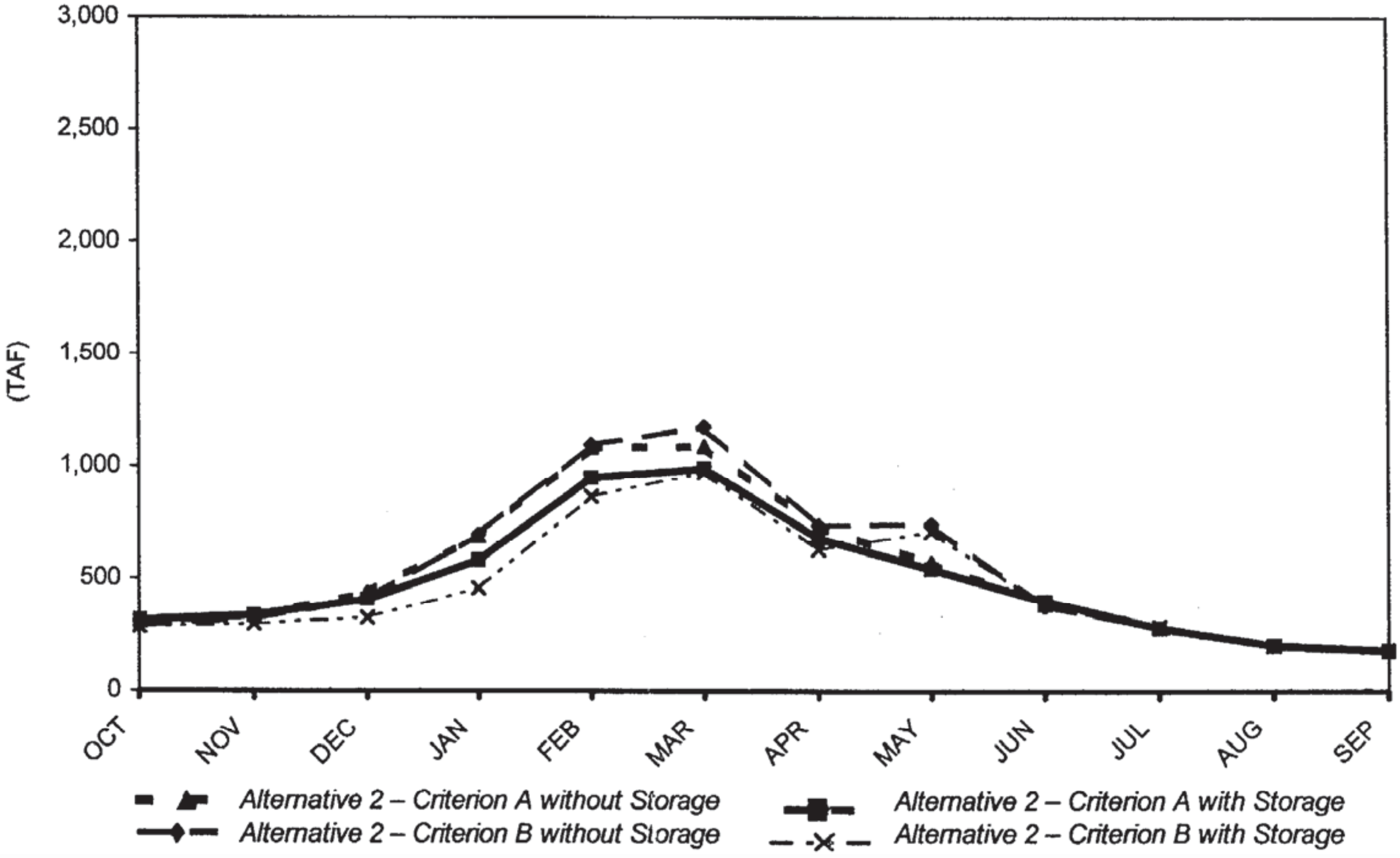


Figure 5.1-29. Delta Outflow under Alternative 2
for Dry and Critical Years



Alternative 2 does not change the water supply reliability in the Sacramento River and San Joaquin River Regions relative to the No Action Alternative. All water demands in the Sacramento River and San Joaquin River Regions are met through CVP/SWP project deliveries and through locally derived water supplies. Refer to Section 5.1.4, "Assessment Methods," for details related to the DWRSIM hydrology development process. However, as discussed later in this section, surface water acquisitions through the Ecosystem Restoration Program could reallocate supplies from willing sellers to in-stream uses.

Existing Storage. End-of-September carryover storage in the major Sacramento River Region surface storage facilities (Shasta, Oroville, and Folsom) was evaluated for Alternative 2 and the No Action Alternative. Figure 5.1-30 depicts the ranges of long-term period and dry and critical year carryover storage for Alternative 2 and the No Action Alternative.

Under the No Action Alternative, average carryover storage in Sacramento River Region reservoirs ranges from 5.3 to 5.4 MAF for the long-term period, and from 3.8 to 3.9 MAF for dry and critical years. Alternative 2 long-term period carryover storage ranges from 5.1 to 5.5 MAF, while dry and critical year carryover storage ranges from 3.6 to 4.0 MAF.

In the absence of new storage facilities, implementation of Alternative 2 has little impact on carryover storage under Criterion A water management assumptions. Alternative 2 results in a slight reduction in carryover storage under Criterion B water management assumptions. Without new storage, the reduction in average long-term carryover storage under Alternative 2 may vary from 100 to 210 TAF. The same trend and magnitude is demonstrated for the dry and critical years with the reduction in average carryover storage from 50 to 210 TAF.

With new storage facilities, implementation of Alternative 2 under Criterion A assumptions reduces long-term and dry and critical carryover storage in existing facilities on the order of 70 TAF relative to the No Action Alternative. Under Criterion B assumptions, Alternative 2 increases carryover storage on the order of 220 TAF.

End-of-September carryover storage in the major San Joaquin River Region surface facilities (New Melones, New Don Pedro, and McClure) was also evaluated for Alternative 2 and the No Action Alternative. Implementation of Alternative 2 had no measurable effect on system carryover storage. Similarly, no variation is evident based on water management criteria or implementation of additional storage facilities.

New Storage. New Sacramento River and San Joaquin River Regions surface storage facilities were evaluated under Alternative 2. The evaluation distinguished between storage for water supply and storage for environmental enhancement.

Figure 5.1-31 presents Sacramento River Region carryover storage comparisons for the long-term period and dry and critical years. Peak storage in the new facilities generally occurs in early summer under all hydrologic conditions. For the long-term period, peak water supply storage ranges from 770 TAF to 1.3 MAF, while dry and critical year peak storage typically ranges from 500 to 850 TAF. Carryover storage ranges from 590 TAF to 890 TAF for the long-term period, and from 360 to 470 TAF for dry and critical years. Criterion A water management assumptions consistently resulted in lower water supply storage. For the long-term period, peak environmental storage ranges from 520 to 900 TAF, while dry and critical year peak storage typically ranges from 450 to 860 TAF. Carryover storage ranges from 450

Figure 5.1-30. Carryover Storage for Existing Surface Reservoirs in the Sacramento River Region under Alternative 2 for the Long-Term Period and Dry and Critical Years

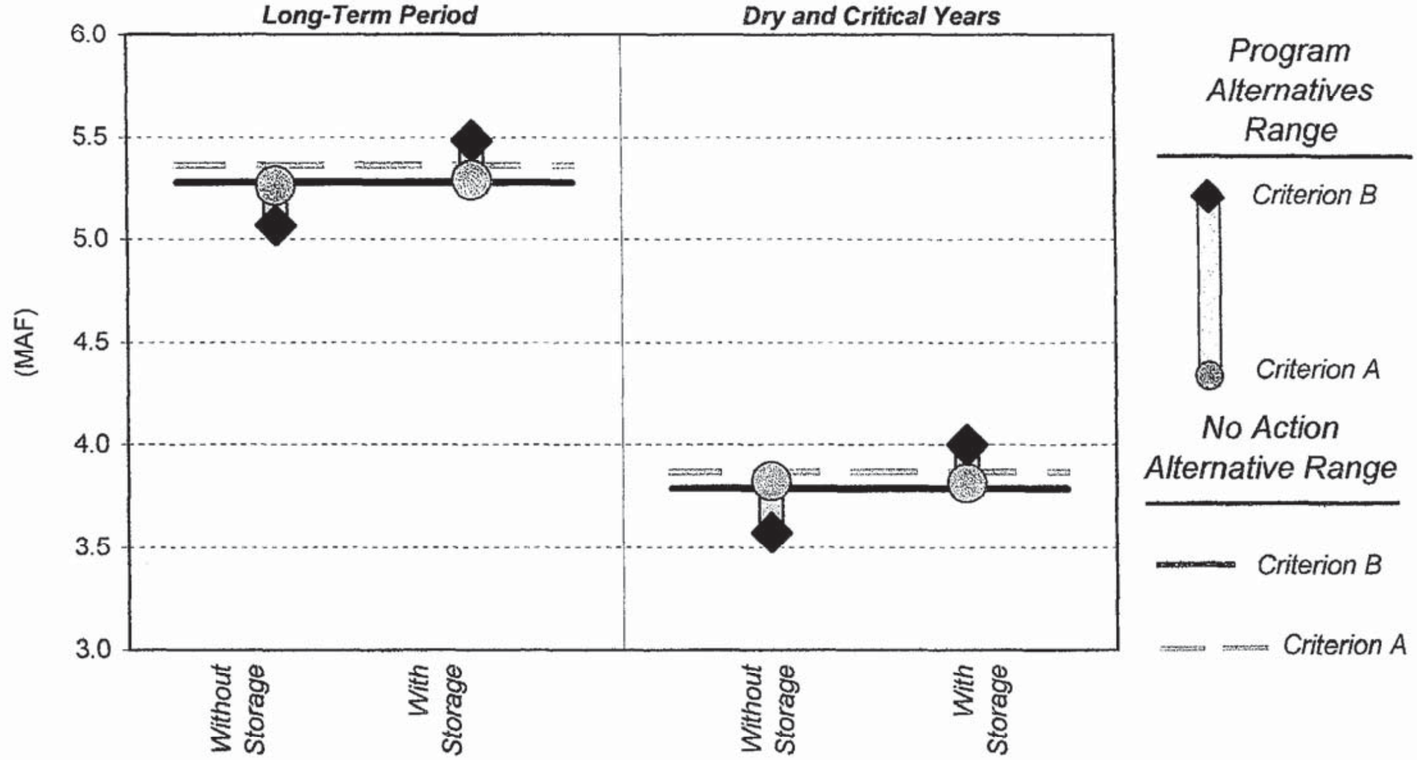
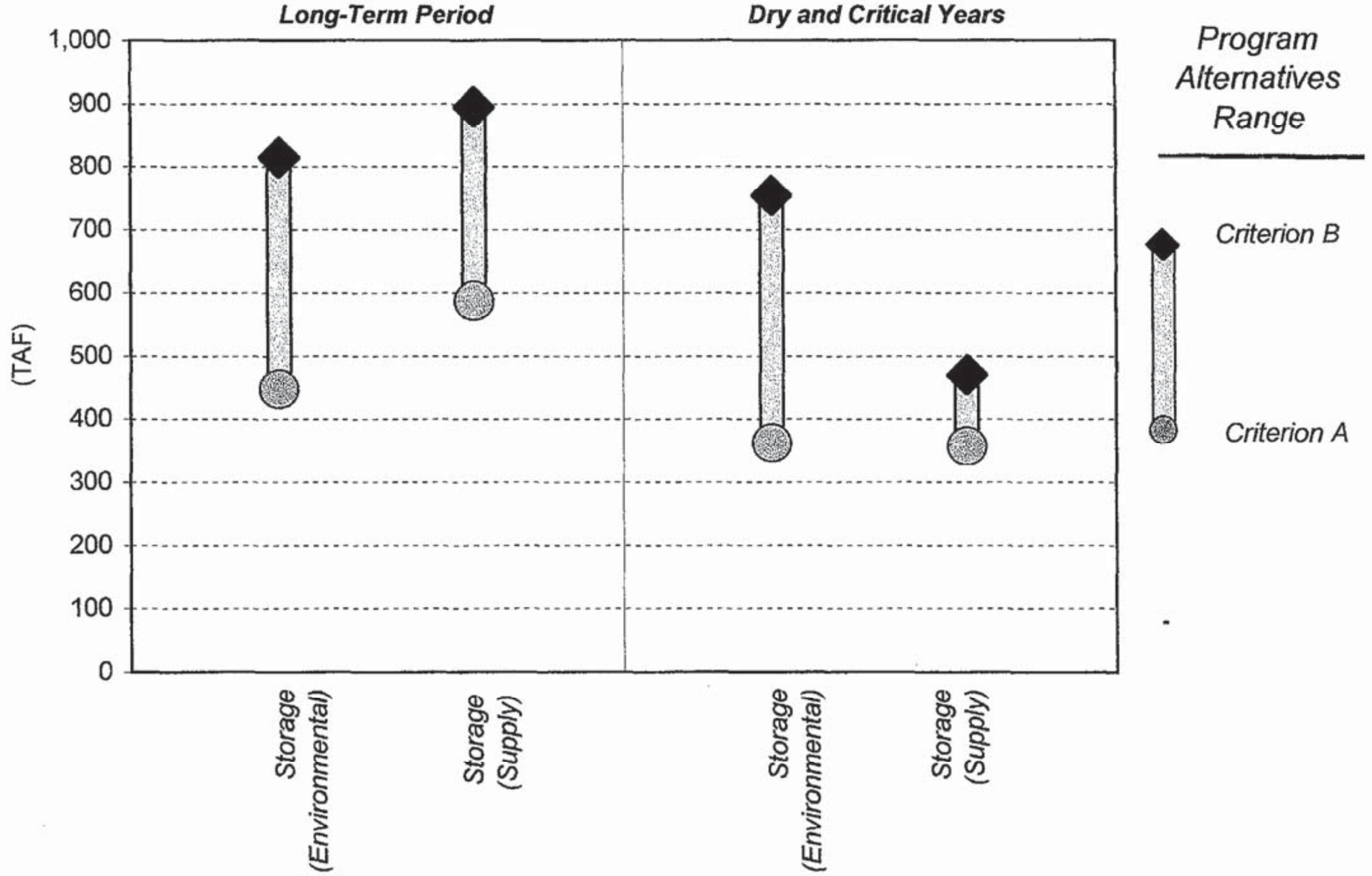


Figure 5.1-31. Carryover Storage for New Surface Reservoirs in the Sacramento River Region under Alternative 2 for the Long-Term Period and Dry and Critical Years



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to 810 TAF for the long-term period, and from 360 to 750 TAF for dry and critical years. Criterion A water management assumptions consistently resulted in lower environmental storage.

New Sacramento River Region groundwater storage facilities also were evaluated under Alternative 2. These facilities are assumed to have a maximum capacity of 250 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 40 to 45 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

In this evaluation, new San Joaquin River Region storage facilities were dedicated to providing water for Ecosystem Restoration Program flow targets. Peak average annual storage tends to occur in late spring at approximately 240 TAF for the long-term period and ranges from 220 to 230 TAF for dry and critical years. Carryover storage ranges from 200 to 220 TAF for the long-term period, and from 200 to 210 TAF for dry and critical years. Criterion B water management assumptions consistently resulted in lower storage.

Ecosystem Restoration Program Acquisition. Table 5.1-5 shows the water acquisitions quantities under Alternative 2 estimated to meet proposed Ecosystem Restoration Program flow targets.

Table 5.1-5. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions Without New Storage under Alternative 2 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	90	20	0
Yuba River [a]	0	0-10	0	0-10	0
Feather River [a]	0	50	80	60	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	80-100	10	0	0
Additional Delta flows [a]	0	110-140	180-210	220-250	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	30	40	30	50
Merced River [b]	0	10	30	20	40
Total acquisitions	**0**	**310-380**	**510-550**	**400-440**	**170**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

When new storage in the Sacramento River and San Joaquin River Regions is included in Alternative 2, fewer water acquisitions would be necessary to meet Ecosystem Restoration Program flow targets. New storage also could be operated to provide Ecosystem Restoration Program flows for other tributaries by exchange agreements. These types of arrangement are not reflected in this analysis. Table 5.1-6 shows the water acquisitions quantities estimated to meet the proposed Ecosystem Restoration Program flow targets under Alternative 2 with new storage.

Table 5.1-6. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions with New Storage under Alternative 2 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0	20-50	0-10	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	40	70	40	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	0-30	0	0	0
Additional Delta flows [a]	0	50-60	110-130	160-200	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	10	20-30	10	30
Merced River [b]	0	0	0	0	10
Total acquisitions	**0**	**130-190**	**300-370**	**260-320**	**120**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

South-of-Delta SWP and CVP Service Areas

Programmatic comparisons of deliveries to the South-of-Delta SWP and CVP Service Areas were made between Alternative 2 and the No Action Alternative using DWRSIM modeling results. This section also evaluates surface water storage in existing and new off-aqueduct facilities.

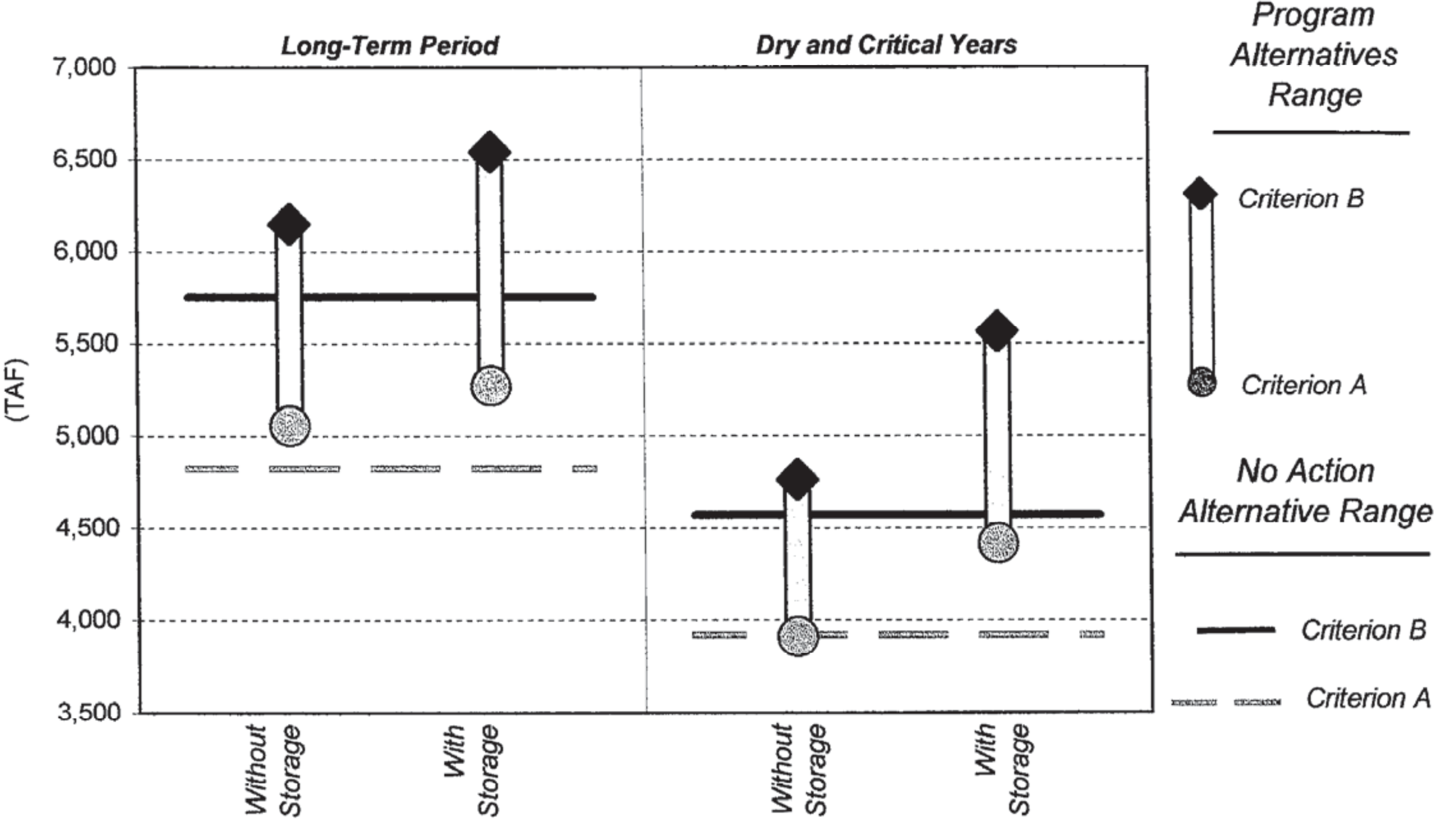
Delta Deliveries. The range of annual Delta deliveries under the No Action Alternative was compared to the range of deliveries expected under Alternative 2. Deliveries are generally higher under Alternative 2 with implementation of new storage facilities and Criterion B water management assumptions.

Under Alternative 2, average annual deliveries over the long-term period range from 5.1 to 6.5 MAF. The low end of this range assumes no new storage facilities and Criterion A water management assumptions; the high end of this range assumes new storage facilities and Criterion B water management assumptions. The No Action Alternative results in a long-term average annual delivery range from 4.8 to 5.8 MAF. During dry and critical years, Alternative 2 average annual deliveries range between 3.9 and 5.6 MAF and No Action Alternative deliveries range between 3.9 and 4.6 MAF.

Without additional storage facilities, Alternative 2 would increase long-term average annual deliveries by 240-400 TAF relative to the No Action Alternative. For dry and critical years, Alternative 2 would modify deliveries from (-10) to 190 TAF. Implemen-tation of Alternative 2 in conjunction with new surface storage would increase long-term average annual deliveries by 450-790 TAF. In dry and critical years, Alternative 2 would increase deliveries by 500-990 TAF. Therefore, annual long-term Delta deliveries increases of 210-390 TAF are related to additional storage under Alternative 2. The range of average long-term and dry and critical water-year Delta deliveries for Alternative 2 compared to the No Action Alternative is depicted in Figure 5.1-32.

Existing Off-Aqueduct Storage Facilities. San Luis Reservoir is the primary existing off-aqueduct storage facilities serving the South-of-Delta SWP and CVP Service Areas. San Luis Reservoir carryover storage and reservoir releases were evaluated under Alternative 2 and the No Action Alternative.

Figure 5.1-32. Average Annual Delta Deliveries under Alternative 2 for the Long-Term Period and Dry and Critical Years



With no additional storage, Alternative 2 modifies San Luis Reservoir carryover storage from (-10) to 140 TAF for long term and by 10-140 TAF for dry and critical years (above the No Action Alternative). If additional storage is implemented, Alternative 2 increases long-term carryover storage by 170-280 TAF and dry and critical carryover storage by 130-200 TAF above the No Action Alternative. Therefore, a long-term average carryover storage increase of 140-180 TAF is directly attributed to additional storage under Alternative 2. The average carryover storage increase of 60-120 TAF for dry and critical years is directly related to additional storage under Alternative 2. Figure 5.1-33 presents carryover storage comparisons for the long-term period and dry and critical years.

The broadest range in monthly average storage releases from San Luis Reservoir generally occurs in summer months for both water management criteria under all hydrologic conditions. The largest long-term summer releases are generally associated with Criterion A water management in the absence of new storage facilities, while the lowest summer releases are associated with Criterion B water management in conjunction with additional storage capacity. The broadest range of long-term monthly average reservoir releases under Alternative 2 is approximately 190-390 TAF. Under the No Action Alternative, peak average monthly summer releases range from 270 to 310 TAF over the long-term period. Winter releases are similar under Alternative 2 and the No Action Alternative.

New Off-Aqueduct Storage Facilities. Carryover storage and releases associated with new off-aqueduct surface storage facilities were evaluated under Alternative 2. Such facilities would serve South-of-Delta SWP and CVP Service Areas similar to San Luis Reservoir.

Over the long-term period, carryover storage in new off-aqueduct surface storage facilities ranges from 750 to 770 TAF under Alternative 2. For dry and critical years, carryover storage ranges from 300 to 380 TAF. Criterion B provides higher carryover storage in both wetter and drier water years. Figure 5.1-34 presents carryover storage comparisons for the long-term period and dry and critical years.

Releases from new off-aqueduct surface storage facilities generally occur from spring to late summer under Alternative 2. Peak releases typically occur in mid summer for all hydrologic conditions. The approximate peak releases are between 160 and 170 TAF for the long-term period and between 180 and 190 TAF for dry and critical years. In dry and critical years, monthly average releases tend to be similar under both water management criteria. Over the long-term period, Criterion A water management results in early spring peak releases while Criterion B results in late spring peak releases. Reduced Delta exports associated with Criterion A create more reliance on off-aqueduct storage releases to meet spring demands.

New off-aqueduct groundwater storage facilities also were evaluated under Alternative 2. These facilities are assumed to have a maximum capacity of 500 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 65 to 80 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

5.1.8.3 ALTERNATIVE 3

For evaluation purposes, Alternative 3 was simulated with a 5,000- and 15,000-cfs isolated facility. Evaluation of the smaller configuration assumes full south Delta improvements are in place. Evaluation of the larger configuration assumes a subset of the south Delta improvements are in place and includes service to Delta islands along the route of the canal. To fully describe potential consequences of

Figure 5.1-33. Carryover Storage for Exisiting Off-Aqueduct Reservoirs under Alternative 2 for the Long-Term Period and Dry and Critical Years

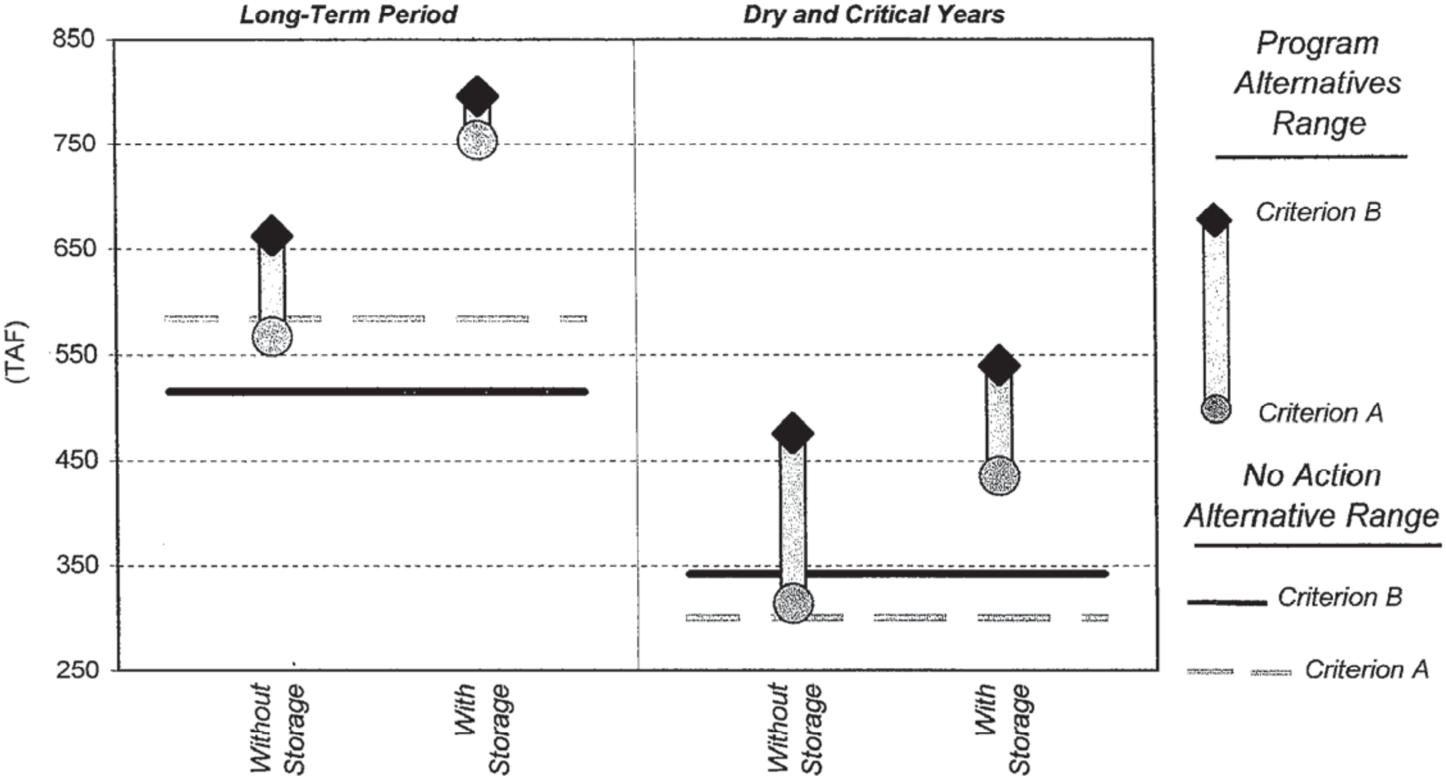
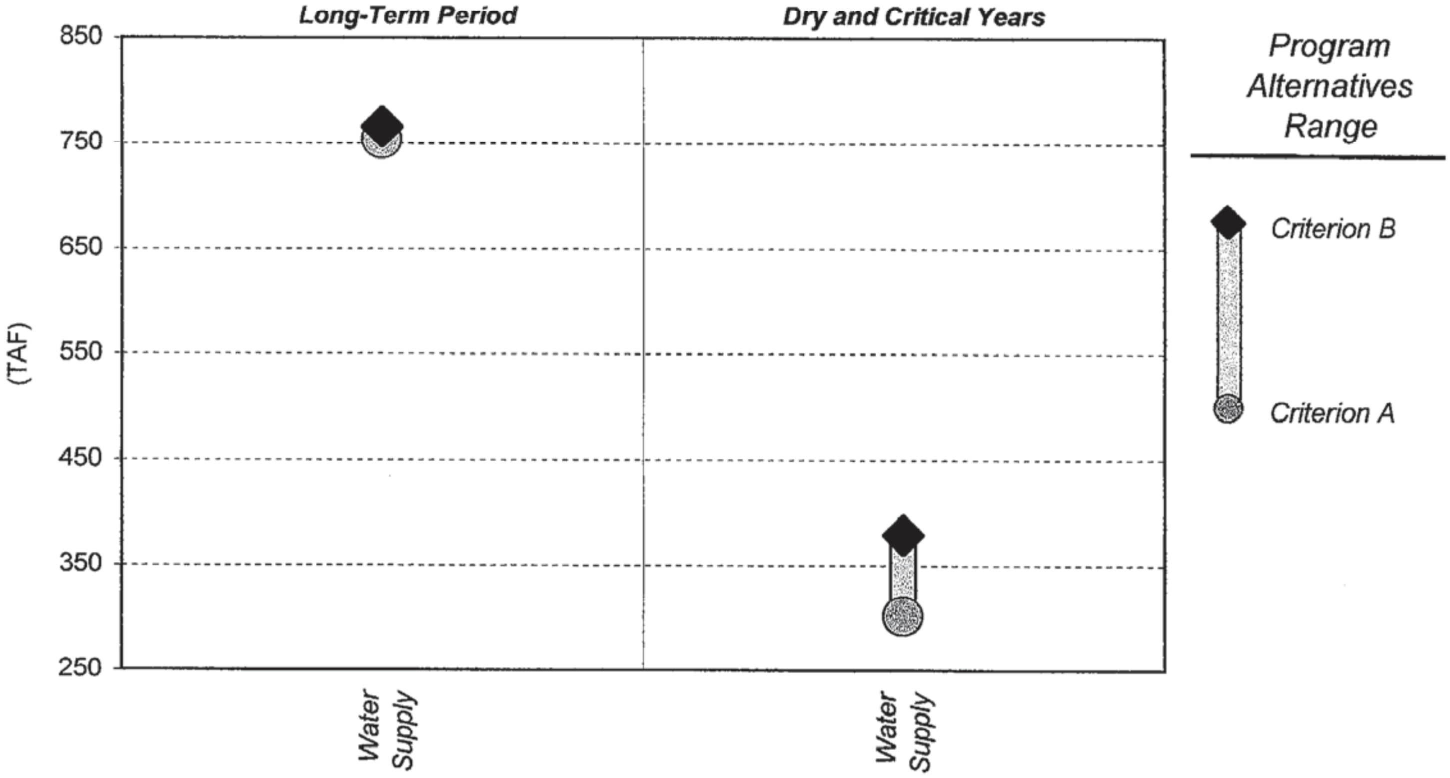


Figure 5.1-34. Carryover Storage for New Off-Aqueduct Reservoirs under Alternative 2 for the Long-Term Period and Dry and Critical Years



Alternative 3, the 15,000-cfs isolated facility is evaluated under Criterion A assumptions and the 5,000-cfs isolated facility is evaluated under Criterion B assumptions. See Attachment A for further details.

Some improvements to water supply and water management would be realized from improved export pumping capacity under the Alternative 3. Greater water supply and water management benefits may be obtained if additional storage facilities are constructed.

Delta Region

Programmatic comparisons of Delta inflows and exports were made between Alternative 3 and the No Action Alternative using DWRSIM modeling results. Both bookend Delta water management criteria were used to define the range of uncertainty associated with each alternative.

Average monthly Delta inflow is typically lower under Alternative 3 than under the No Action Alternative. Over the long-term period, Delta inflow normally peaks in February. Average February flow is approximately 190 TAF under the No Action Alternative and ranges from 160 to 170 TAF under Alternative 3. For dry and critical years, peak monthly flow is approximately 70 TAF under both the No Action Alternative and Alternative 3. Additional storage slightly reduces total Delta inflow for the long-term average and dry and critical years.

Under Alternative 3, south-of-Delta exports at Banks and Tracy Pumping Plants are comprised of diversions from south Delta channels and diversions through an isolated conveyance facility. Total south-of-Delta exports are described below, followed by a discussion of the diversions occurring through the isolated conveyance facility and through south Delta channels.

The pattern of long-term average Delta exports would be modified somewhat by Alternative 3, with greater exports occurring August through January relative to the No Action Alternative. Figure 5.1-35 compares average monthly Delta exports for the long-term period. Similarly, Figure 5.1-36 compares average monthly Delta exports during dry and critical years. The range of average annual Delta exports under Alternative 3 for both hydrologic periods are compared to the No Action Alternative in Figure 5.1-37.

Combined south Delta exports from Banks and Tracy Pumping Plants peak in winter months, with long-term period values ranging from 560 to 680 TAF in January under the No Action Alternative and from 560 to 760 TAF under Alternative 3. Delta exports, at minimum values in spring months, could change significantly under Alternative 3 depending on operation criteria. Long-term period exports range from 120 to 200 TAF in May under the No Action Alternative and range from 120 to 410 TAF under Alternative 3. On an annual basis, without additional storage, Alternative 3 increases long-term period Delta exports by an additional 140-590 TAF over the No Action Alternative. With additional storage, Alternative 3 increases annual south Delta exports by 410 TAF to 1.3 MAF over the No Action Alternative. Therefore, annual south Delta export increases of 270-710 TAF are directly related to additional storage under Alternative 3.

Alternative 3 has a similar influence on dry and critical year Delta exports. Under the No Action Alternative, Delta exports range from 530 to 640 TAF in the peak winter months and from 90 to 140 TAF in May. Under Alternative 3, dry and critical year exports range from 520 to 750 TAF in the peak winter months and from 80 to 350 TAF during the lower spring months. On an annual basis,

Figure 5.1-35. Delta Exports at Banks and Tracy under Alternative 3 for the Long-Term Period

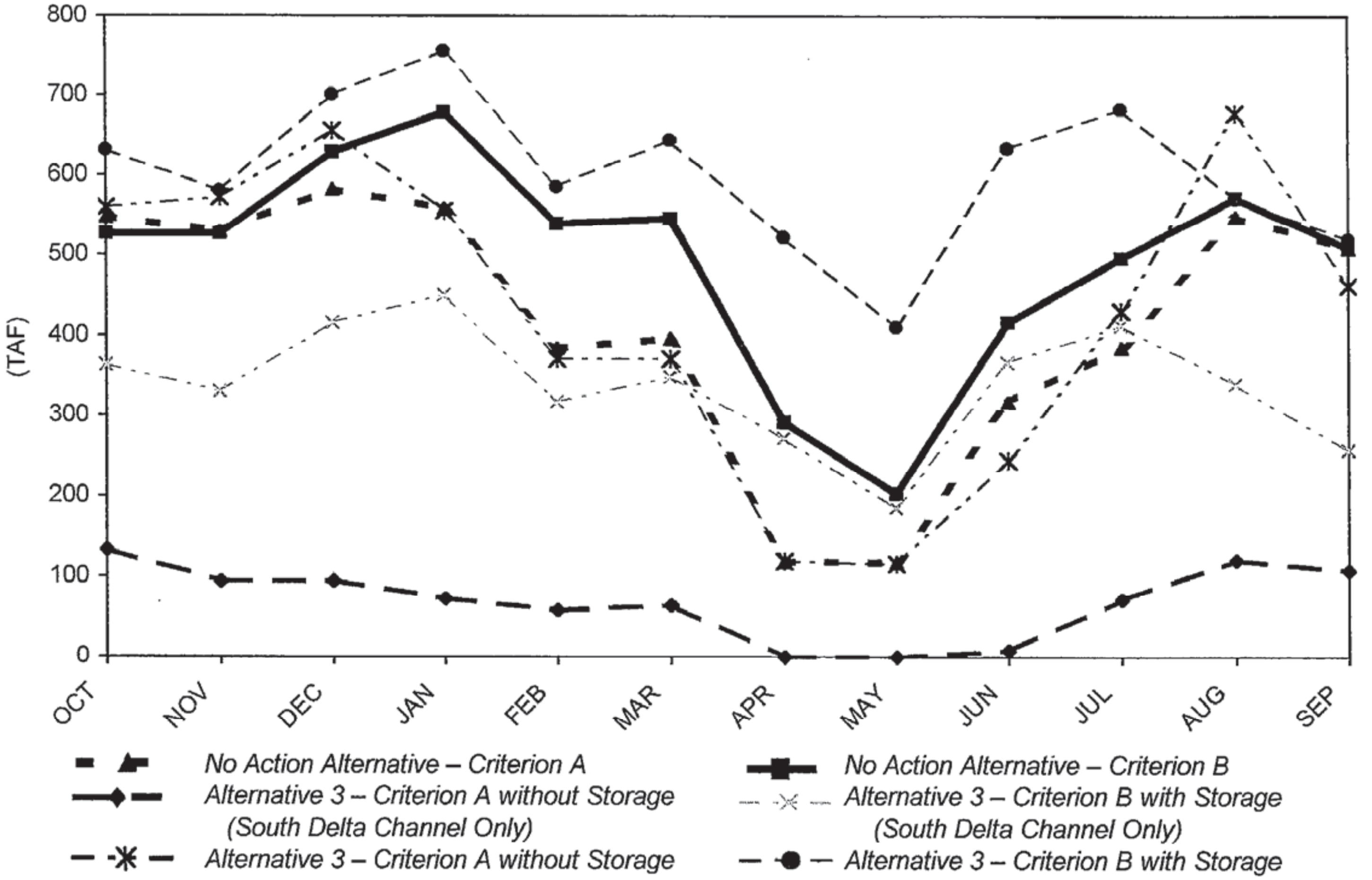


Figure 5.1-36. Delta Exports at Banks and Tracy under Alternative 3 for Dry and Critical Years

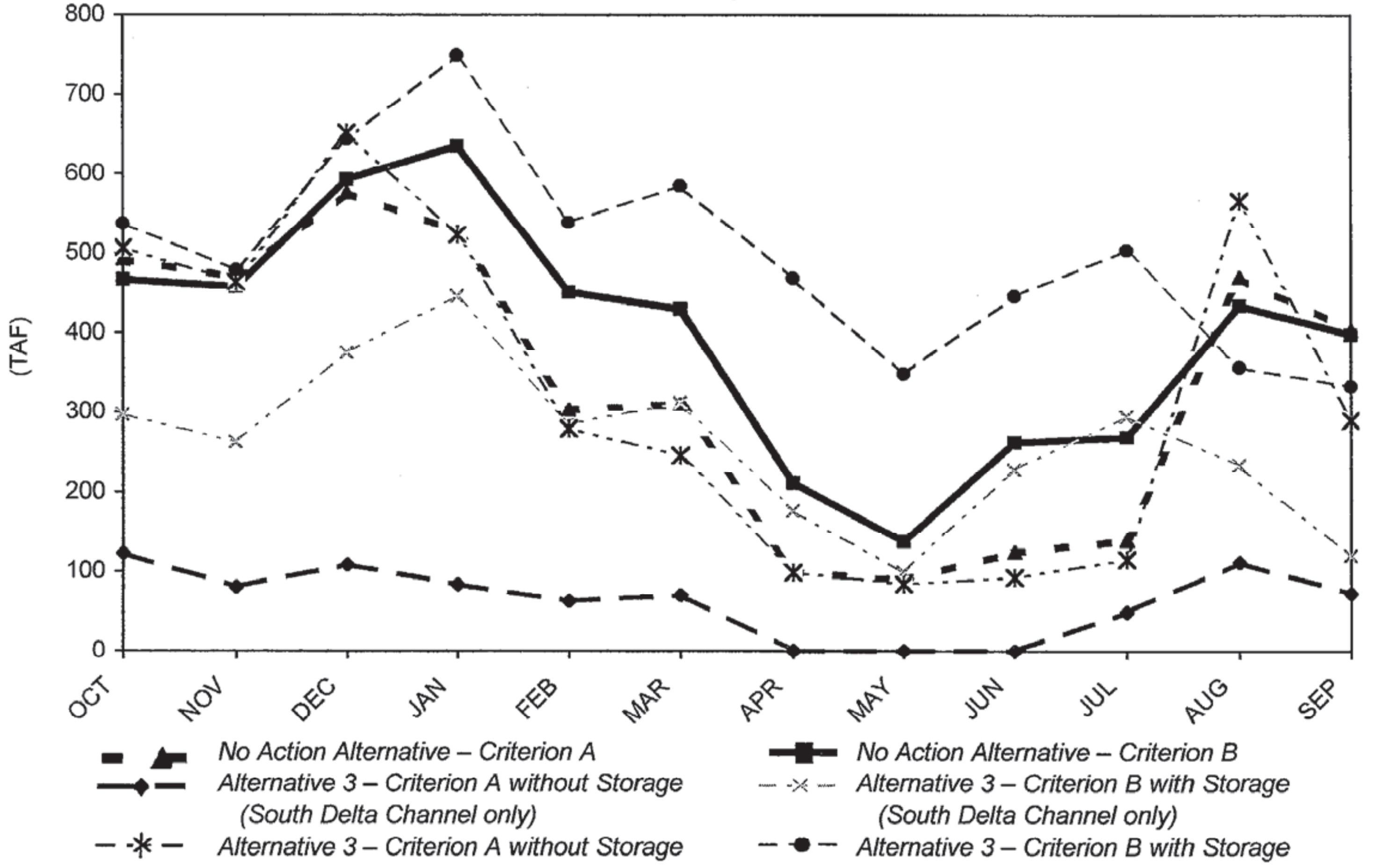
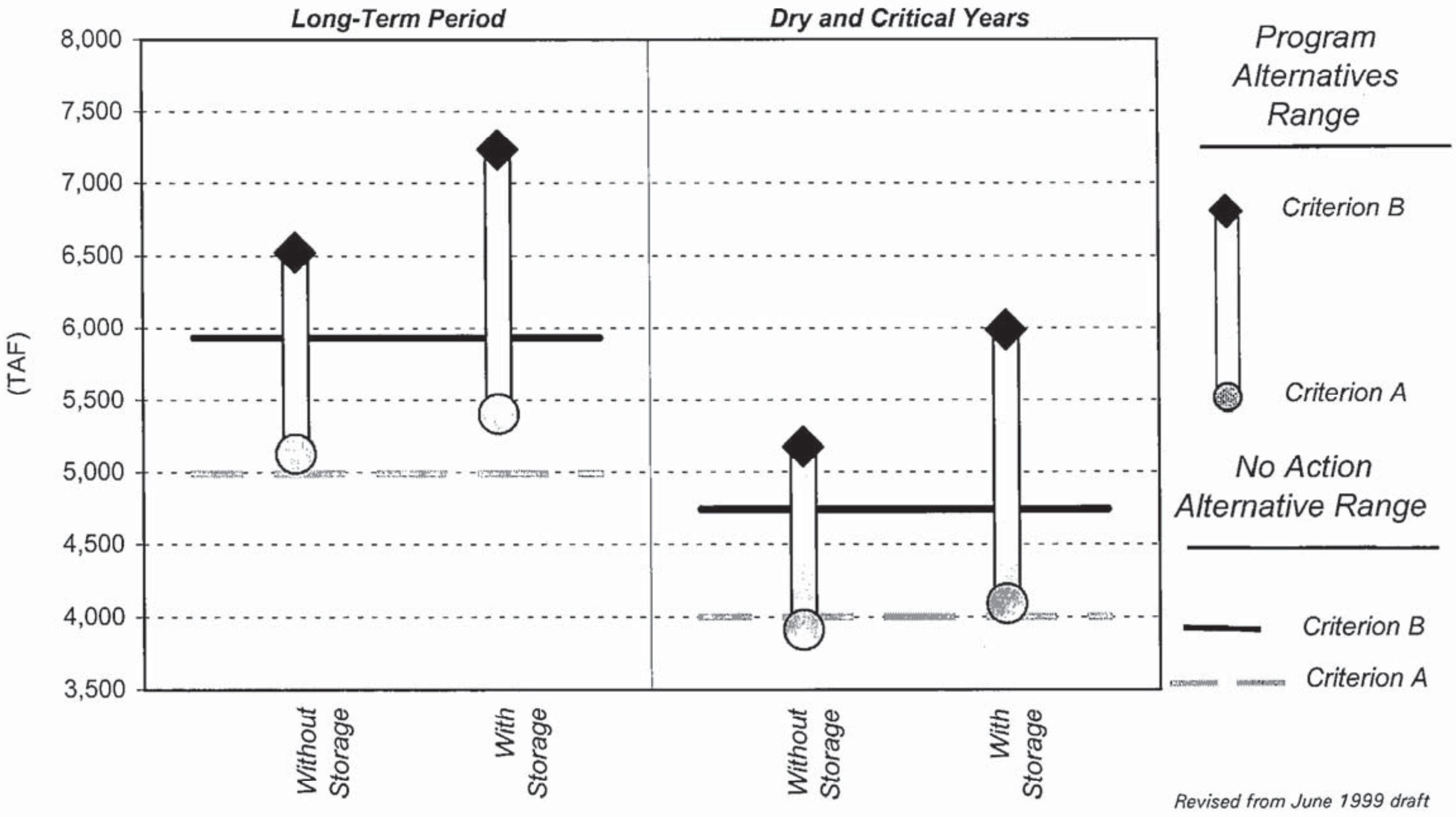


Figure 5.1-37. Average Annual Delta Exports at Banks and Tracy under Alternative 3 for the Long-Term Period and Dry and Critical Years



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without additional storage, Alternative 3 modifies dry and critical year Delta exports from (-90) to 440 TAF over the No Action Alternative. With additional storage, Alternative 3 increases annual south Delta exports from 90 TAF to 1.2 MAF over the No Action Alternative. Therefore, annual dry and critical year export increases of 180-800 TAF are directly related to additional storage under Alternative 3.

Isolated facility diversions under Alternative 3 occur throughout the year. Details regarding the isolated conveyance facility diversion assumptions are presented in Section 5.1.4 and Attachment A. In general, the pattern of diversions peak in the early winter and midsummer months with lower diversions in the spring. Figure 5.1-38 compares average monthly isolated facility diversions for the long-term period. Similarly, Figure 5.1-39 compares average monthly isolated facility diversions during dry and critical years.

Monthly average isolated facility diversions are typically greatest in winter, with long-term diversions between 300 and 520 TAF occurring in January. Lower monthly average diversions occur during spring due to more restrictive operation criteria, with long-term diversions ranging from 170 to 220 TAF in May. For dry and critical years, diversions range from 300 to 460 TAF in peak winter months and from 100 to 250 TAF in the lower spring months.

Under Alternative 3 without additional storage, the annual average isolated facility diversions over the long-term period range between 3.0 and 4.8 MAF and for dry and critical years range between 2.5 and 3.7 MAF. When additional system storage is applied to Alternative 3, the annual long-term isolated facility diversions average from 3.2 to 5.0 MAF. For dry and critical years, annual diversions average between 2.9 and 3.7 MAF. Annual average isolated facility diversions directly attributable to new storage ranges from 140 to 190 TAF for the long-term period, and range from 10 to 340 TAF during dry and critical years.

In addition to isolated facility diversions, south Delta channel diversions contribute to total Banks and Tracy south-of-Delta exports under Alternative 3. South Delta channel diversions are typically greatest in winter. Long-term diversions peak in January with monthly average diversions ranging between 70 and 450 TAF. Lower monthly average diversions occur during spring due to more fishery operation criteria, with long-term diversions ranging from 0 to 200 TAF in May. For dry and critical years, diversions range from 80 to 450 TAF in January and from 0 to 120 TAF in May.

On an annual basis, without additional storage, Alternative 3 decreases long-term period south Delta channel diversions by 2.4-4.2 MAF relative to the No Action Alternative. With additional storage, Alternative 3 decreases annual south Delta channel diversions by 1.9-4.1 MAF relative to the No Action Alternative. Therefore, additional storage increases the annual south Delta channel diversions by 90-570 TAF. For dry and critical years, Alternative 3 without additional storage decreases south Delta channel diversions by 2.1-3.2 MAF on an annual basis relative to the No Action Alternative. With additional storage, Alternative 3 decreases annual south Delta channel diversions by 1.6-3.1 MAF, relative to the No Action Alternative. Therefore, annual dry and critical year south Delta channel diversions increases of 170-470 TAF are directly related to additional storage under Alternative 3.

Bay Region

Programmatic comparisons of Delta outflow to San Francisco Bay were made between Alternative 3 and the No Action Alternative using DWRSIM modeling results. Figures 5.1-40 and 5.1-41 present monthly average Delta outflow comparisons for the long-term period and dry and critical years, respectively.

Figure 5.1-38. Isolated Facility Diversions under Alternative 3 for the Long-Term Period

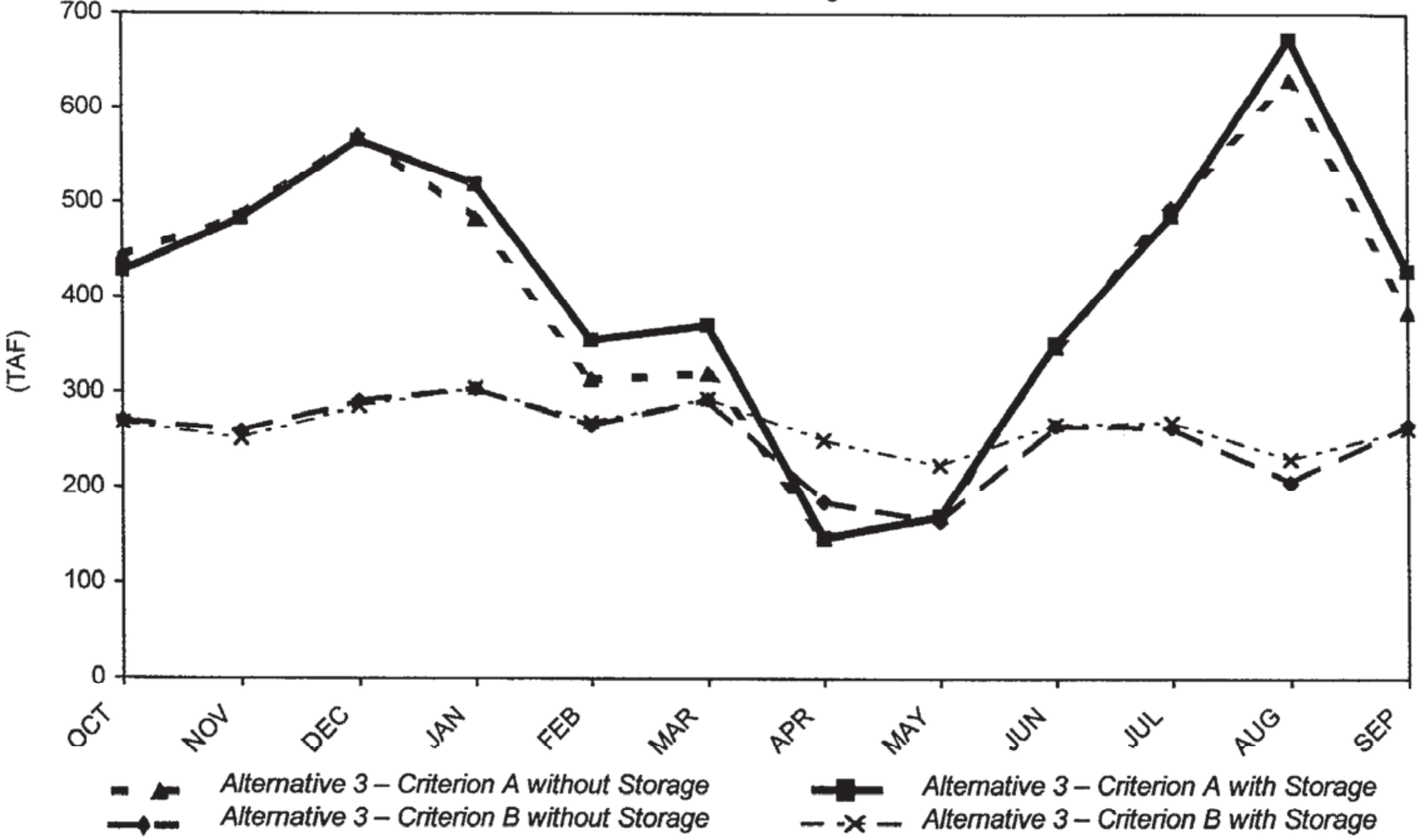


Figure 5.1-39. Isolated Facility Diversions under Alternative 3 for Dry and Critical Years

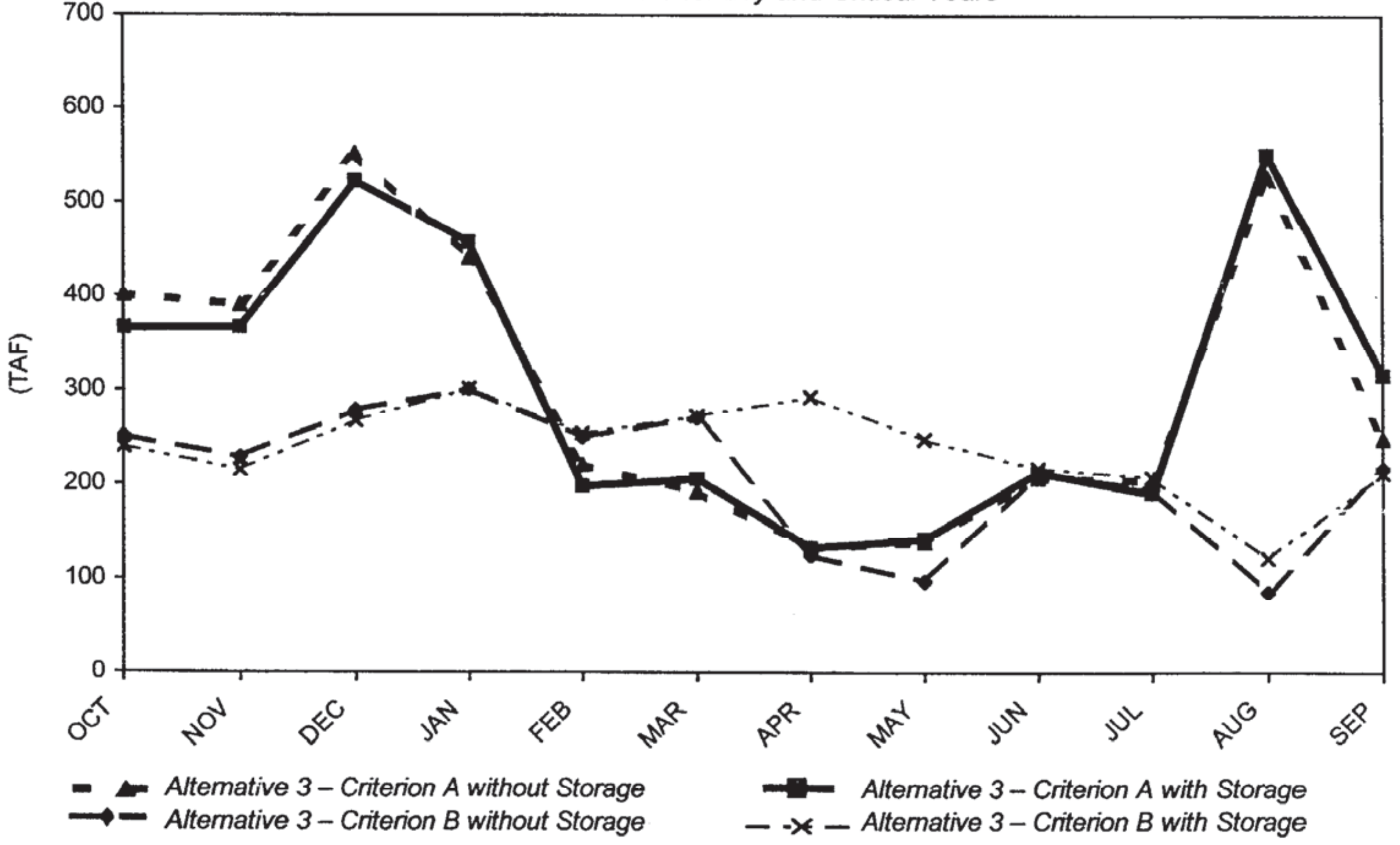


Figure 5.1-40. Monthly Average Delta Outflow under Alternative 3 for the Long-Term Period

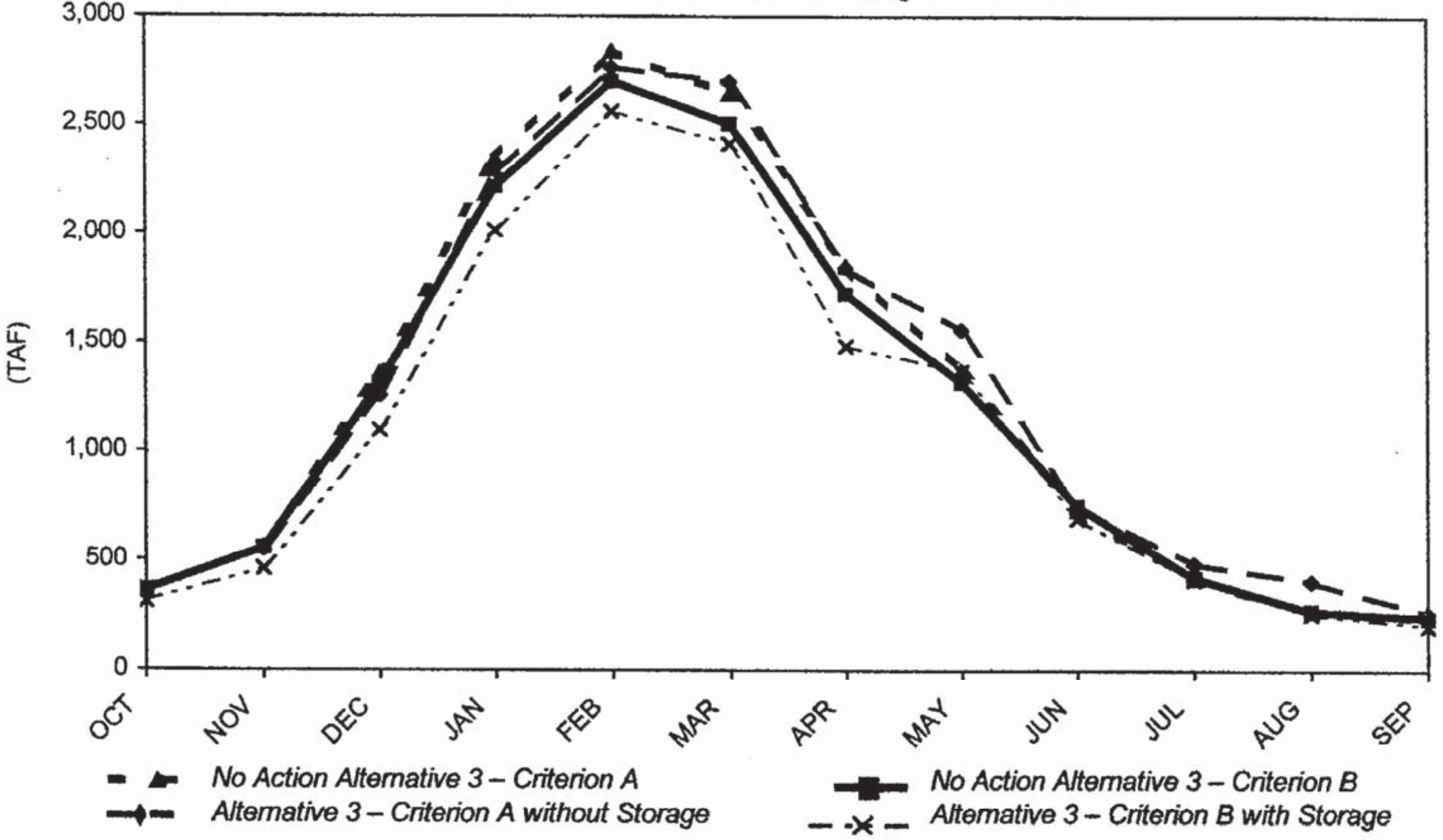
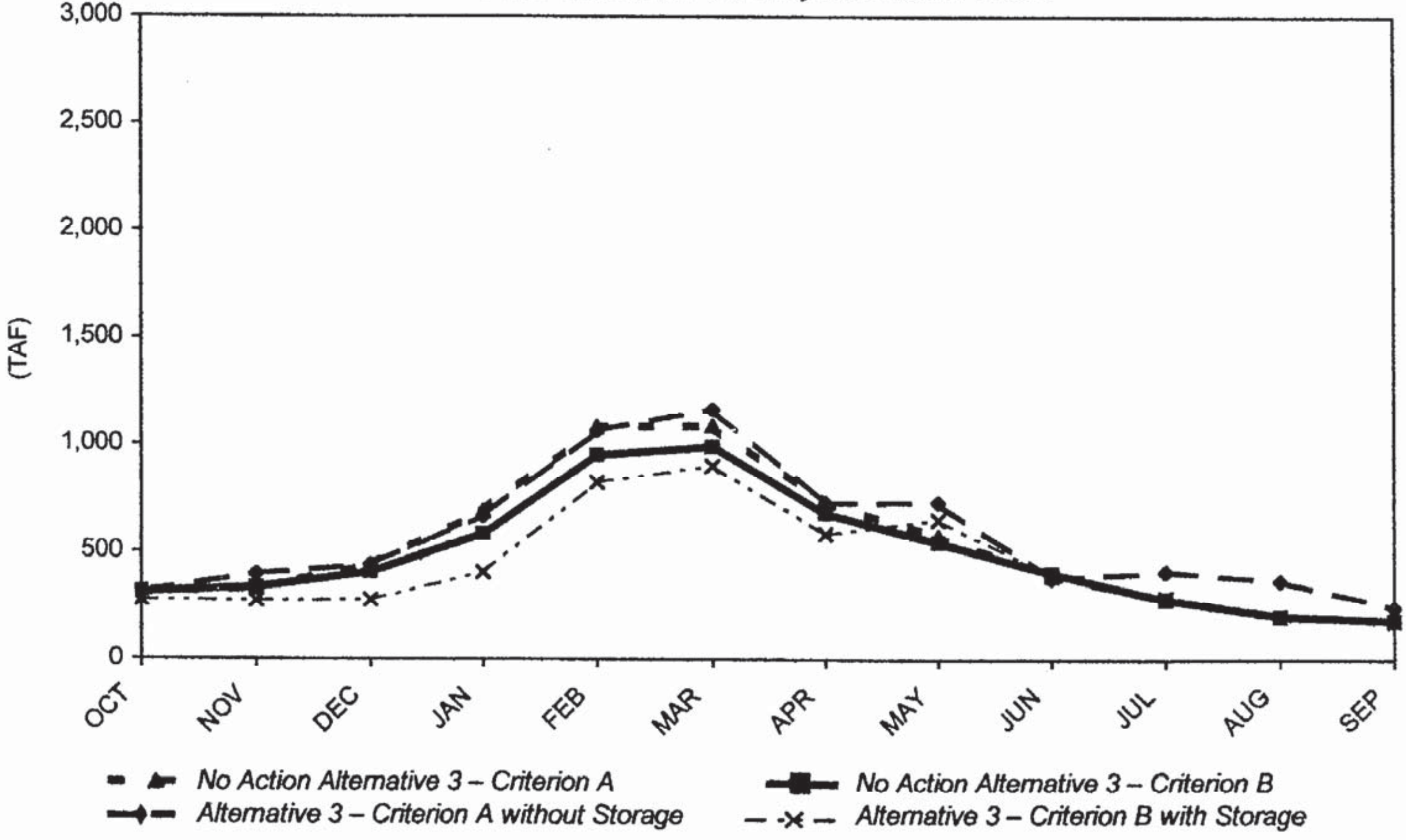


Figure 5.1-41. Monthly Average Delta Outflow under Alternative 3 for Dry and Critical Years



Delta outflow is typically lower under Alternative 3 than under the No Action Alternative during November through March. Percentage differences are typically small, however. Over the long-term period, Delta outflow normally peaks in February. Average February outflow ranges from 2.7 to 2.8 MAF under the No Action Alternative and ranges from 2.6 to 2.8 MAF under Alternative 3. The differences in Delta outflow are smaller from April through October. Ecosystem Restoration Program flows provide some additional May outflow under Alternative 3. On an annual basis, without additional storage, Alternative 3 modifies average long-term period Delta outflow from (-250) to 220 TAF compared to the No Action Alternative. With additional storage, Alternative 3 decreases average annual Delta outflow by 150 TAF to 1.1 MAF. Therefore, annual Delta outflow decreases of 360-850 TAF are directly related to additional storage under Alternative 3.

During dry and critical years, February outflow ranges from 950 TAF to 1.1 MAF under the No Action Alternative and ranges from 820 TAF to 1.1 MAF under Alternative 3. On an annual basis, without additional storage, Alternative 3 modifies average dry and critical year Delta outflow from (-40) to 610 TAF over the No Action Alternative. With additional storage, Alternative 3 modifies average dry and critical year outflow from (-610) to 500 TAF relative to the No Action Alternative. Therefore, annual Delta outflow decreases of 110-570 TAF are directly related to additional storage under Alternative 3.

Sacramento River and San Joaquin River Regions

This section provides a comparison of Alternative 3 and the No Action Alternative with respect to water supply and water management in the Sacramento River and San Joaquin River Regions using DWRSIM modeling results. The programmatic comparison focuses on existing storage, new storage, and Ecosystem Restoration Program acquisitions.

Alternative 3 does not change the water supply reliability in the Sacramento River and San Joaquin River Regions relative to the No Action Alternative. All water demands in the Sacramento River and San Joaquin River Regions are met through CVP/SWP project deliveries and through locally derived water supplies. Refer to Section 5.1.4, "Assessment Methods," for details related to the DWRSIM hydrology development process. However, as discussed later in this section, surface water acquisitions through the Ecosystem Restoration Program could reallocate supplies from willing sellers to in-stream uses.

Existing Storage. End-of-September carryover storage in the major Sacramento River Region surface storage facilities (Shasta, Oroville, and Folsom) was evaluated for Alternative 3 and the No Action Alternative. Figure 5.1-42 depicts the ranges of long-term period and dry and critical year carryover storage for Alternative 3 and the No Action Alternative.

Under the No Action Alternative, average carryover storage in Sacramento River Region reservoirs ranges from 5.3 to 5.4 MAF for the long-term period, and from 3.8 to 3.9 MAF for dry and critical years. Alternative 3 long-term period carryover storage ranges from 4.8 to 5.2 MAF, while dry and critical year carryover storage ranges from 3.1 to 3.6 MAF.

In the absence of new storage facilities over the long-term period, implementation of Alternative 3 results in a carryover storage reduction ranging from 210 to 550 TAF. In dry and critical years, the reduction in carryover storage under Alternative 3 may vary from 330 to 810 TAF.

Figure 5.1-42. Carryover Storage for Existing Surface Reservoirs in the Sacramento River Region under Alternative 3 for the Long-Term Period and Dry and Critical Years

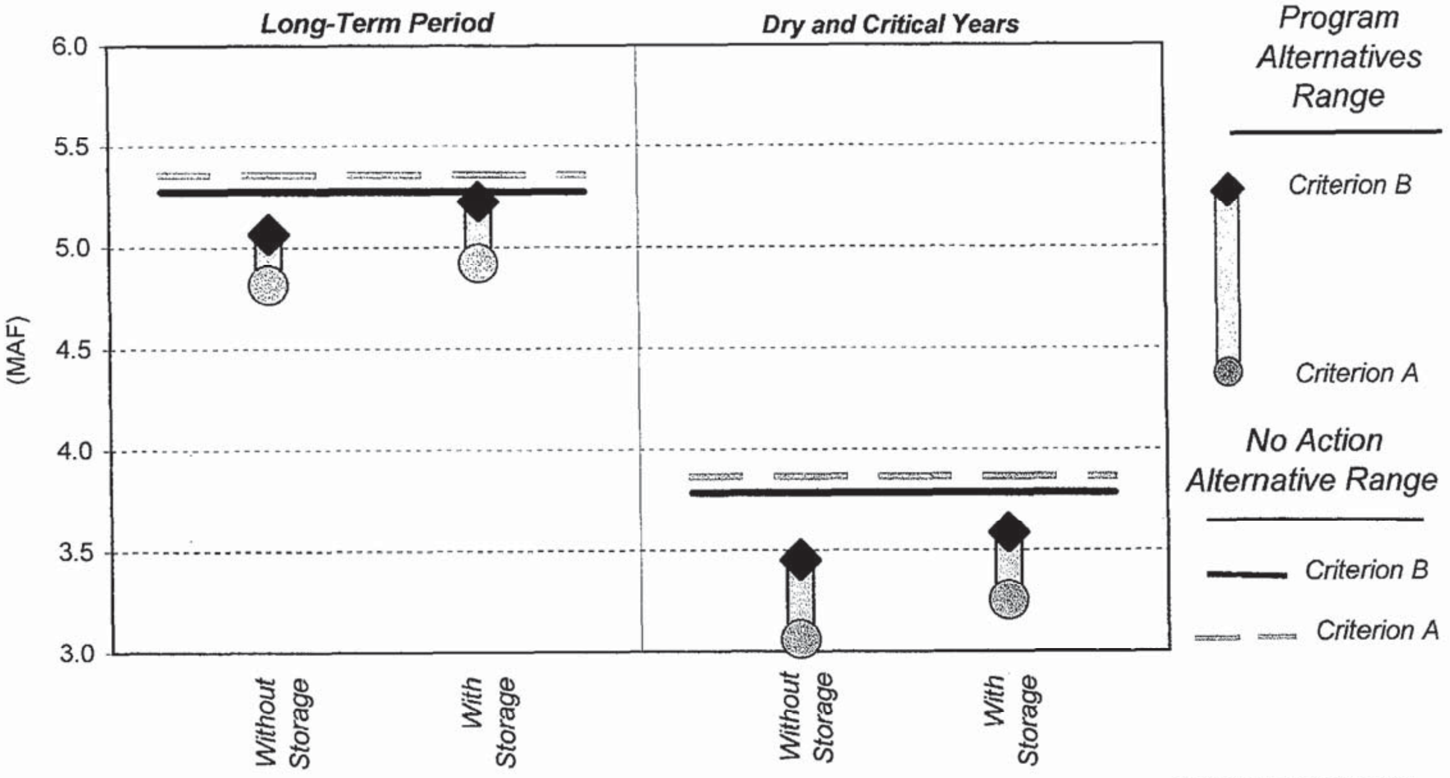


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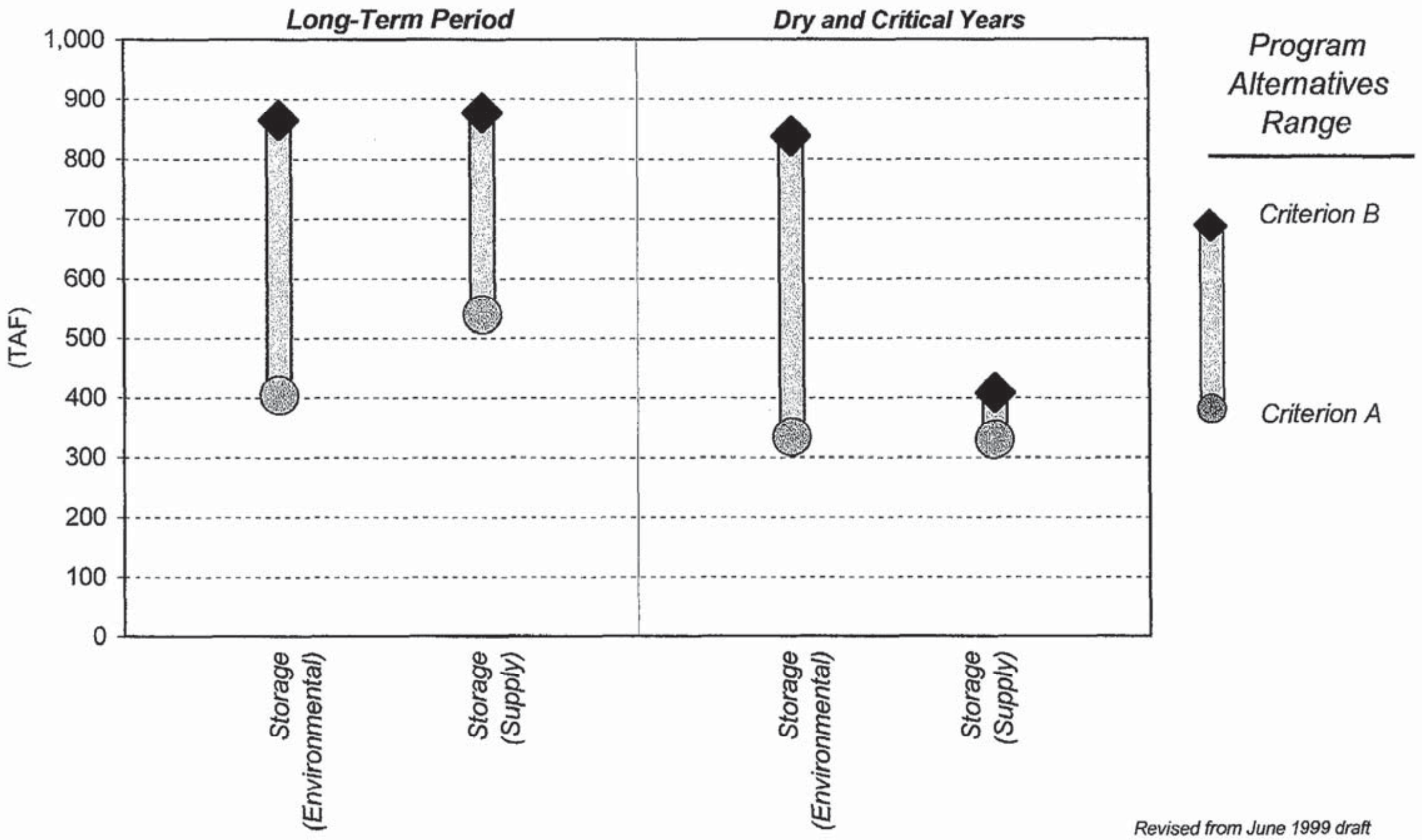
Figure 5.1-43. Carryover Storage for New Surface Reservoirs in the Sacramento River Region under Alternative 3 for the Long-Term Period and Dry and Critical Years



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With new storage facilities, implementation of Alternative 3 under Criterion A assumptions reduces long-term and dry and critical carryover storage in existing facilities by 440 and 620 TAF, respectively. Under Criterion B assumptions, Alternative 3 reduces long-term and dry and critical years carryover storage by 50 and 190 TAF, respectively.

End-of-September carryover storage in the major San Joaquin River Region surface facilities (New Melones, New Don Pedro, and McClure) was evaluated for Alternative 3 and the No Action Alternative. Implementation of Alternative 3 had no measurable effect on system carryover storage. Similarly, no variation is evident based on water management criteria or implementation of additional storage facilities.

New Storage. New Sacramento River and San Joaquin River Region surface storage facilities were evaluated under Alternative 3. The evaluation distinguished between storage for water supply and storage for environmental enhancement.

Figure 5.1-43 presents Sacramento River Region carryover storage comparisons for the long-term period and dry and critical years. Peak storage in the new facilities generally occurs in early summer under all hydrologic conditions. For the long-term period, peak water supply storage ranges from 700 TAF to 1.3 MAF, while dry and critical year peak storage typically ranges from 460 to 840 TAF. Carryover storage ranges from 540 to 880 TAF for the long-term period. For dry and critical years, the carryover storage is very similar for both Criteria A and B. Criterion B water management assumptions consistently resulted in lower water supply storage. For the long-term period, peak environmental storage ranges from 470 to 940 TAF, while dry and critical year peak storage typically ranges from 410 to 910 TAF. Carryover storage ranges from 400 to 860 TAF for the long-term period, and from 330 to 840 TAF for dry and critical years. Criterion A water management assumptions consistently resulted in lower environmental storage.

New Sacramento River Region groundwater storage facilities also were evaluated under Alternative 3. These facilities are assumed to have a maximum capacity of 250 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 60 to 110 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

In this evaluation, new San Joaquin River Region storage facilities were dedicated to providing water for Ecosystem Restoration Program flow targets. Peak average annual storage tends to occur in late spring and ranges from 230 to 240 TAF for the long-term period and from 200 to 230 TAF for dry and critical years. Carryover storage ranges from 200 to 220 TAF for the long-term period, and from 180 to 200 TAF for dry and critical years. Criterion B water management assumptions consistently resulted in lower storage.

Ecosystem Restoration Program Acquisition. Table 5.1-7 shows the water acquisition quantities under Alternative 3 estimated to meet the proposed Ecosystem Restoration Program flow targets.

When new Sacramento River and San Joaquin River Region storage is included in Alternative 3, fewer water acquisitions are necessary to meet Ecosystem Restoration Program flow targets. New storage also could be operated to provide Ecosystem Restoration Program flows for other tributaries by exchange agreements. These types of arrangements are not reflected in this analysis. Table 5.1-8 shows the water acquisition quantities estimated to meet the proposed Ecosystem Restoration Program flow targets under Alternative 3 with new storage.

Table 5.1-7. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions Without New Storage under Alternative 3 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	90-110	20	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	50-60	80	50	0
American River [a]	0	30	40-50	20	40
Lower Sacramento River [a]	0	50-110	10-20	0	0
Additional Delta flows [a]	0	110-170	180-240	240-280	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	30	40-50	30	50
Merced River [b]	0	10	30	20	40
Total acquisitions	**0**	**280-430**	**510-630**	**410-460**	**170**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

Table 5.1-8. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions with New Storage under Alternative 3 (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	30-60	0-20	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	40	70-80	30-40	0
American River [a]	0	30	40-50	20	40
Lower Sacramento River [a]	0	0-50	0	0	0
Additional Delta flows [a]	0	70-110	120-170	160-230	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	10	20-30	10	30
Merced River [b]	0	0	0	0	10
Total acquisitions	**0**	**150-260**	**320-440**	**250-360**	**120**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

South-of-Delta SWP and CVP Service Areas

Programmatic comparisons of deliveries to the South-of-Delta SWP and CVP Service Areas were made between Alternative 3 and the No Action Alternative using DWRSIM modeling results. This section also evaluates surface water storage in existing and new off-aqueduct facilities.

Delta Deliveries. The range of annual Delta deliveries under the No Action Alternative was compared to the range of deliveries expected under Alternative 3. Deliveries are generally higher under Alternative 3 with implementation of new storage facilities and under Criterion B water management assumptions.

Under Alternative 3, the range of average annual deliveries over the long-term period is 5.0-7.0 MAF. The low end of this range assumes no new storage facilities and Criterion A water management assumptions; the high end of this range assumes new storage facilities and Criterion B water management assumptions. The No Action Alternative results in a long-term average annual delivery range of 4.8-5.8 MAF. During dry and critical years, Alternative 3 average annual deliveries range between 3.8 and 5.9 MAF and No Action Alternative deliveries range between 3.9 and 4.6 MAF.

Without additional storage facilities, Alternative 3 would increase long-term average annual deliveries between 140 and 560 TAF relative to the No Action Alternative. For dry and critical years, Alternative 3 would modify deliveries from (-170) to 380 TAF.

Implementation of Alternative 3 in conjunction with new surface storage would increase long-term average annual deliveries from 380 TAF to 1.3 MAF. In dry and critical years, Alternative 3 would increase deliveries by 370 TAF to 1.4 MAF. Therefore, annual long-term Delta deliveries increases of 240-690 TAF are directly related to additional storage under Alternative 3. The range of average long-term and dry and critical water-year Delta deliveries for Alternative 3 compared to the No Action Alternative is depicted in Figure 5.1-44.

Existing Off-Aqueduct Storage Facilities. San Luis Reservoir is the primary existing off-aqueduct storage facility serving the South-of-Delta SWP and CVP Service Areas. San Luis Reservoir carryover storage and reservoir releases were evaluated under Alternative 3 and the No Action Alternative.

With no additional storage, Alternative 3 increases average annual long-term period San Luis Reservoir carryover storage up to 350 TAF above the No Action Alternative. If additional storage is implemented, Alternative 3 increases carryover storage by 260-480 TAF above the No Action Alternative. Therefore, a long-term average carryover storage increase of 130-230 TAF is directly attributed to additional storage under Alternative 3.

With no additional storage, Alternative 3 increases average annual carryover storage during dry and critical years from 130 to 330 TAF above the No Action Alternative. If additional storage is implemented, Alternative 3 increases carryover storage by 310-480 TAF above the No Action Alternative. Therefore, a dry and critical year carryover storage increase of 150-180 TAF is directly attributed to additional storage under Alternative 3. Figure 5.1-45 presents carryover storage comparisons for the long-term period and dry and critical years.

The broadest range in monthly average storage releases from San Luis Reservoir generally occurs in summer months for both alternatives under all hydrologic conditions. The greatest long-term summer releases are generally associated with Criterion A water management in the absence of new storage facilities, while the lowest summer releases are associated with Criterion B water management in conjunction with additional storage capacity. The broadest range of long-term monthly average reservoir releases under Alternative 3 is approximately 170-400 TAF. Under the No Action Alternative, peak average monthly summer releases range from 270 to 310 TAF over the long-term period. Winter releases are similar under Alternative 3 and the No Action Alternative.

New Off-Aqueduct Storage Facilities. Carryover storage and releases associated with new off-aqueduct surface storage facilities were evaluated under Alternative 3. Such facilities would serve the South-of-Delta SWP and CVP Service Areas similar to San Luis Reservoir.

Figure 5.1-44. Average Annual Delta Deliveries under Alternative 3 for the Long-Term Period and Dry and Critical Years

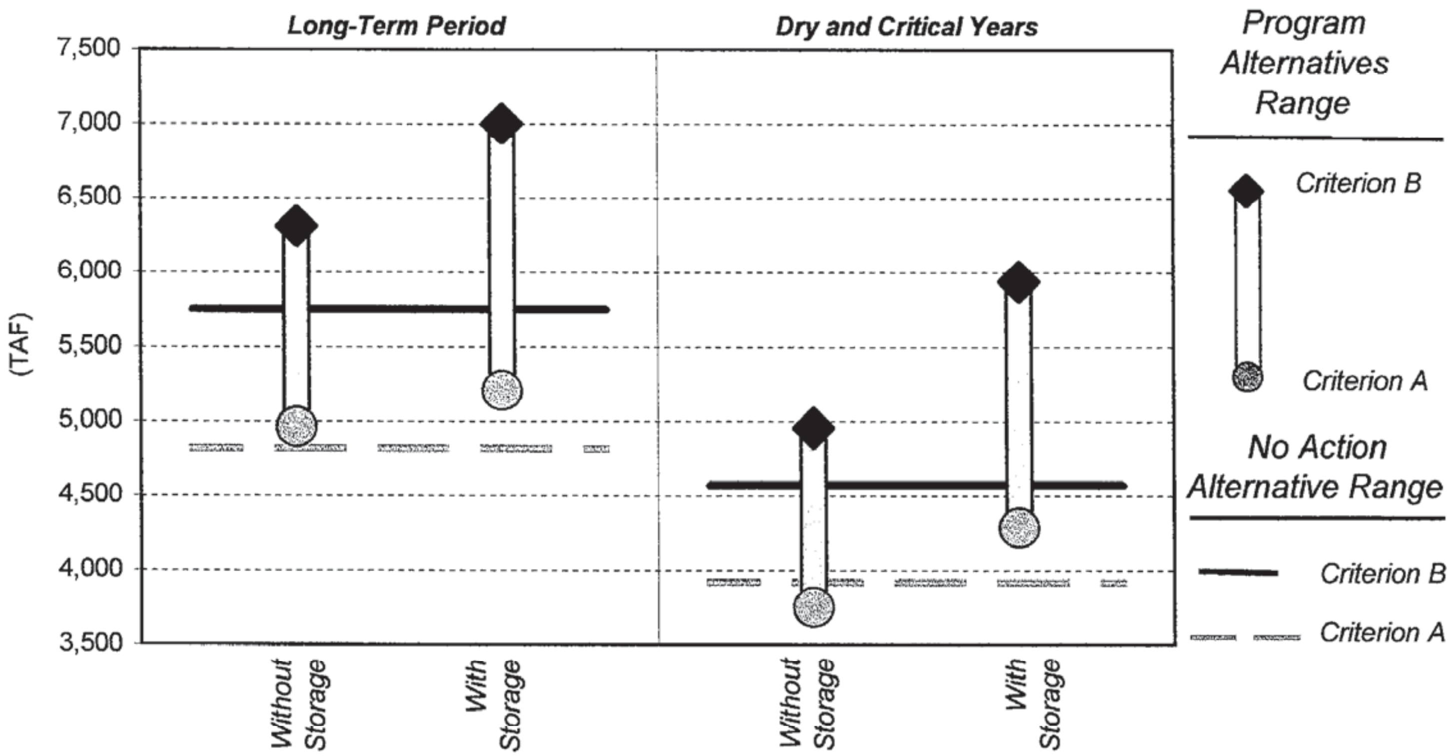


Figure 5.1-45. Carryover Storage for Existing Off-Aqueduct Reservoirs under Alternative 3 for the Long-Term Period and Dry and Critical Years

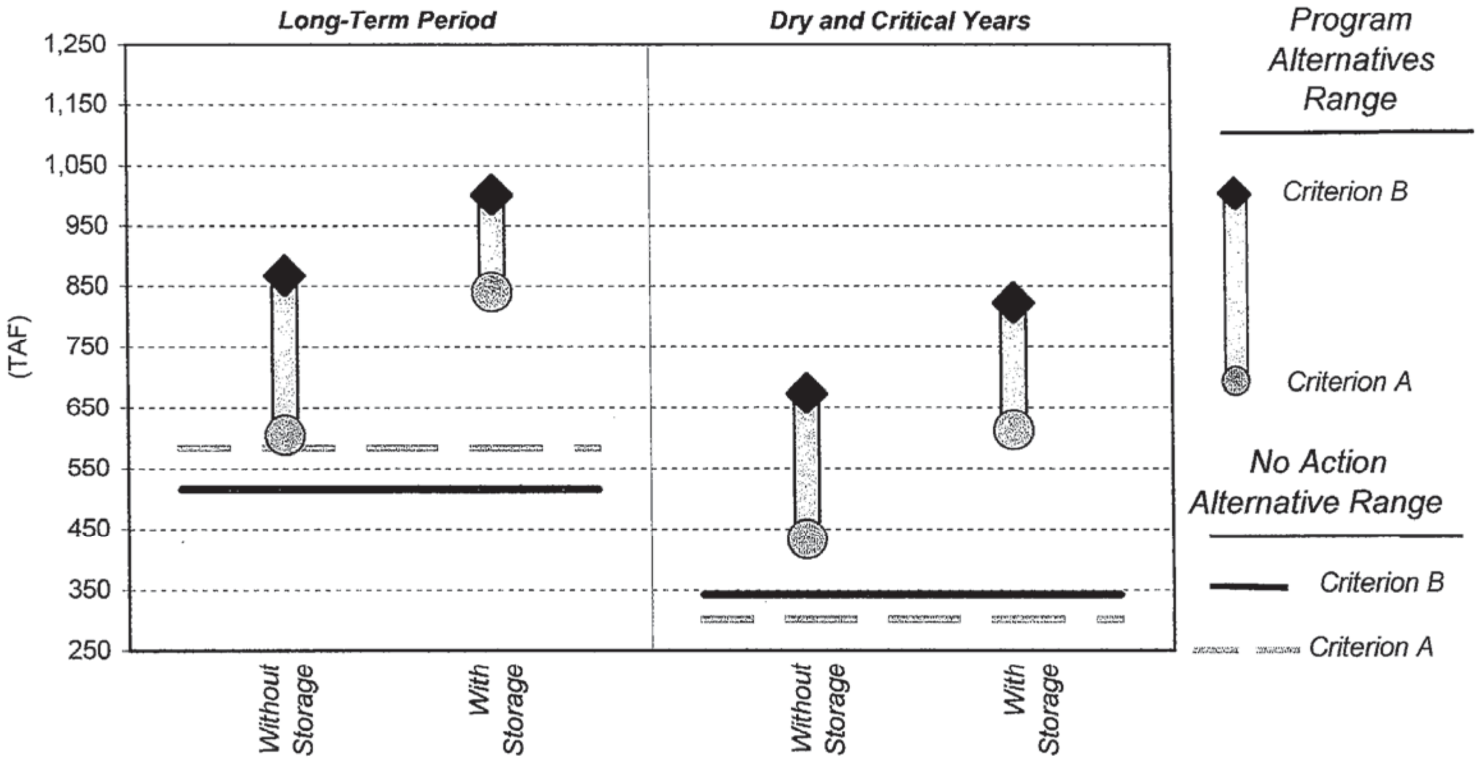
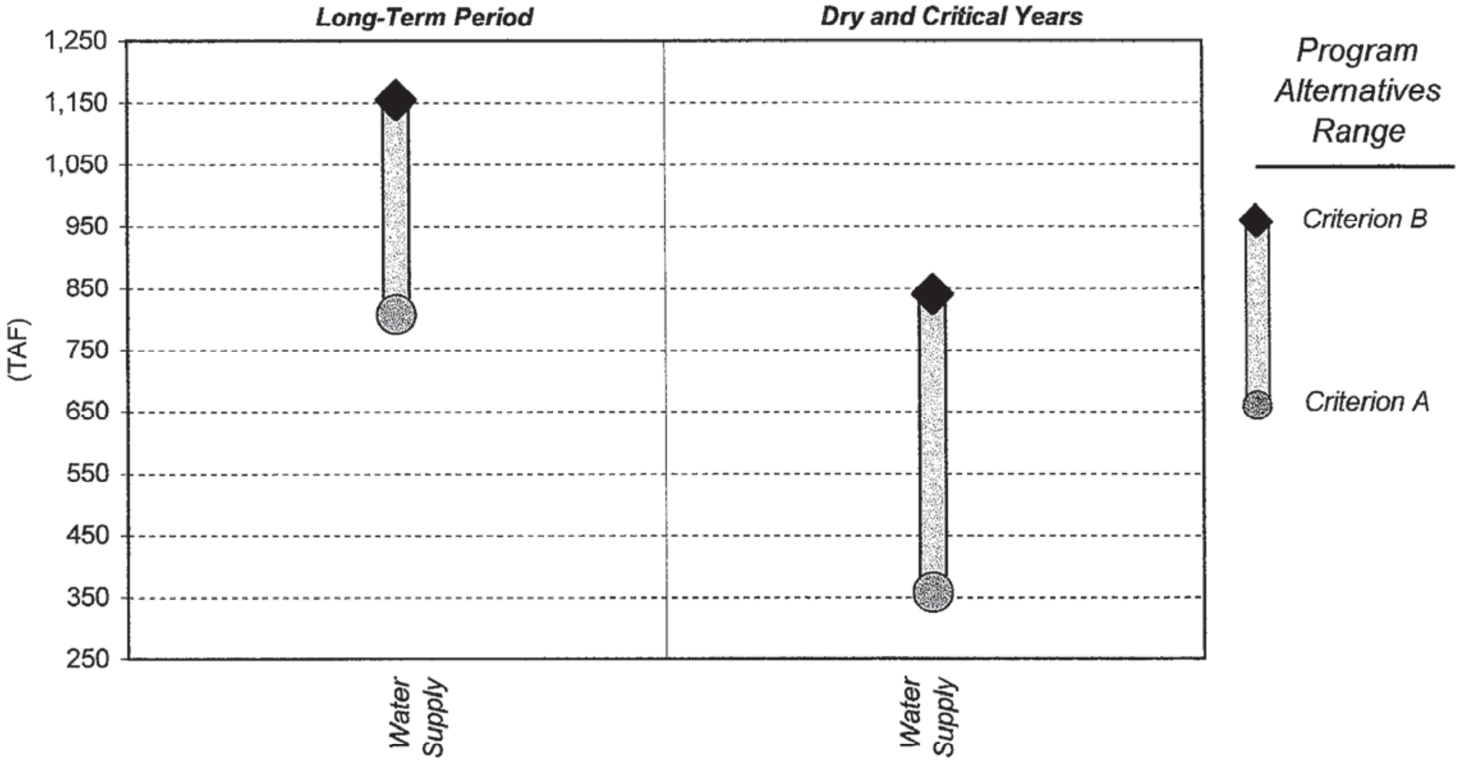


Figure 5.1-46. Carryover Storage for New Off-Aqueduct Reservoirs under Alternative 3 for the Long-Term Period and Dry and Critical Years



Over the long-term period, carryover storage in new off-aqueduct surface storage facilities ranges from 810 TAF to 1.2 MAF under Alternative 3. For dry and critical years, carryover storage ranges from 360 to 840 TAF. Water management Criterion A provides higher carryover storage in wetter water-years while water management Criterion B provides higher carryover storage in wetter and drier water-years. Figure 5.1-46 presents carryover storage comparisons for the long-term period and dry and critical years.

Releases from new off-aqueduct surface storage facilities generally occur from spring to late summer under Alternative 3. Peak releases typically occur in midsummer for all hydrologic conditions. The approximate peak releases are between 170 and 190 TAF for the long-term period and dry and critical years, respectively. Over the long-term period, Criterion A water management results in early spring peak releases while Criterion B results in late spring peak releases. Reduced Delta exports associated with Criterion A create more reliance on off-aqueduct storage releases to meet spring demands.

New off-aqueduct groundwater storage facilities also were evaluated under Alternative 3. These facilities are assumed to have a maximum capacity of 500 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 80 to 90 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

5.1.8.4 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

For evaluation purposes, the Preferred Program Alternative was simulated with and without a new screened diversion (2,000-4,000 cfs) from the Sacramento River to the Mokelumne River system. Without the diversion, consequences of the Preferred Program Alternative to water supply and water management are similar to consequences under Alternative 1, as described in Section 5.1.8.1. With a new diversion, consequences of the Preferred Program Alternative to water supply and water management are described below.

Some improvements to water supply and water management would be realized from improved export pumping capacity under the Preferred Program Alternative relative to the No Action Alternative. Greater water supply and water management benefits may be obtained if additional storage facilities are constructed.

Delta Region

Programmatic comparisons of Delta inflows and exports were made between the Preferred Program Alternative and the No Action Alternative using DWRSIM modeling results. Both bookend Delta water management criteria were used to define the range of uncertainty associated with each alternative.

Average monthly Delta inflow is typically lower under the Preferred Program Alternative than under the No Action Alternative. Over the long-term period, Delta inflow normally peaks in February. Average February flow is approximately 190 TAF under the No Action Alternative and is approximately 180 TAF under the Preferred Program Alternative. For dry and critical years, peak monthly flow ranges from 70 to 80 TAF under both the No Action Alternative and the Preferred Program Alternative. Additional storage appears to slightly reduce total Delta inflow for the long-term average and dry and critical years.

The pattern of long-term average Delta exports would be modified somewhat by the Preferred Program Alternative, with greater exports occurring August through January relative to the No Action Alternative. Figure 5.1-47 compares average monthly Delta exports for the long-term period. Similarly, Figure 5.1-48 compares average monthly Delta exports during dry and critical years.

Combined exports from Banks and Tracy Pumping Plants peak in January, with long-term period values ranging from 560 to 680 TAF under the No Action Alternative and from 540 to 790 TAF under the Preferred Program Alternative. Delta exports, at minimum values in May, change little under the Preferred Program Alternative. Long-term period exports range from 120 to 200 TAF under the No Action Alternative and range from 120 to 210 TAF under the Preferred Program Alternative. On an annual basis, without additional storage, the Preferred Program Alternative increases long-term period Delta exports by an additional 250-380 TAF over the No Action Alternative. With additional storage, the Preferred Program Alternative increases annual Delta exports by 490-900 TAF over the No Action Alternative. Therefore, annual export increases of 240-520 TAF are directly related to additional storage under the Preferred Program Alternative.

The Preferred Program Alternative has a similar influence on dry and critical year Delta exports. Under the No Action Alternative, Delta exports range from 530 to 640 TAF in January and from 90 to 140 TAF in May. Under the Preferred Program Alternative, dry and critical year exports range from 520 to 720 TAF in the peak winter months and from 90 to 140 TAF during the spring months. On an annual basis, without additional storage, the Preferred Program Alternative increases dry and critical year Delta exports by an additional 50 to 180 TAF over the No Action Alternative. With additional storage, the Preferred Program Alternative increases annual Delta exports from 180 to 670 TAF over the No Action Alternative. Therefore, annual dry and critical year export increases of 130-490 TAF are directly related to additional storage under the Preferred Program Alternative.

Delta exports under the Preferred Program Alternative also were compared to Delta exports under the other Program alternatives. The long-term period comparison is summarized in Table 5.1-9. The dry and critical year comparison is summarized in Table 5.1-10. Additionally, Figures 5.1-49 and 5.1-50 present Delta export comparisons for the long-term period and dry and critical years, respectively.

Table 5.1-9. Banks and Tracy Exports under All Program Alternatives for the Long-Term Period (TAF)

PERIOD	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
High export month (January)	560-680	540-760	540-760	560-760	540-790
Low export month (May)	120-200	120-210	120-210	120-410	120-210
Annual difference without storage	-	270-390	230-410	140-590	250-380
Annual difference with storage	-	580-800	460-800	410-1,300	490-900

Note:
PPA = Preferred Program Alternative.

Figure 5.1-47. Delta Exports at Banks and Tracy under the Preferred Program Alternative for the Long-Term Period

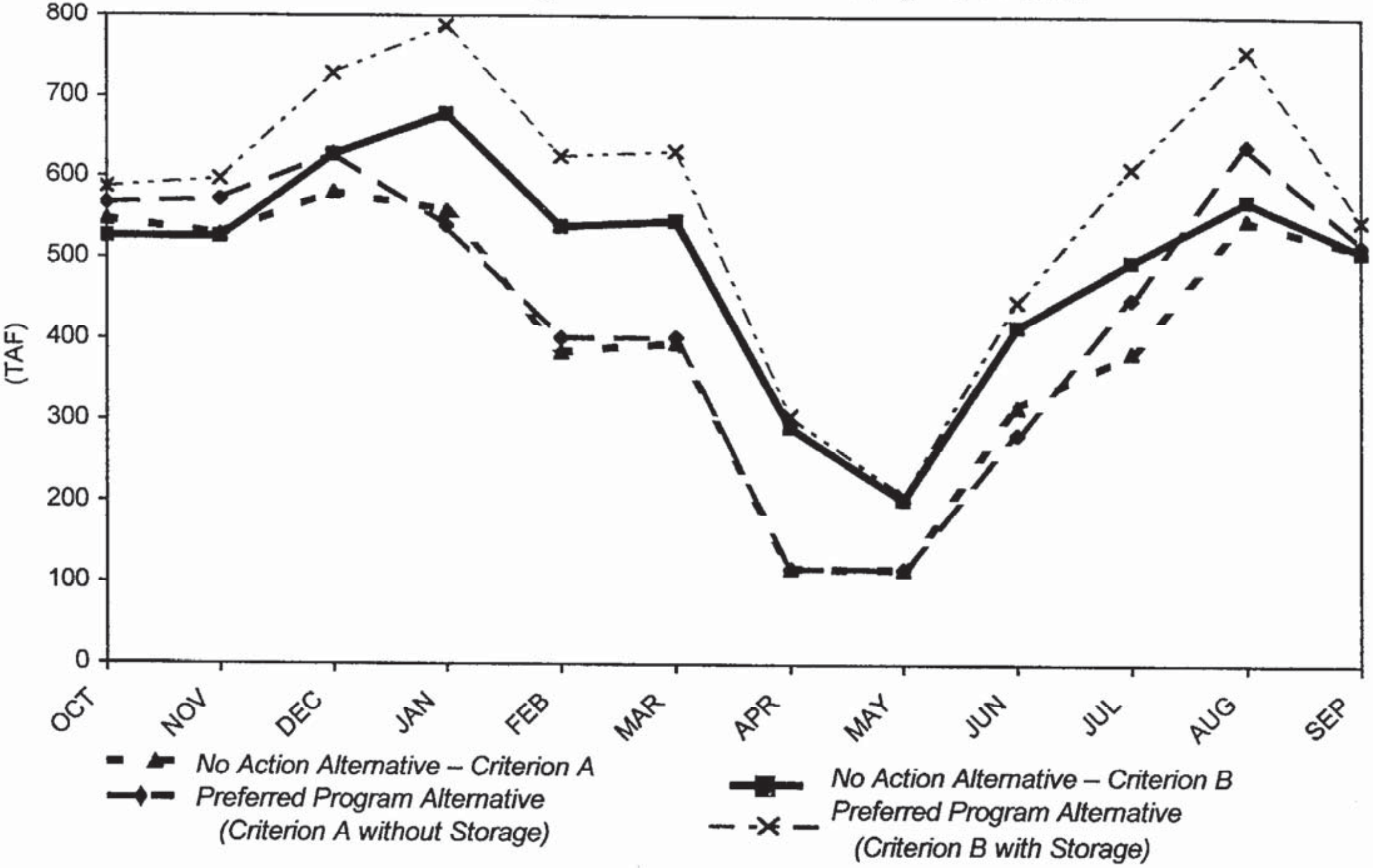


Figure 5.1-48. Delta Exports at Banks and Tracy under the Preferred Program Alternative for Dry and Critical Years

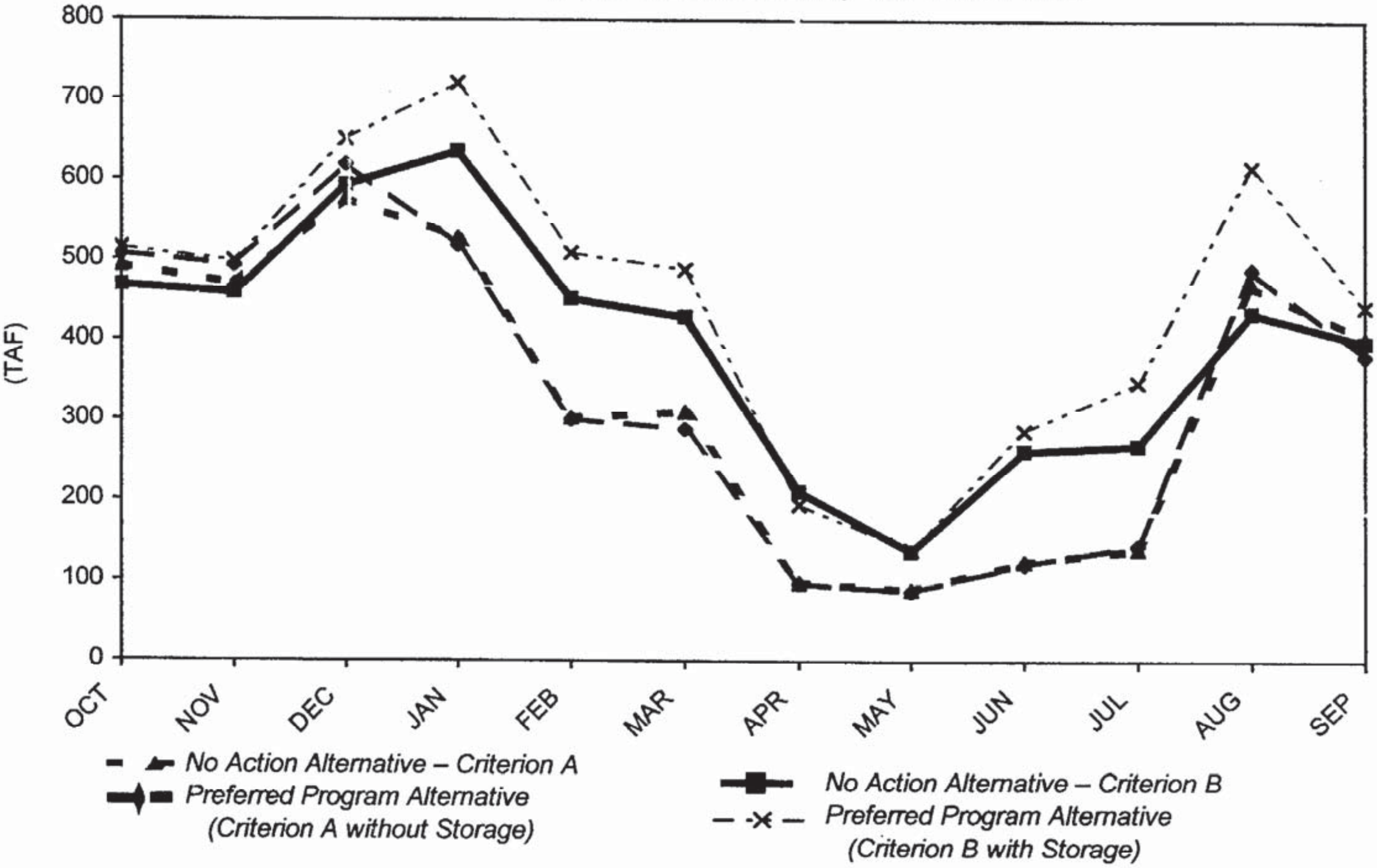


Figure 5.1-49. Average Annual Delta Exports at Banks and Tracy under All Program Alternatives for the Long-Term Period

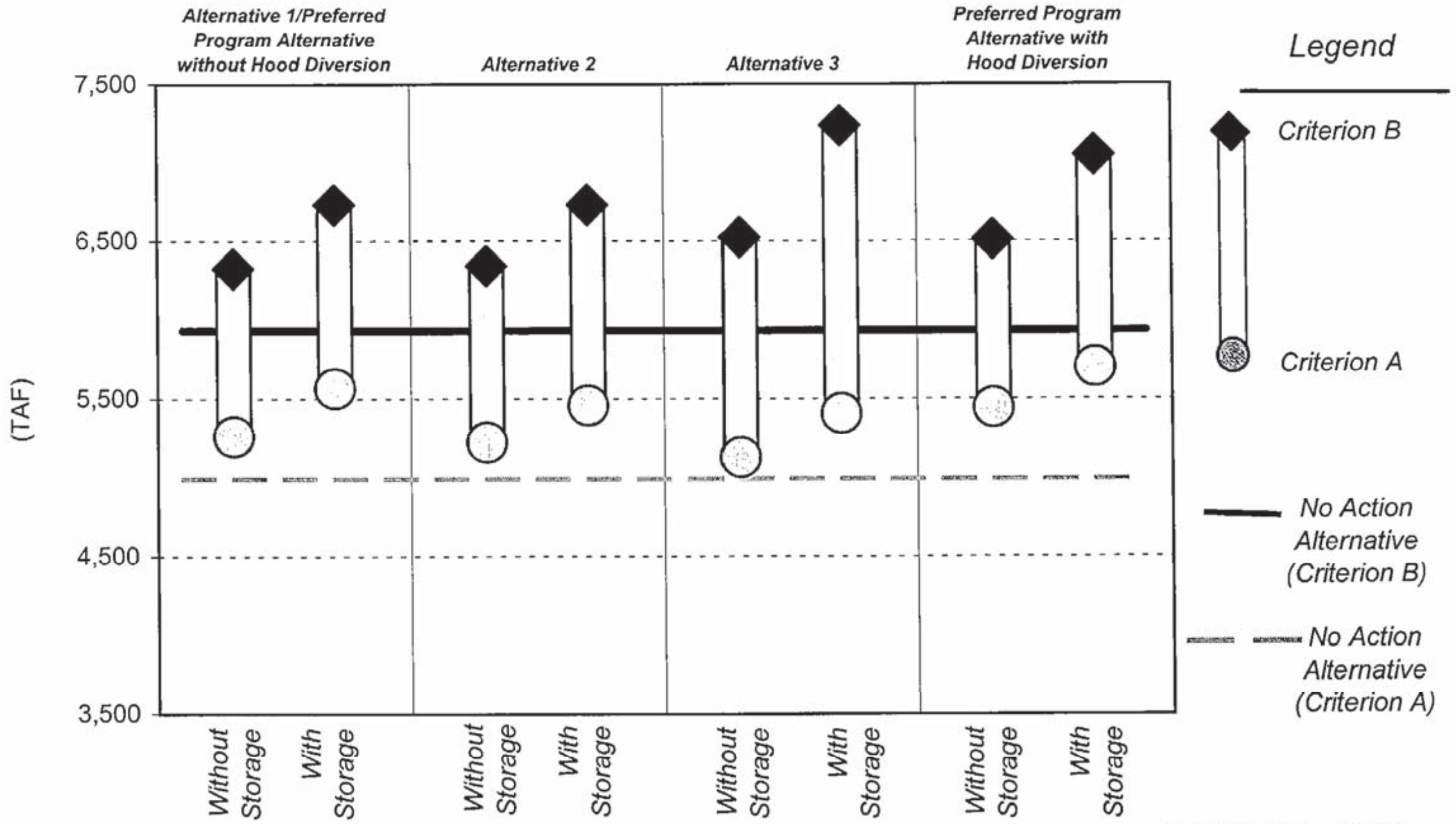


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Figure 5.1-50. Average Annual Delta Exports at Banks and Tracy under All Program Alternatives for Dry and Critical Years

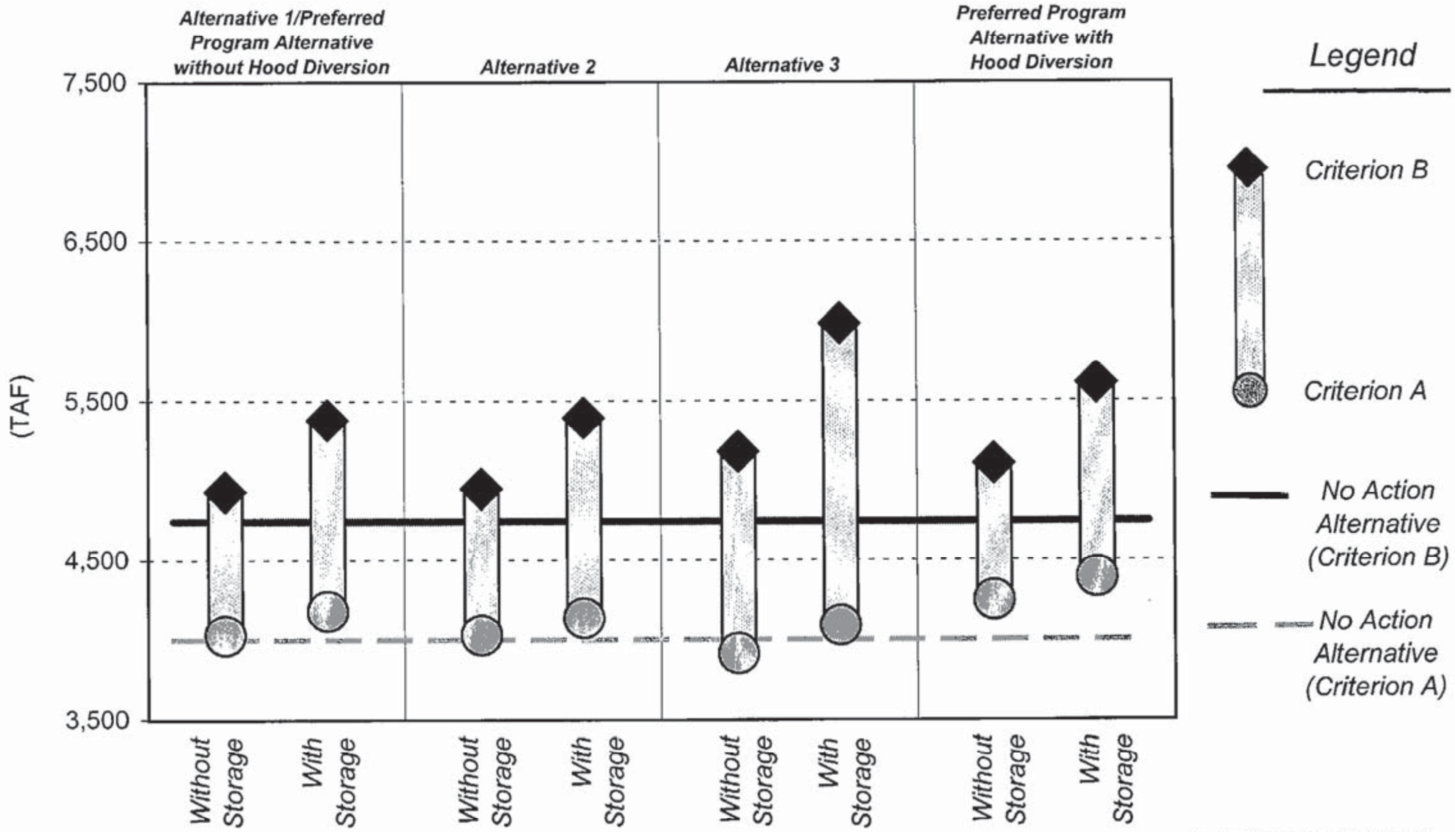

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Table 5.1-10. Banks and Tracy Exports under All Program Alternatives for Dry and Critical Years(TAF)

PERIOD	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
High export month (January)	530-640	530-720	520-710	520-750	520-720
Low export month (May)	90-140	90-140	90-140	80-350	90-140
Annual difference without storage	-	30-190	30-200	(-90)-440	50-180
Annual difference with storage	-	180-640	130-650	90-1,200	180-670

Note:
PPA = Preferred Program Alternative.

Diversions from a facility on the Sacrament River under the Preferred Program Alternative occur throughout the year. Details regarding the assumptions for the diversion facility on the Sacramento River are presented in Section 5.1.4 and Attachment A. In general, the pattern of diversions peak in early winter and midsummer, with lower diversions in spring. Figure 5.1-51 compares average monthly Sacramento River diversions for the long-term period. Similarly, Figure 5.1-52 compares average monthly diversions from a facility on the Sacramento River during dry and critical years.

Diversions from a facility on the Sacramento River are typically greatest in January, with long-term diversions peaking on average from 120 to 250 TAF. May reflects lower average diversions due to more restrictive operation criteria, ranging from 60 to 190 TAF. For dry and critical water-years, diversions average from 120 to 240 TAF in peak winter months and from 40 to 140 TAF in spring months.

Under the Preferred Program Alternative without additional storage, annual diversions from a facility on the Sacramento River over the long-term period range from 1.2 to 2.6 MAF. For dry and critical years, average annual diversions range from 1.1 to 2.2 MAF. When additional system storage is applied to the Preferred Program Alternative, annual long-term diversions on the Sacramento River average between 1.2 and 2.7 MAF. For dry and critical years, annual diversions on the Sacramento River range on average between 1.2 and 2.5 MAF. Average annual Sacramento River diversions directly attributed to additional storage range from 0 to 160 TAF for the long-term period, and from 10 to 290 TAF for dry and critical years.

Bay Region

Programmatic comparisons of Delta outflow to San Francisco Bay were made between the Preferred Program Alternative and the No Action Alternative using DWRSIM modeling results. Figures 5.1-53 and 5.1-54 present monthly average Delta outflow comparisons for the long-term period and dry and critical years, respectively.

Delta outflow is typically lower under the Preferred Program Alternative than under the No Action Alternative during November through March. Percentage differences are typically small, however. Over the long-term period, Delta outflow normally peaks in February. Average February outflow ranges from 2.7 to 2.8 MAF under the No Action Alternative and ranges from 2.6 to 2.8 MAF under the Preferred Program Alternative. The differences in Delta outflow are smaller from April through October. Ecosystem Restoration Program flows provide some additional May outflow under the Preferred Program

Figure 5.1-51. Hood Diversions under the Preferred Program Alternative for the Long-Term Period

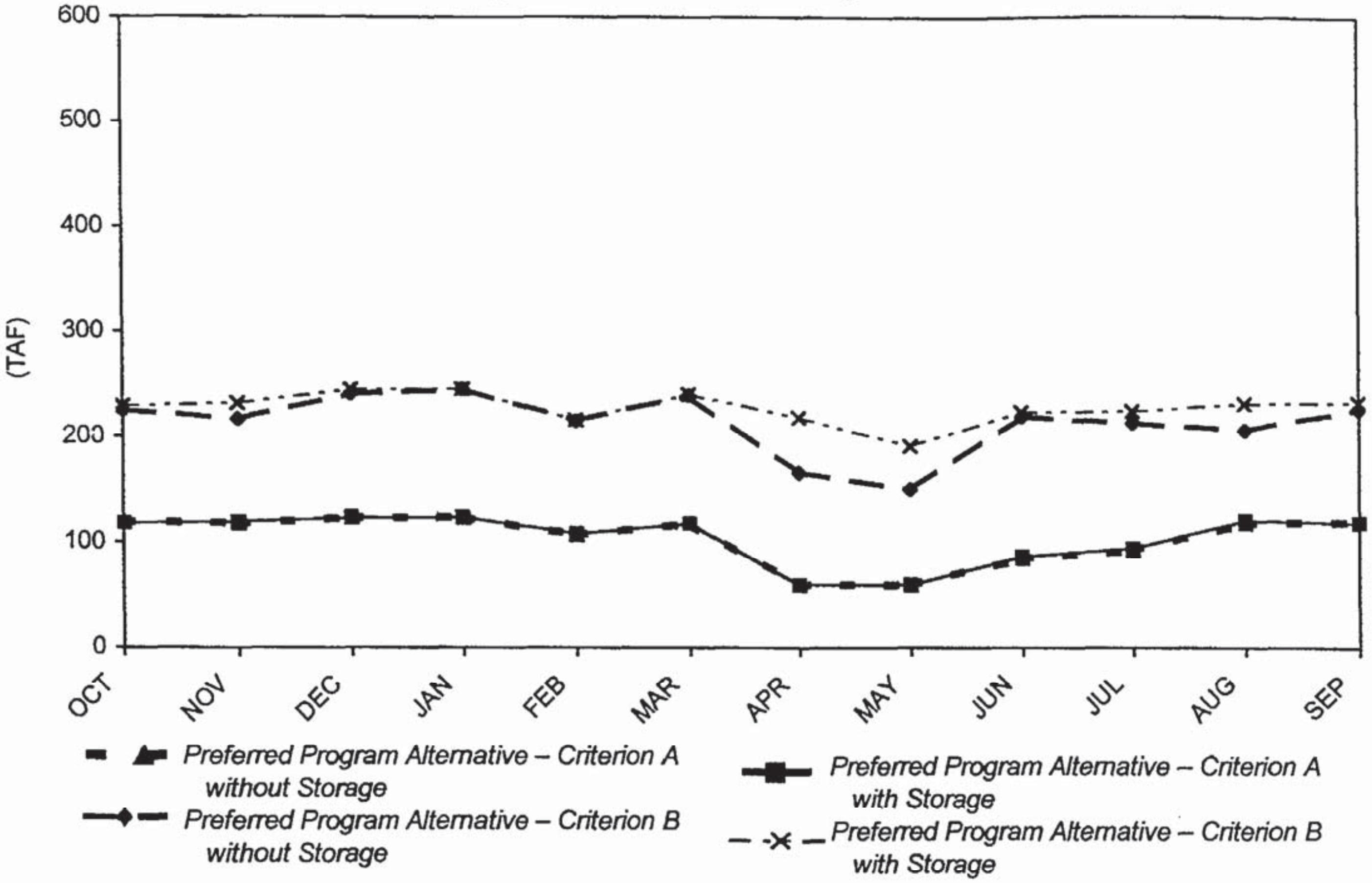


Figure 5.1-52. Hood Diversions under the Preferred Program Alternative for Dry and Critical Years

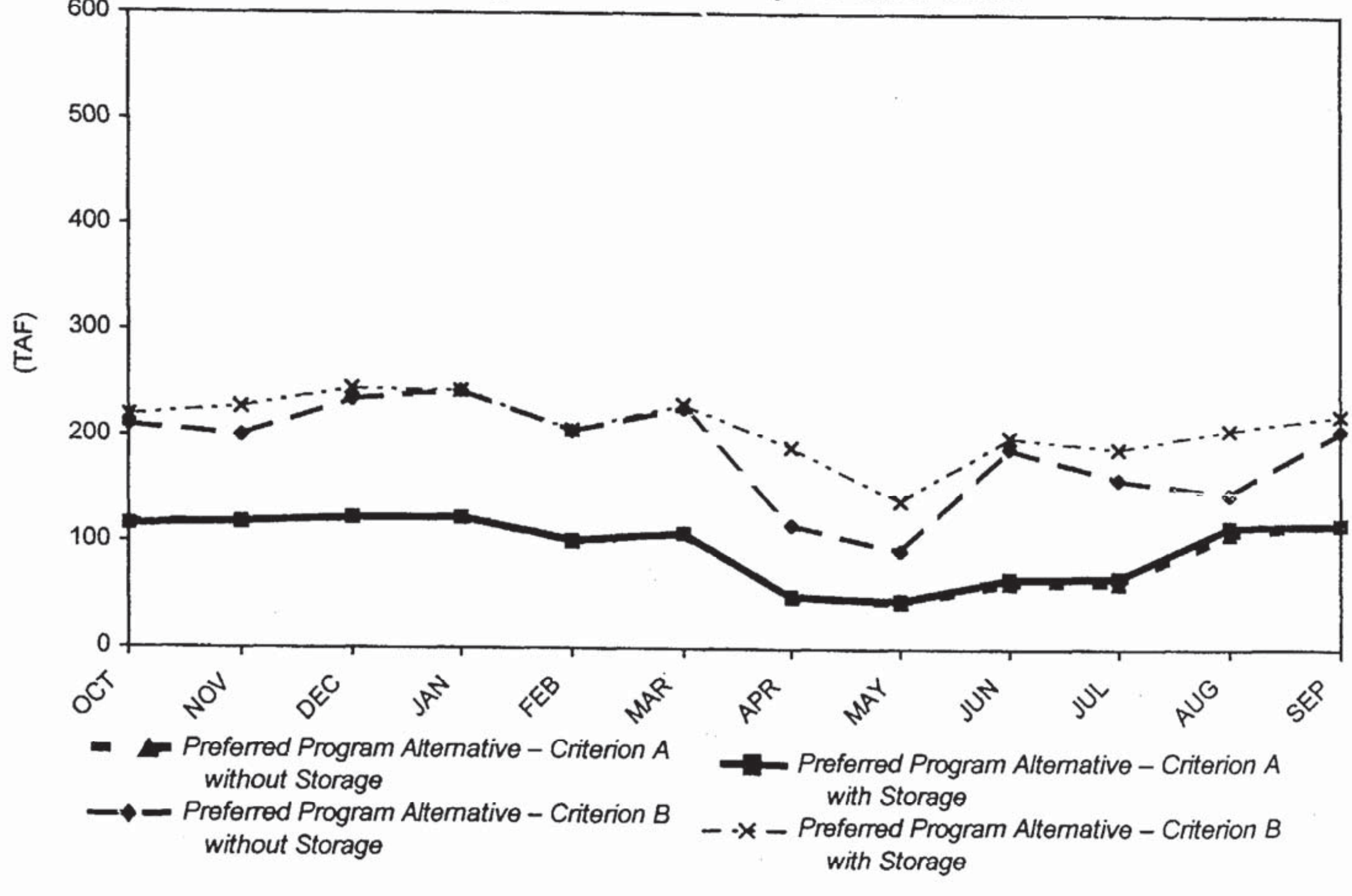


Figure 5.1-53. Delta Outflow under the Preferred Program Alternative for the Long-Term Period

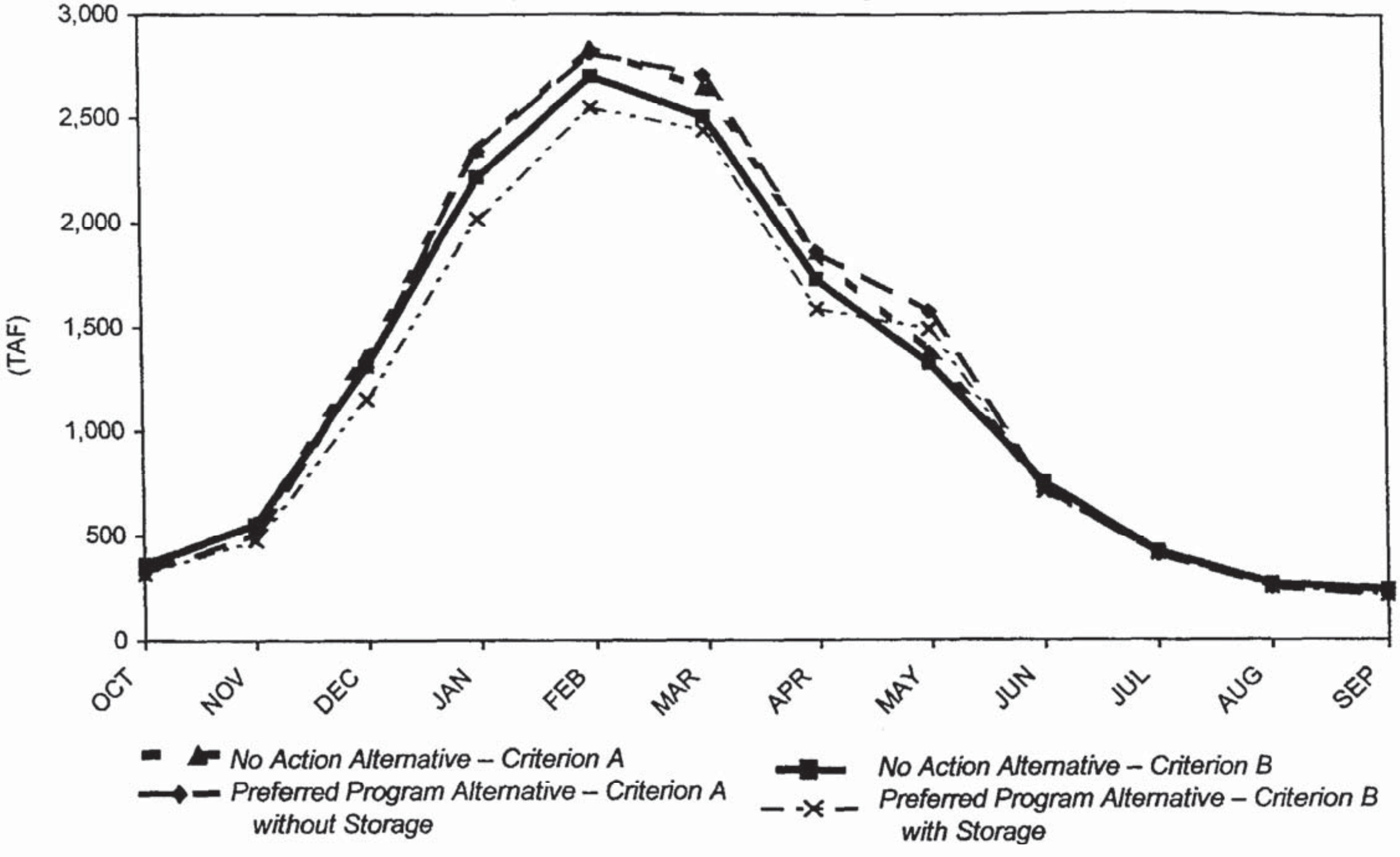
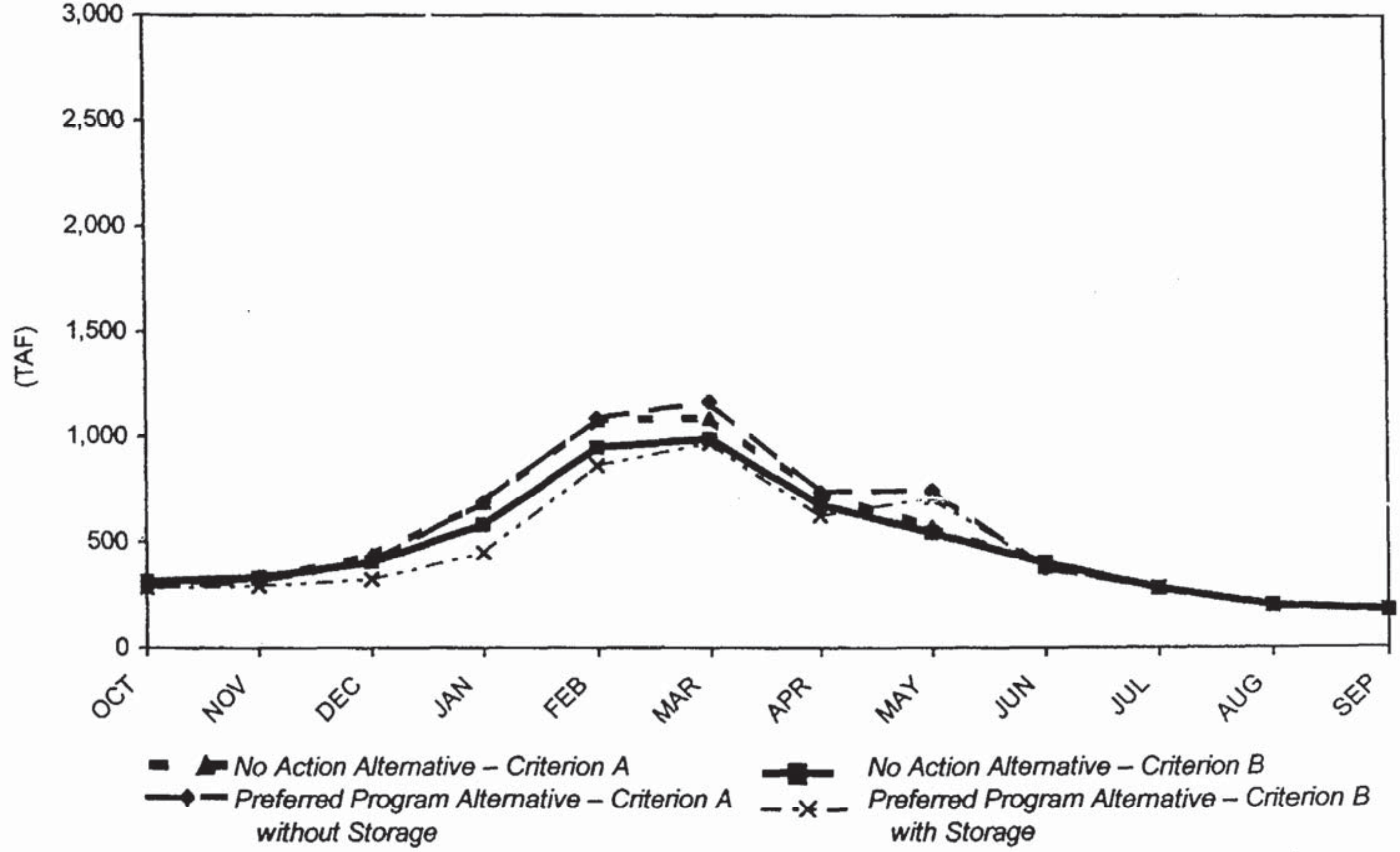


Figure 5.1-54. Delta Outflow under the Preferred Program Alternative for Dry and Critical Years



Alternative. On an annual basis, without additional storage, the Preferred Program Alternative modifies average long-term period Delta outflow from (-70) to 50 TAF compared to the No Action Alternative. With additional storage, the Preferred Program Alternative decreases average annual Delta outflow from 290 to 760 TAF. Therefore, annual Delta outflow decreases of 340-700 TAF are directly related to additional storage under the Preferred Program Alternative.

During dry and critical years, February outflow ranges from 950 TAF to 1.1 MAF under the No Action Alternative and ranges from 870 TAF to 1.1 MAF under the Preferred Program Alternative. On an annual basis, without additional storage, the Preferred Program Alternative increases average dry and critical year Delta outflow from 70 to 180 TAF over the No Action Alternative. With additional storage, the Preferred Program Alternative could decrease average dry and critical year outflow by 280 TAF or could increase outflow by 170 TAF relative to the No Action Alternative. Therefore, annual Delta outflow decreases of 20-350 TAF are directly related to additional storage under the Preferred Program Alternative.

Delta outflow under the Preferred Program Alternative was also compared to Delta outflow under the other Program alternatives. The long-term period comparison is summarized in Table 5.1-11. The dry and critical year comparison is summarized in Table 5.1-12.

Table 5.1-11. Delta Outflow under All Program Alternatives for the Long-Term Period(TAF)

PERIOD	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
High outflow month (February)	2,700-2,840	2,560-2,840	2,560-2,840	2,560-2,760	2,550-2,810
Annual difference without storage	-	(-80)-30	(-90)-60	(-250)-220	(-70)-50
Annual difference with storage	-	(-660)-(-460)	(-660)-(-270)	(-1,100)-(-150)	(-760)-(-290)

Note:
PPA = Preferred Program Alternative.

Table 5.1-12. Delta Outflow under All Program Alternatives for Dry and Critical Years (TAF)

PERIOD	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
High outflow month (February)	950-1,080	860-1080	870-1,090	820-1,080	870-1,090
Annual difference without storage	-	70-180	40-210	(-40)-610	70-180
Annual difference with storage	-	(-260)-70	(-260)-210	(-610)-500	(-280)-170

Note:
PPA = Preferred Program Alternative.

Sacramento River and San Joaquin River Regions

This section provides a comparison of the Preferred Program Alternative and the No Action Alternative with respect to water supply and water management in the Sacramento River and San Joaquin River Regions using DWRSIM modeling results. The programmatic comparison focuses on existing storage, new storage, and Ecosystem Restoration Program acquisitions.

The Preferred Program Alternative does not change the water supply reliability in the Sacramento River and San Joaquin River Regions relative to the No Action Alternative. All water demands in the Sacramento River and San Joaquin River Regions are met through CVP/SWP project deliveries and through locally derived water supplies. Refer to Section 5.1.4, "Assessment Methods," for details related to the DWRSIM hydrology development process. However, as discussed later in this section, surface water acquisitions through the Ecosystem Restoration Program could reallocate supplies from willing sellers to in-stream uses.

Existing Storage. End-of-September carryover storage in the major Sacramento River Region surface storage facilities (Shasta, Oroville, and Folsom) was evaluated for the Preferred Program Alternative and the No Action Alternative. Figure 5.1-55 depicts the ranges of long-term period and dry and critical year carryover storage for the Preferred Program Alternative and the No Action Alternative.

Under the No Action Alternative, average carryover storage in Sacramento River Region reservoirs ranges from 5.3 to 5.4 MAF for the long-term period, and from 3.8 to 3.9 MAF for dry and critical years. The Preferred Program Alternative long-term period carryover storage ranges from 5.1 to 5.5 MAF, while dry and critical year carryover storage ranges from 3.6 to 4.0 MAF.

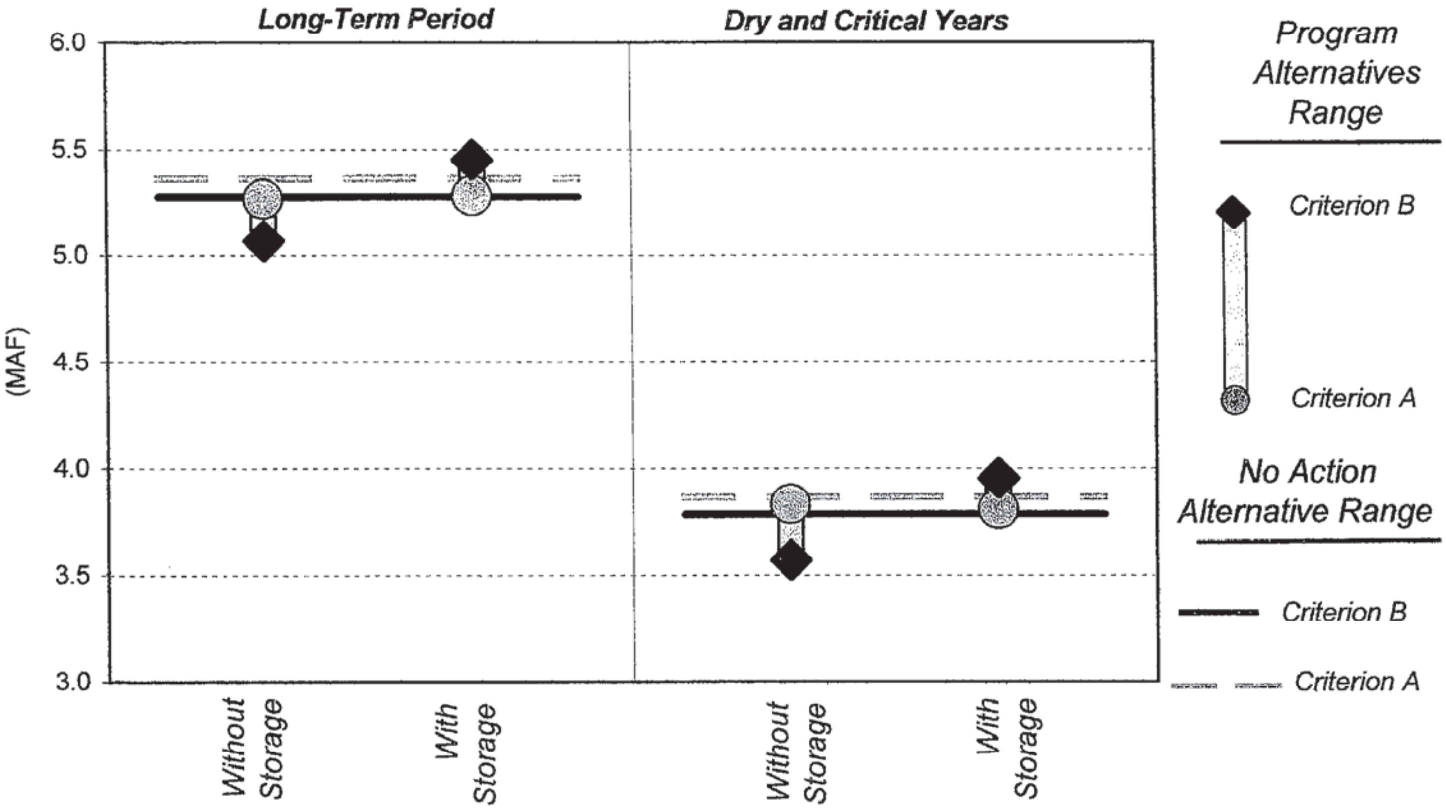
In the absence of new storage facilities, implementation of the Preferred Program Alternative has little impact on carryover storage under Criterion A water management assumptions. The Preferred Program Alternative results in a slight reduction in carryover storage under Criterion B water management assumptions. Without new storage, the reduction in average long-term carryover storage under the Preferred Program Alternative may vary from 90 to 210 TAF. The same trend is demonstrated for the dry and critical years with the reduction in carryover storage varying from 40 to 210 TAF.

With new storage facilities, implementation of the Preferred Program Alternative under Criterion A assumptions reduces average long-term period and dry and critical year carryover storage in existing facilities on the order of 80 TAF relative to the No Action Alternative. Under Criterion B assumptions, the Preferred Program Alternative increases average carryover storage on the order of 180 TAF.

End-of-September carryover storage in the major San Joaquin River Region surface facilities (New Melones, New Don Pedro, and McClure) was evaluated for the Preferred Program Alternative and the No Action Alternative. Implementation of the Preferred Program Alternative has no measurable effect on system carryover storage. Similarly, no variation is evident based on water management criteria or implementation of additional storage facilities.

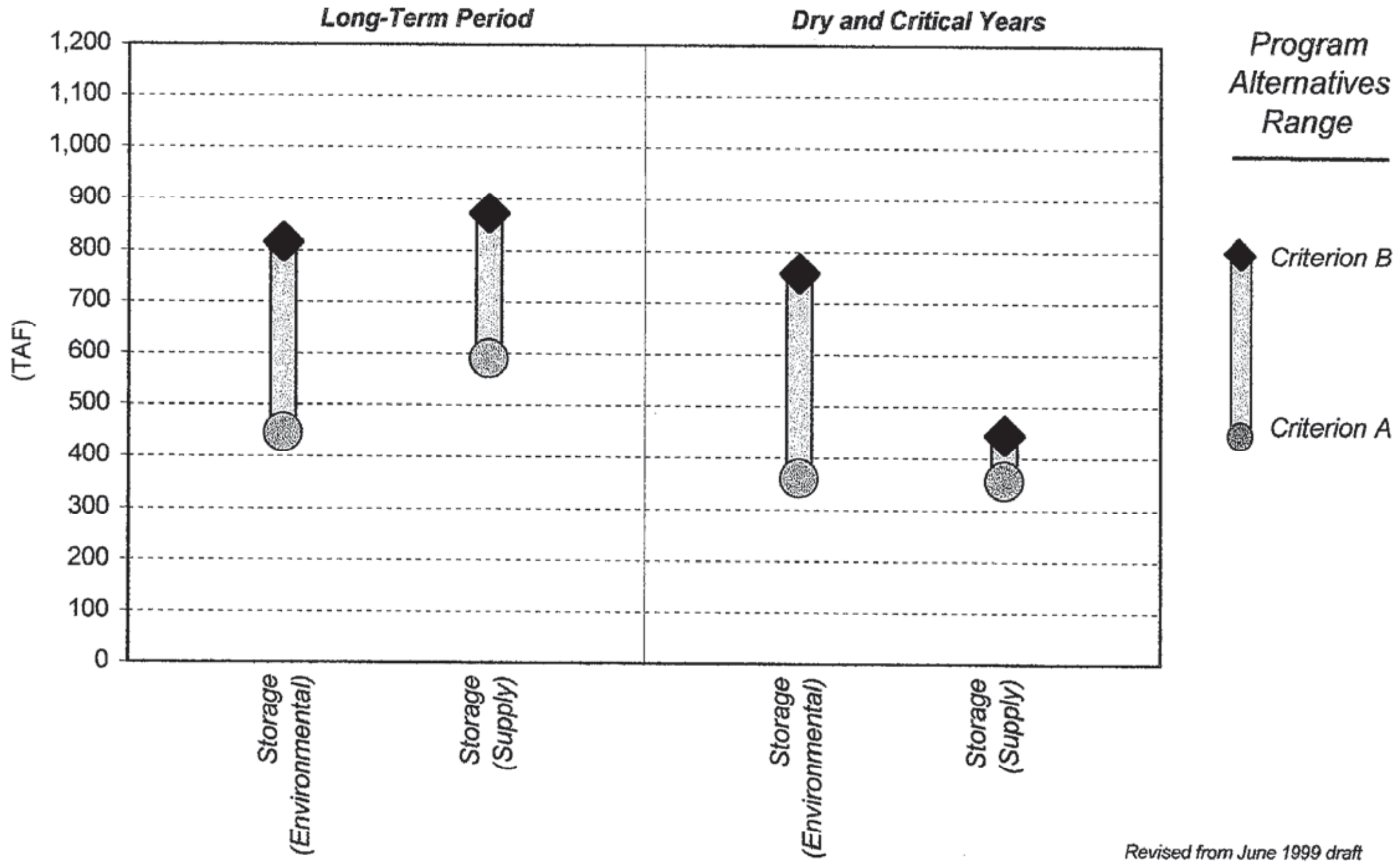
New Storage. New Sacramento River and San Joaquin River Regions surface storage facilities were evaluated under the Preferred Program Alternative. The evaluation distinguished between storage for water supply and storage for environmental enhancement.

Figure 5.1-55. Carryover Storage for Existing Surface Reservoirs in the Sacramento River Region under the Preferred Program Alternative for the Long-Term Period and Dry and Critical Years



Revised from June 1999 draft

Figure 5.1-56. Carryover Storage for New Surface Reservoirs in the Sacramento River Region under the Preferred Program Alternative for the Long-Term Period and Dry and Critical Years



Revised from June 1999 draft

Figure 5.1-56 presents Sacramento River Region carryover storage comparisons for the long-term period and dry and critical years. Peak storage in the new facilities generally occurs in early summer under all hydrologic conditions. For the long-term period, peak water supply storage ranges from 770 TAF to 1.3 MAF, while dry- and critical-year peak storage typically ranges from 510 to 810 TAF. Carryover storage ranges from 590 TAF to 870 TAF for the long-term period, and from 360 to 450 TAF for dry and critical years. Criterion A water management assumptions consistently results in lower water supply storage. For the long-term period, peak environmental storage ranges from 520 to 900 TAF, while dry- and critical -year peak storage typically ranges from 450 to 870 TAF. Carryover storage ranges from 450 to 810 TAF for the long-term period, and from 360 to 760 TAF for dry and critical years. Criterion A water management assumptions consistently results in lower environmental storage.

New Sacramento River Region groundwater storage facilities also were evaluated under the Preferred Program Alternative. These facilities are assumed to have a maximum capacity of 250 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry and critical year yield of these facilities ranges from 40 to 60 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

In this evaluation, new San Joaquin River Region storage facilities were dedicated to providing water for Ecosystem Restoration Program flow targets. Peak average annual storage tends to occur in late spring and is approximately 240 TAF for the long-term period and ranges from 210 to 230 TAF for dry and critical years. Carryover storage ranges from 200 to 220 TAF for the long-term period, and from 190 to 210 TAF for dry and critical years. Criterion B water management assumptions consistently result in lower storage.

Ecosystem Restoration Program Acquisition. Table 5.1-13 shows water acquisitions quantities under the Preferred Program Alternative estimated to meet proposed Ecosystem Restoration Program flow targets.

Table 5.1-13. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions Without New Storage under the Preferred Program Alternative (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	90	20	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	50	80	60	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	80-90	10	0	0
Additional Delta flows [a]	0	110-140	180-210	220-250	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	30	40	30	50
Merced River [b]	0	10	30	20	40
Total acquisitions	**0**	**310-370**	**510-550**	**400-440**	**170**

Note:

See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.

[b] Based on San Joaquin Valley 60-20-20 water-year index.

When new Sacramento River and San Joaquin River Regions surface storage is included in the Preferred Program Alternative, fewer water acquisitions are required to meet Ecosystem Restoration Program flow targets. New storage also could be operated to provide Ecosystem Restoration Program flows for other tributaries by exchange agreements. These types of arrangements are not reflected in this analysis. Table 5.1-14 shows the water acquisition quantities estimated to meet the proposed Ecosystem Restoration Program flow targets under the Preferred Program Alternative with new storage.

Table 5.1-14. Estimated Ecosystem Restoration Program Water Acquisitions in the Sacramento River and San Joaquin River Regions with New Storage under the Preferred Program Alternative (TAF)

LOCATION	CRITICAL	DRY	BELOW NORMAL	ABOVE NORMAL	WET
Sacramento River [a]	0	0-10	30-50	0-10	0
Yuba River [a]	0	0-10	0-10	0-10	0
Feather River [a]	0	40	70	40	0
American River [a]	0	30	40	20	40
Lower Sacramento River [a]	0	0-20	0	0	0
Additional Delta flows [a]	0	50-60	110-120	160-190	0
Stanislaus River [b]	0	0	40	30	40
Tuolumne River [b]	0	10	20-30	10	30
Merced River [b]	0	0	0	0	10
Total acquisitions	**0**	**130-180**	**310-360**	**260-310**	**120**

Note:
See Section A.3.3 in Attachment A for additional information regarding modeling assumptions.

[a] Based on Sacramento Valley 40-30-30 water-year index.
[b] Based on San Joaquin Valley 60-20-20 water-year index.

South-of-Delta SWP and CVP Service Areas

Programmatic comparisons of Delta deliveries to the South-of-Delta SWP and CVP Service Areas were made between the Preferred Program Alternative and the No Action Alternative using DWRSIM modeling results. This section also evaluates surface water storage in existing and new off-aqueduct facilities.

Delta Deliveries. The range of annual Delta deliveries under the No Action Alternative was compared to the range of deliveries expected under the Preferred Program Alternative. Deliveries are generally higher under the Preferred Program Alternative with implemen-tation of new storage facilities and Criterion B water management assumptions.

Under the Preferred Program Alternative, the range of average annual deliveries over the long-term period is from 5.1 to 6.7 MAF. The low end of this range assumes no new storage facilities and Criterion A water management assumptions; the high end of this range assumes new storage facilities and Criterion B water management assumptions. The No Action Alternative results in a long-term average annual delivery range from 4.8 to 5.8 MAF. During dry and critical years, the Preferred Program Alternative average annual deliveries range between 3.9 and 5.6 MAF and No Action Alternative deliveries range between 3.9 and 4.6 MAF.

Without additional storage facilities, the Preferred Program Alternative would increase long-term average annual deliveries by 250-370 TAF relative to the No Action Alternative. Dry and critical year deliveries would increase by up to 190 TAF under the Preferred Program Alternative. Implementation of the Preferred Program Alternative in conjunction with new surface storage would increase long-term average annual deliveries by 470-910 TAF. In dry and critical years, the Preferred Program Alternative would increase deliveries by 530-990 TAF. Therefore, annual long-term Delta delivery increases of 220-540 TAF are directly related to additional storage under the Preferred Program Alternative. Delta deliveries under the Preferred Program Alternative also were compared to Delta deliveries under the other Program alternatives. The long-term period comparison is summarized in Table 5.1-15. The dry and critical year comparison is shown in Table 5.1-16. Additionally, Figures 5.1-57 and 5.1-58 present average annual Delta delivery comparisons for the long-term period and dry and critical years, respectively.

Existing Off-Aqueduct Storage Facilities. San Luis Reservoir is the primary existing off-aqueduct storage facility serving the South-of-Delta SWP and CVP Service Areas. San Luis Reservoir carryover storage and reservoir releases were evaluated under the Preferred Program Alternative and the No Action Alternative.

Table 5.1-15. Delta Deliveries under All Program Alternatives for the Long-Term Period (TAF)

DELTA DELIVERIES	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Total annual deliveries	4,820-5,750	5,090-6,540	5,060-6,540	4,960-7,000	5,070-6,660
Annual difference without storage	-	270-380	240-400	140-560	250-370
Annual difference with storage	-	670-790	450-790	380-1,250	470-910

Note:
PPA = Preferred Program Alternative.

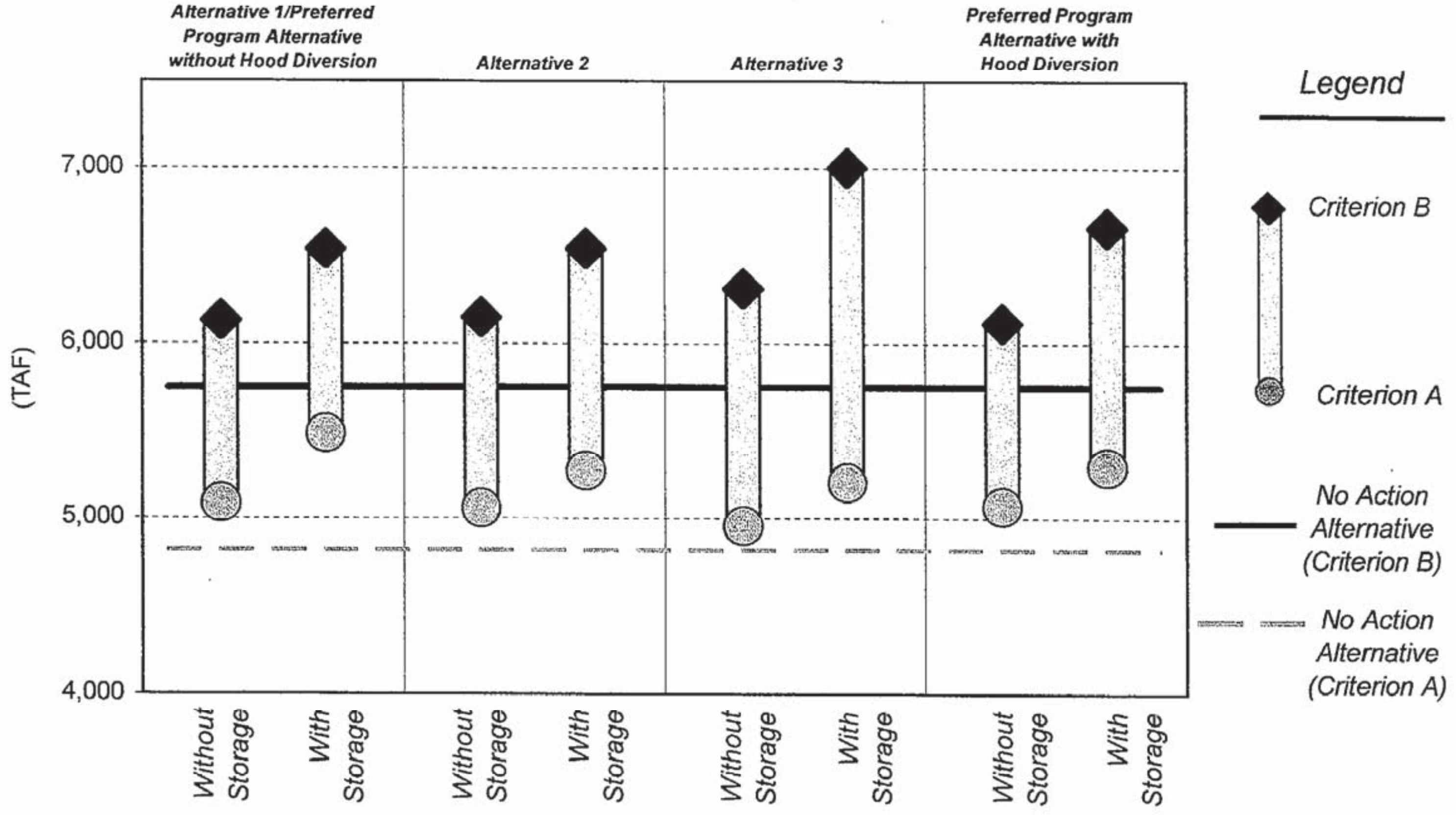
Table 5.1-16. Delta Deliveries under All Program Alternatives for Dry and Critical Years (TAF)

DELTA DELIVERIES	NO ACTION ALTERNATIVE	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Total annual deliveries	3,920-4,570	3,920-5,560	3,910-5,560	3,750-5,940	3,940-5,560
Annual difference without storage	-	0-190	(-10)-190	(-170)-380	20-190
Annual difference with storage	-	600-990	500-990	370-1,370	530-990

Note:
PPA = Preferred Program Alternative.

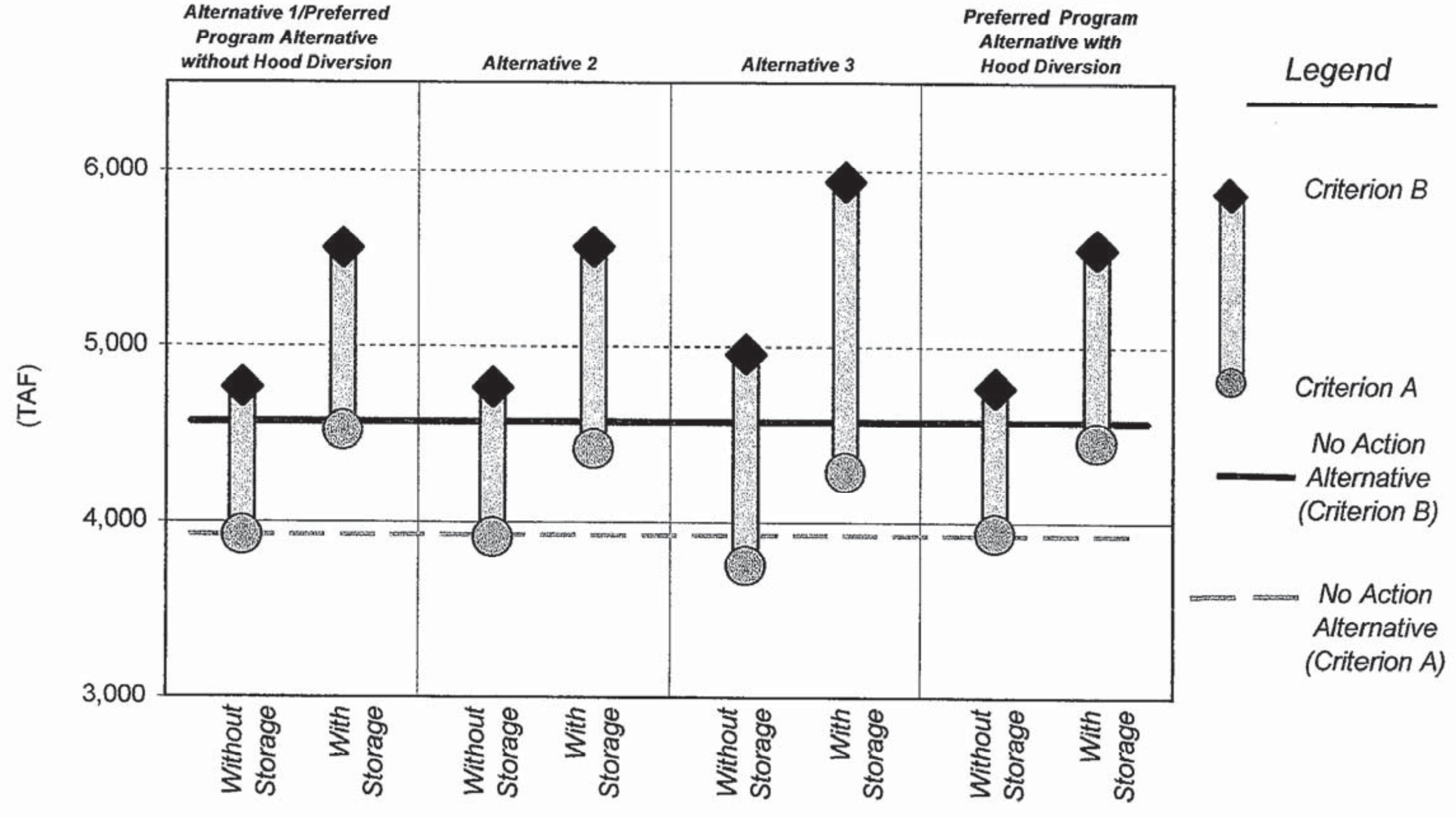
With no additional storage, the Preferred Program Alternative modifies San Luis Reservoir carryover storage from (-10) to 170 TAF for the long-term period, and from 10 to 140 TAF for dry and critical years above the No Action Alternative. If additional storage is implemented, the Preferred Program Alternative

Figure 5.1-57. Average Annual Delta Deliveries under All Program Alternatives for the Long-Term Period



Revised from June1999 draft

Figure 5.1-58. Average Annual Delta Deliveries under All Program Alternatives for Dry and Critical Years



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increases long-term carryover storage from 150 to 190 TAF and dry and critical carryover storage by 140 to 160 TAF above the No Action Alternative. Therefore, a long-term average carryover storage of approximately (-20) to 200 TAF is directly attributed to additional storage under the Preferred Program Alternative. The average carryover storage increase of approximately 20 to 130 TAF for dry and critical years is directly related to additional storage under the Preferred Program Alternative. Figure 5.1-59 presents carryover storage comparisons for the long-term period and dry and critical years.

The broadest range in monthly average storage releases from San Luis Reservoir generally occurs in summer months for both water management criteria under all hydrologic conditions. The largest long-term summer releases generally are associated with Criterion A water management in the absence of new storage facilities, while the lowest summer releases are associated with Criterion B water management in conjunction with additional storage capacity. The broadest range of long-term monthly average reservoir releases under the Preferred Program Alternative is approximately 200-380 TAF. Under the No Action Alternative, long-term peak average monthly summer releases range from 270 to 310 TAF. Winter releases are similar under the Preferred Program Alternative and the No Action Alternative.

New Off-Aqueduct Storage Facilities. Carryover storage and releases associated with new off-aqueduct surface storage facilities were evaluated under the Preferred Program Alternative. Such facilities would serve the South-of-Delta SWP and CVP Service Areas similar to San Luis Reservoir.

Over the long-term period, carryover storage in new off-aqueduct surface storage facilities ranges from 720 to 780 TAF under the Preferred Program Alternative. For dry and critical years, carryover storage ranges from 320 to 330 TAF. Criterion A provides higher carryover storage in both wetter and drier water-years. Figure 5.1-60 presents carryover storage comparisons for the long-term period and dry and critical years.

Releases from new off-aqueduct surface storage facilities generally occur from spring to late summer under the Preferred Program Alternative. Peak releases typically occur in midsummer for all hydrologic conditions. The approximate peak releases are 160 TAF for the long-term period, and the peak releases range from 170 to 180 TAF for dry and critical years, respectively. In dry and critical years, monthly average releases tend to be similar under both water management criteria. Over the long-term period, Criterion A water management results in early spring peak releases while Criterion B results in late-spring peak releases. Reduced Delta exports associated with Criterion A create more reliance on off-aqueduct storage releases to meet spring demands.

New off-aqueduct groundwater storage facilities also were evaluated under the Preferred Program Alternative. These facilities are assumed to have a maximum capacity of 500 TAF with maximum inflow and discharge capacities of 500 cfs. Withdrawals from new groundwater storage facilities are made only in dry and critical years. The estimated average annual dry- and critical-year yield of these facilities ranges from 85 to 90 TAF. The long-term average was not calculated since the storage was operated for dry and critical year yield only.

Figure 5.1-59. Carryover Storage for Existing Off-Aqueduct Reservoirs under the Preferred Program Alternative for the Long-Term Period and Dry and Critical Years

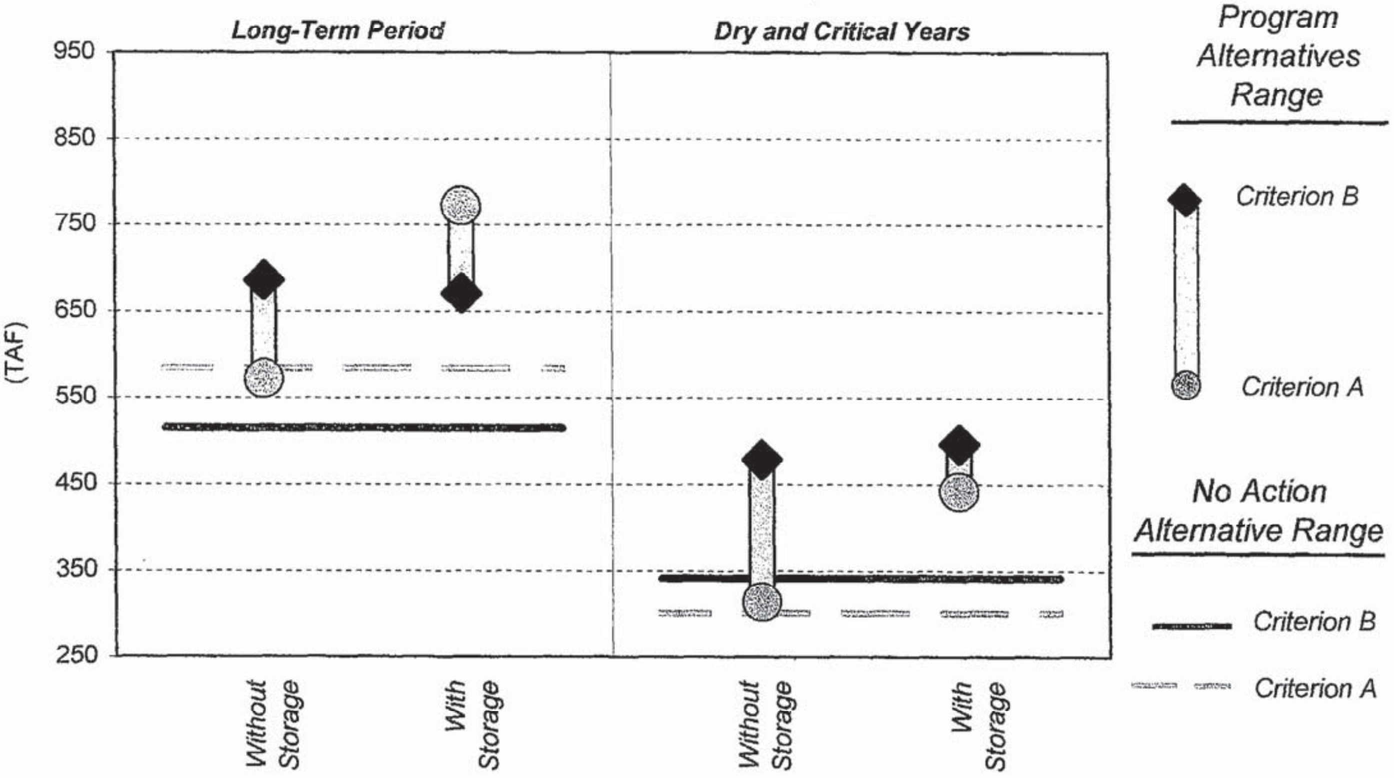
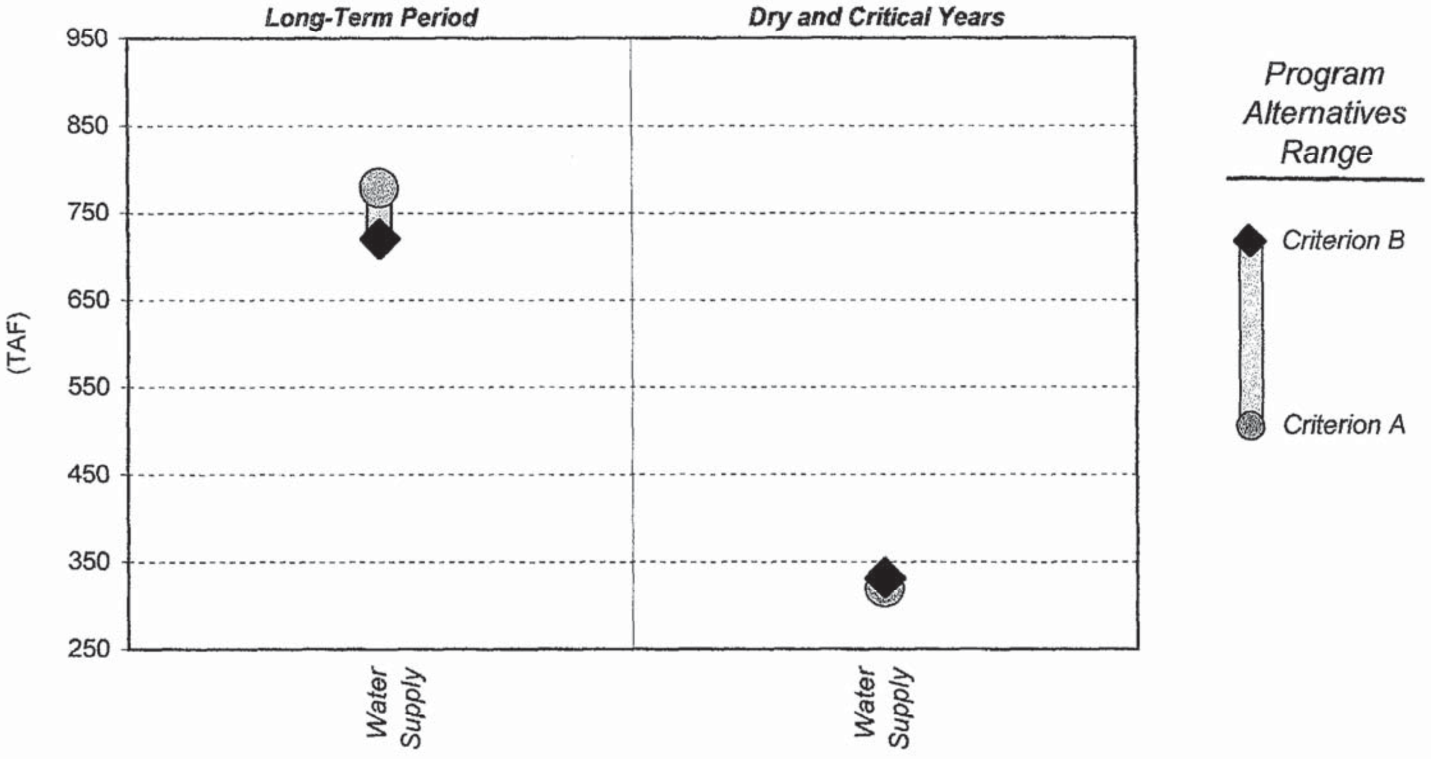


Figure 5.1-60. Carryover Storage for New Off-Aqueduct Reservoirs under the Preferred Program Alternative for the Long-Term Period and Dry and Critical Years



5.1.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents a comparison of the environmental consequences of the Program alternatives relative to existing conditions. The programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions are within the same range of potentially beneficial and adverse impacts as those identified in Sections 5.1.7 and 5.1.8.

As discussed in Section 5.1.4, in order to make programmatic comparisons between the No Action Alternative and Program alternatives, existing conditions were simulated based on an extensive set of modeling assumptions. The No Action Alternative was defined to represent a reasonable range of uncertainty in the pre-implementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta water management criteria that regulate system operations.

A comparison of elements of the Program alternatives to existing conditions indicates that:

- All potentially significant adverse impacts that were identified when compared to the No Action Alternative also are considered potentially significant when compared to existing conditions. These impacts include potential temporary local water supply interruptions due to turbidity of water during construction of Program facilities and habitat restoration activities.

- No additional potentially significant environmental consequences have been identified when Program effects are compared to existing conditions as opposed to the No Action Alternative.

- The beneficial effects on water supply availability and reliability also are considered beneficial when compared to existing conditions.

5.1.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts on water supply and water management. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For water supply and water management, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.1.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts to a less-than-significant level. At the programmatic level, the analysis did not identify any impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level. Sections 5.1.7 and 5.1.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on water supply and water management in the Delta, Bay, Sacramento River, and San Joaquin River Regions and in the Other SWP and CVP Service Areas: American River Water Resource Investigation, other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Red Bluff Diversion Dam Fish Passage Program, Sacramento Water Forum process, Supplemental Water Supply Project, and Sacramento County municipal and industrial water supply contracts. These projects could reduce the availability of water supplies or water management options and cause cumulative impacts. The Trinity River Restoration Project, ISDP, and urbanization would cause water supply effects that were included in the evaluation presented in Sections 5.1.7 and 5.1.8. Consequently, these projects would not contribute to cumulative impacts on water supply and water management. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.1.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level.

Growth-Inducing Impacts. The Preferred Program Alternative is expected to result in an improvement in water supply reliability and availability for beneficial use in the Bay Region, Sacramento River Region, and San Joaquin River Region, and South-of-Delta SWP and CVP Service Areas. The amount of water supply increase made possible by the Program is small relative to the amount of water used in these affected regions. The Water Use Efficiency and Water Transfer Programs will increase water supply reliability by more efficient use and reuse of existing water supplies. Through water quality improvements, the Water Quality Program may reduce demands for certain beneficial uses, thereby increasing available water supply. Improvements from the Conveyance element may allow more water to be exported from the Delta while meeting in-Delta needs. Storage of water under the Storage element may be used for additional water supply, as well as for other beneficial uses.

There are differences of opinion as to whether additional water supplies and/or improvements in water supply reliability would stimulate growth. Because this issue cannot be determined with certainty at this general level of analysis, the assumption was made for this programmatic document that an increase in water supplies and/or improvement in water supply reliability that is associated with the Program could stimulate growth. This assumption assures that the document discloses the environmental consequences associated with growth in the event that Program actions ultimately lead to this type of change.

At this programmatic level, it is unknown where any increases in population growth or construction of additional housing would take place, or what level of growth might be associated with improved water supply reliability/availability. When and if they occur, these changes will be subject to local land use decisions by individual cities and counties. Future development at the local level is guided by many considerations, only one of which is the reliability of water supply. These other factors include the policies in local general plans and zoning ordinance restrictions; the availability of a wide range of community services and infrastructure, such as sewage treatment facilities and transportation infrastructure; the availability of developable land; the types and availability of employment opportunities; and the analysis and conclusions based on an environmental review of proposed projects pursuant to CEQA. These local land use decisions and the environmental impacts associated with these site-specific decisions are outside the scope of this Programmatic EIS/EIR but can and should be considered by the local governments acting on future development proposals.

Short- and Long-Term Relationships. The Preferred Program Alternative generally would maintain and enhance long-term productivity of water supply resources. However, the Preferred Program Alternative may also cause adverse impacts on water supply resources resulting from short-term uses of the environment.

Significant overall benefits to the long-term productivity of water supply resources result from Program actions. Benefits resulting from increased water use efficiency, improved water transfer processes, better water quality, improved Delta water conveyance and additional water storage opportunities outweigh the short-term adverse impacts.

Construction of water facilities may result in local construction-, operation-, and maintenance-induced impacts on the environment like temporary increase of water use due to workers and their families living in the area. Specific local construction-related impacts depend on the specific project and would be addressed at project-level analysis.

Short-term construction-related impacts on water supply resources would be localized and cease after construction is completed. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on these resources. Potentially significant long-term unavoidable impacts are discussed below.

Irreversible and Irretrievable Commitments. The Water Use Efficiency, Water Transfer, Water Quality, Storage, Conveyance, and other Program elements of the Preferred Program Alternative can be considered to cause significant irreversible changes to water supply resources. Avoidance and mitigation measures could be implemented to lessen adverse effects, but changes will be experienced by future generations. The long-term beneficial irreversible changes include the beneficial effects of improved water supplies to urban and agricultural sectors. Long-term adverse irreversible changes include potential displacement of water supplies from regions or uses to other areas or uses.

5.1.11 MITIGATION STRATEGIES

Potential decreases in agricultural and urban water supplies from Bay-Delta sources could result from increased environmental water needs and drinking water quality requirements under the No Action Alternative. These potential consequences may be reduced or eliminated by several strategies included in the Preferred Program Alternative. Implementation of an EWA may allow for more efficient use of water for environmental purposes and decrease the conflict in uses of Bay-Delta water supplies. Optimizing the use of alternative water management tools, including water use efficiency measures, water recycling, and water transfers may improve the availability and economic utility of water supplies. Implementing water quality improvement actions may enhance the quality of source water supplies, thereby providing additional operational flexibility to meet water supply reliability and quality goals. Conveyance improvements may also increase the flexibility of water project operations and improve water supply reliability. Finally, new storage may provide improved water management capability and enhanced water supply reliability.

Potential long-term adverse effects on specific regional agricultural and urban water supplies could result from increased water transfers. Areas with adequate water supplies could transfer portions of those supplies to areas with higher economic return from the use of water. Water transfers can affect third parties (those not directly involved in the transaction), local groundwater, environmental conditions, or other resource areas. Additional discussion on the potential impacts of water transfers on groundwater resources, agricultural social issues, and regional economics is included in Sections 5.4, 7.3, and 7.10, respectively. These chapters describe mitigation strategies to reduce third-party impacts associated with transfers. In addition, some of the actions described in the Water Transfer Program Plan, in conjunction with existing requirements, will protect against adverse third-party impacts associated with water transfers. (See Chapter 4 in the Water Transfer Program Plan.)

Conversion of Delta land use from agriculture to wetlands and marshes under the Ecosystem Restoration Program could result in increased water use and potential negative impacts on agricultural and urban water supply reliability. The combined beneficial effect on water supply and water management resources from actions under the Preferred Program Alternative, including the Water Quality Program, Water Use Efficiency Program, Water Transfer Program, conveyance improvements, and potential new water storage facilities, is expected to offset this potential loss of water supply, resulting in no significant adverse impacts.

Temporary local impacts on water supply reliability could occur during construction of the Program's proposed facilities. Potential temporary interruptions in water supply due to turbidity of water during levee work could negatively impact water supply and water management. This impact can be mitigated to a less-than-significant level.

Additional mitigation strategies will be considered during project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

5.1.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Despite the many effects on water supply caused by the Preferred Program Alternative, no potentially significant unavoidable impacts are expected.

5.2 Bay-Delta Hydrodynamics and Riverine Hydraulics

The CALFED Bay-Delta Program alternatives could result in changes to Delta inflow and export patterns, and modifications to the configuration of Delta channels. Environmental implications of changes in Bay-Delta hydrodynamics and riverine hydraulics are discussed in other sections of this report in the context of each of the resources affected by the changes.

5.2 Bay-Delta Hydrodynamics and Riverine Hydraulics

5.2.1 SUMMARY

Delta hydrodynamic conditions are primarily determined by tides, Delta inflow and outflow, diversions, and Delta channel configuration. The CALFED Bay-Delta Program (Program) alternatives could result in changes to Delta inflow and export patterns, and modifications to the configuration of Delta channels. These changes would affect Bay-Delta hydrodynamics and riverine hydraulics, and could result in impacts or benefits to other environmental resources dependent on Delta flow patterns.

Although Program-induced changes in hydraulic parameters, including flow, velocity, stage, and related variables, such as X2 position, are described in this section, the environmental implications of these changes are not. Environmental implications of changes in Bay-Delta hydrodynamics and riverine hydraulics are addressed in other sections of this report in the context of each of the resources affected by the changes.

Preferred Program Alternative. The Preferred Program Alternative could affect Bay-Delta hydrodynamics and riverine hydraulics through changes in the configuration of Delta channels, construction of new storage facilities, and related changes in system operations. Construction of a diversion facility on the Sacramento River could significantly affect Bay-Delta hydrodynamics. With a diversion facility on the Sacramento River of 4,000 cfs, net flow in the San Joaquin River west of the Mokelumne River is more frequently positive. Similar to the No Action Alternative, under the Preferred Program Alternative without a diversion facility near Hood, net flow in the San Joaquin River is generally negative toward the pumping plants in the south Delta from the junction of the Sacramento and San Joaquin Rivers. This condition is most pronounced at times of high exports and low Delta inflow.

Under the Preferred Program Alternative, new storage facilities may be constructed in the Sacramento River, San Joaquin River, and Delta Regions. Storage of water takes place during high-flow periods; release of water generally takes place during lower-flow periods. Resulting changes in Delta inflow and diversion patterns would cause relatively small effects on Delta channel flows when compared to Delta inflows, diversions, and tidal actions.

Alternatives 1, 2, and 3. During most months under Alternative 1, the direction of net flows in the San Joaquin River is negative toward the pumping plants from the junction of the Sacramento and San Joaquin Rivers. This condition is most pronounced at times of high exports and low Delta inflow. Under Alternative 2, sufficient quantities of water would be diverted near Hood to maintain net positive flow in the San Joaquin River west of the Mokelumne River. Under Alternative 3, about 40-90% of the water exported from the Delta would pass through an isolated conveyance facility and about 10-60% would be diverted directly from the south Delta—depending on the operating rules and capacity of the isolated conveyance facility. For most Delta channels, net positive flow occurs under Alternative 3. The effects on Bay-Delta hydrodynamics and riverine hydraulics from potential new storage facilities under Alternatives 1, 2, and 3 are similar to those described for the Preferred Program Alternative.

5.2.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use.

Evaluation of Bay-Delta hydrodynamics and riverine hydraulics relies on the development of assumptions and methodologies that may result in disagreements among technical experts and, therefore, constitute areas of controversy as used by CEQA. The use of different assumptions and methodologies may lead to conclusions that overestimate or underestimate the impact of Program actions on Bay-Delta hydrodynamics and riverine hydraulics. To fully describe potential consequences of Program actions, a reasonable range of uncertainty has been incorporated into this programmatic analysis. For details, refer to Section 5.1.4.2, "Addressing Uncertainty," in Section 5.1, "Water Supply and Water Management."

The Program recognizes the importance of Bay-Delta hydrodynamics and riverine hydraulics to regions potentially affected by Program actions. One important area of controversy centers on the magnitude of effects of Program actions on Delta hydro-dynamics and the subsequent effect on access to water supplies for Delta agriculture. As a multi-million dollar industry, agriculture is the basis of livelihood for many small communities in the Delta. Another important area of controversy centers on the potential impacts of riverine flow modification on ecosystem health. Regardless of disagreements over the measurement of Program effects, CALFED recognizes the importance of adequate access to water supplies and flows to Delta agriculture and ecosystems. Potential adverse effects on flows or water levels that affect individuals or businesses dependent on Delta diversions for their livelihood are discussed throughout this document. Water supply issues are discussed in Section 5.1, agricultural economics are discussed in Section 7.2, and urban water supply economics are discussed in Section 7.5. Likewise, any potential adverse effects on riverine flow patterns that affect ecosystem health are discussed in other chapters of this document. Fisheries and aquatic resources are discussed in Section 6.1, and vegetation and wildlife are discussed in Section 6.2. Subsequent project-specific environmental analysis will evaluate these impacts in more detail.

5.2.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

This section describes existing conditions for Bay-Delta hydrodynamics and riverine hydraulics. As discussed further in Section 5.2.4, existing Bay-Delta hydrodynamics and riverine hydraulics were assessed through simulation of 1995-level conditions. A comparison of existing conditions with the 2020-level No Action Alternative is provided in Section 5.2.6.

5.2.3.1 DELTA REGION

Delta hydraulics and hydrodynamics are influenced by the interaction of tributary inflows, tides, Delta geometry, and diversions. The Delta receives runoff from a watershed that includes more than 40% of the state's land area. Tributaries that directly discharge into the Delta include the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers.

Existing conditions in the Delta are the result of the many changes that have occurred as the Delta Region has developed over the past 150 years. During the mid-1800s, the Delta, an area of nearly 750,000 acres, was mostly undeveloped tidal marsh. The Delta was inundated each year by winter and spring runoff. During this early period prior to development, Delta channel geometry changed in response to the forces of floods and tides. By 1930, nearly all Delta marshland had been reclaimed for agriculture, peat production, and urban and industrial uses. Delta channels and islands became more permanently established. New linear channels were dredged, replacing natural meandering channels. These new channels were constructed for navigation, to improve circulation, and to provide the material needed for levee construction. Examples of new channels include Grant Line Canal, Victoria Canal, Empire Cut, Columbia Cut, and the Delta Cross Channel (DCC). The two major navigation waterways include the Stockton Deep Water Channel, completed in 1933 (along the San Joaquin River), and the Sacramento Deep Water Channel, completed in 1963.

Today, the Delta consists of about 740,000 acres, including approximately 500,000 acres of rich farmland, interlaced with hundreds of miles of waterways that divide the Delta into islands. Some of the island interiors are as much as 25 feet below sea level. Therefore, the Delta relies on about 1,100 miles of levees for flood protection. Refer to Figure 5.2-1 for a Delta location map.

Water exports from the Delta began in 1940, following completion of the Contra Costa Canal, a unit of the CVP. In 1951, the Tracy Pumping Plant began supplying water to the Delta-Mendota Canal (DMC). The SWP began exporting water through the South Bay Aqueduct (SBA) in 1962 (through an interim connection to the CVP's DMC). As statewide water demands grew, the SWP began pumping from the south Delta in 1967 (supplying the California Aqueduct) and from the north Delta in 1987 (supplying the North Bay Aqueduct [NBA]).

To facilitate movement of Sacramento River water to pumping facilities in the south Delta, Reclamation completed the DCC in 1951. This channel connects the Sacramento River to Snodgrass Slough and the Mokelumne River system. The flow from the Sacramento River is controlled by two 60-foot gates on the Sacramento River near Walnut Grove. Downstream from the DCC, Georgiana Slough also connects the Sacramento River to the Mokelumne River system, allowing Sacramento River water to enter the central Delta.

Delta hydrodynamic conditions primarily are determined by inflow to the Delta from tributary streams, daily tidal inflow and outflow through the Bay, and pumping from the south Delta through the Harvey O. Banks Delta Pumping Plant (Banks Pumping Plant) and Tracy Pumping Plant. Since tidal inflows are about equal to tidal outflows during each daily tidal cycle, tributary inflows and export pumping are the principal variables that define the range of hydrodynamic conditions in the Delta.

Twice-daily tides move water from San Francisco Bay into the Delta. The average incoming and outgoing Delta tidal flow is about 170,000 cfs at Chipps Island. By comparison, the current allowable SWP and

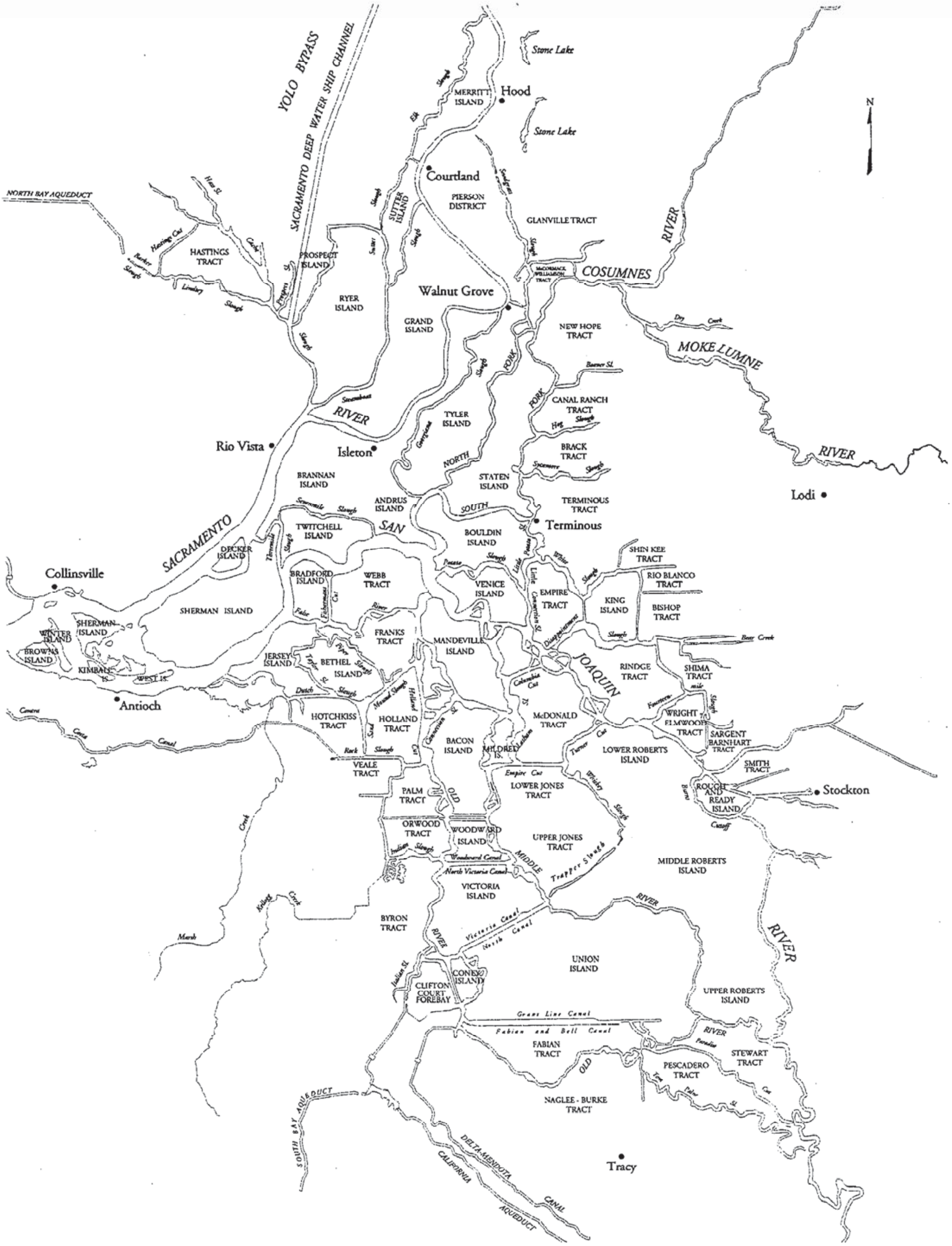


Figure 5.2-1 Delta Location Map

CVP combined export capacity is about 11,000 cfs. Historically, during extremely low runoff periods in summer, salt from tidal flows intruded into the Delta as far as Hood. During winter and spring, fresh water from heavy rains pushed the salt water back, well into the Bay, and sometimes beyond. Salt-water intrusion into the Delta during summer is controlled by tides, fresh-water inflows from reservoir releases, and Delta pumping. Reservoir storage and releases have resulted in increased summer and fall flows, and dampened peak winter and spring flows. In very wet years, reservoirs are unable to control runoff, and salinity in the Bay is nearly reduced to fresh-water levels.

The three major sources of fresh water to the Delta are the Sacramento River, the San Joaquin River, and east side streams. The Sacramento River (including the Yolo Bypass) contributes about 77-85% of the fresh-water inflows to the Delta. The San Joaquin River contributes roughly 10-15%. Streams on the east side, including the Mokelumne River, provide the remainder of the Delta inflow. On average, about 10% of the Delta inflow is withdrawn for local use, 30% is withdrawn for export by the CVP and SWP, 20% is required for salinity control, and the remaining 40% provides outflow to the San Francisco Bay ecosystem in excess of minimum identified requirements. These unallocated outflows are negligible during most dry seasons.

Each region in the Delta is dominated by different hydraulic variables during any given period of time. In the west Delta, for example, tidal influences are strong and reverse flows occur frequently. The north Delta is more dominated by Sacramento River and Mokelumne River inflows. The south Delta is more affected by both San Joaquin River inflows and export pumping. All of these influences intersect in the central Delta.

QWEST is a measure of net flow in the lower San Joaquin River and other smaller Delta channels. In this evaluation, QWEST is estimated as a function of cross-Delta flow, San Joaquin River and eastside tributary inflow to the Delta, in-Delta diversions, and exports from the Delta. Over the long-term period under existing conditions, the greatest average monthly positive QWEST flow typically occurs in February and is about 7,300 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and is about (-3,600) cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under existing conditions, the greatest average monthly positive QWEST flow typically occurs in April and is about 1,300 cfs. The greatest average monthly reverse flow typically occurs in December and is about (-5,000) cfs.

Water levels, or stage, vary greatly during each tidal cycle, from less than 1 foot on the San Joaquin River near Interstate 5 to more than 5 feet near Pittsburg. In the south Delta, lowering water levels associated with CVP and SWP pumping are of concern for local agricultural diverters. Over the long-term period under existing conditions, the highest minimum stage in Middle River typically occurs in February and is about 0.1 foot below mean sea level (msl). The lowest minimum stage typically occurs in August and is about 0.8 foot below msl. During dry and critical years under existing conditions, the highest minimum stage in Middle River typically occurs in April and is about 0.6 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl.

5.2.3.2 BAY REGION

The San Francisco Bay system includes the Suisun, San Pablo, and South Bays. The outlet of San Francisco Bay at Golden Gate Bridge is located 74 km from Chipps Island, the interface between the Delta and

Suisun Bay. North of Suisun Bay and east of Carquinez Strait lies the Suisun Marsh, an extensive mosaic of variably controlled tidal marshlands. Tributaries to San Pablo Bay include the Napa, Sonoma, and Petaluma Rivers. The principal tributary to the South Bay is Coyote Creek. Numerous lesser streams collectively drain the Bay Region.

San Francisco Bay currently has a surface area of about 400 square miles at mean tide level. Most of the Bay's shoreline has a mild slope, which creates a relatively large intertidal zone. The volume of water in the Bay changes by about 21% from mean higher-high tide to mean lower-low tide. The overall average depth of the Bay is only about 20 feet, with the Central Bay averaging 43 feet and the South Bay averaging 15 feet. San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

Average net Delta outflow into the Bay Region as measured at Chipps Island is about 20,400 cfs, or about 15 MAF per year. Average natural fresh-water inflow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During summer months of critically dry years, net Delta outflow can fall as low as 3,000 cfs.

In addition to Delta outflow, San Francisco Bay receives fresh-water inflow from the Napa, Petaluma, and Guadalupe Rivers and from Alameda, Coyote, Walnut, and Sonoma Creeks and a number of smaller streams. The total average inflow of these tributaries (excluding the Delta) is about 350 TAF. Stream flow is highly seasonal, with more than 90% of the annual runoff occurring during November through April.

Suisun Bay and the adjacent 80,000-acre Suisun Marsh are located near the downstream end of the Delta. Suisun Bay is the area where the effects of mixing fresh water and salt water are typically most pronounced.

Downstream of Carquinez Strait are the San Pablo and central San Francisco Bays. Carquinez Strait separates these bays from Suisun Bay and the Delta, and allows tides to play a leading role in their salinity and circulation. These embayments can become quite fresh, especially at the surface, during extremely high fresh-water flows. During these high flows, the entrapment zone can be temporarily relocated downstream to San Pablo Bay. During periods of low fresh-water flows and high tides, these embayments are quite saline.

The South Bay is different from the other parts of the system. This area is not in the main path of Delta outflows. Thus, except during sustained high-outflow periods, water quality is not significantly affected by Delta outflow. These sustained events do, however, play a significant role in flushing contaminants such as copper and nickel from the South Bay. During low Delta outflow periods, evaporation, combined with limited tidal flushing, can cause salinity levels to be higher in the South Bay than in the ocean outside the Golden Gate. Large level tracts of the South Bay are still used as evaporation ponds for salt production.

The Bay Region receives unallocated and minimum required outflows from the Delta Region. These can range from the minimum required flow of less than 4 to nearly 60 MAF, depending on precipitation and diversions. This water is used in the Bay Region primarily for ecological and water quality maintenance purposes.

The location of the mixing zone between fresh water from the Delta and saline water from the Bay varies with the amount of Delta outflow, as well as tides. The mixing zone is pushed downstream during periods of high Delta outflow and can move upstream into the Delta if Delta outflow is low or during spring neap tides. In order to track and regulate this movement, a standard has been developed, called X2, which represents the mean distance in kilometers (km) from the Golden Gate Bridge, where the salinity concentration is 2 parts per thousand (ppt) and the electrical conductivity (EC) is 2,640 μmhos/cm. The X2 position approximates the location of the entrapment zone, an area of high biological productivity. The Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta defines requirements for maintaining X2 at Port Chicago and Chipps Island. The CVPIA provides water supplies to further enhance X2 position for environmental benefits.

5.2.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region contains the entire drainage area of the Sacramento River and its tributaries, and extends almost 300 miles from Collinsville in the Delta north to the Oregon border. The total land area within the region is 26,960 square miles. Average annual precipitation is 36 inches, and average annual runoff is approximately 22.4 MAF.

The Sacramento River enters the Delta at Freeport. The drainage area of the Sacramento River above Sacramento, 11 miles north of Freeport, is 23,502 square miles. The average annual flow of the Sacramento River at Freeport is 16 MAF, more than twice the average annual flow measured in the Sacramento River above the confluence with the Feather River. The maximum mean monthly discharge at Freeport measured for the period of record was 71,340 cfs; the minimum mean monthly discharge was 4,494 cfs. Most flood flows that come from the upper Sacramento River, Feather River, and Sutter Bypass are diverted west of Freeport and the Sacramento area into the Yolo Bypass through the Fremont Weir at Verona. Overflows occur at this point when Sacramento River flows exceed 55,000 cfs at Verona. Sacramento River overflows also may enter the Yolo Bypass just north of Sacramento through the Sacramento Weir.

The two major tributaries to the Sacramento River along its lower reach are the Feather River (which also includes flows from the Yuba River) and the American River. The combined flows of the Feather River and the Sutter Bypass enter the river near Verona. The American River joins the Sacramento River north of downtown Sacramento. Smaller contributions are made by the Natomas Cross Canal, draining the area between the Bear River and American River, and the Colusa Basin Drain, which drains the west side of the Sacramento Valley from about Willows south to Knights Landing.

Six locations were selected as the focal points for analyzing current hydraulic conditions in the Sacramento River Region (Table 5.2-1). The locations were selected based on their proximity to principal hydraulic features in the region, and include stations on both the Feather and American Rivers.

The DWRSIM model was used to simulate monthly flows. Flow simulations illustrate how current storage and conveyance facility configurations would respond to the 73-year record of hydrologic input data from water year 1922 through water year 1994. Hydraulic geometry equations were derived from recent USGS gaging station data. These equations were used to estimate the mean velocity, stream width, and mean depth corresponding to the simulated average monthly discharges at each study location.

The results of the flow simulations for existing conditions for February and September are presented in Table 5.2-1. The maximum, minimum, and average values of hydraulic parameters for February and September are shown in the table. February was selected to represent wet season flows because average flows are highest in that month. September represents dry season flows because average flows are lowest during that month.

Table 5.2-1. Range of Existing Hydraulic Conditions at Selected Stations in the Sacramento River Region for February and September

FLOW CONDITION BASED ON 73-YEAR HYDROLOGICAL RECORD	SACRAMENTO RIVER AT				AMERICAN RIVER AT FAIR OAKS	FEATHER RIVER AT GRIDLEY
	FREEPORT	VERONA	WILKIN SLOUGH	KESWICK		
February						
Discharge (cfs)						
Maximum	90,878	95,756	95,758	41,772	30,098	26,992
Minimum	10,569	4,472	4,472	2,943	455	813
Average	34,554	22,411	22,411	9,535	4,470	5,987
Mean velocity (fps)						
Maximum	4.3	4.4	5.6	6.2	5.8	4.4
Minimum	1.3	1.7	2.3	0.7	0.7	0.3
Average	2.5	2.9	3.7	2.3	2.2	1.8
Top width (feet)						
Maximum	651.3	799.4	367.0	612.5	456.6	318.4
Minimum	584.9	464.2	217.3	423.0	256.1	273.8
Average	620.5	530.6	286.3	505.2	351.0	298.5
Mean depth (feet)						
Maximum	34.5	29.1	46.6	9.7	11.8	17.2
Minimum	15.2	5.6	8.9	3.8	2.6	9.4
Average	23.9	14.4	21.2	5.5	6.0	10.9
September						
Discharge (cfs)						
Maximum	22,439	9,870	9,870	8,553	5,089	6,228
Minimum	7,545	3,382	3,382	4,358	309	732
Average	12,141	5,463	5,463	5,946	2,745	1,718
Mean velocity (fps)						
Maximum	2.0	2.2	2.9	2.4	2.3	1.8
Minimum	1.1	1.6	2.1	0.6	0.5	0.3
Average	1.4	1.8	2.5	1.8	1.7	0.6
Top width (feet)						
Maximum	607.3	495.7	248.8	582.0	357.3	298.9
Minimum	575.1	453.5	207.1	571.3	242.8	272.6
Average	588.9	471.9	224.9	576.2	328.2	282.8
Mean depth (feet)						
Maximum	20.3	8.9	13.6	8.2	6.2	11.0
Minimum	13.4	4.7	7.6	7.4	2.3	9.3
Average	16.0	6.3	9.9	7.7	5.0	9.6

Notes:
cfs = Cubic feet per second.
fps = Feet per second.

The values shown in the table are estimates for comparison purposes. They depend on local stream channel geometry at the measurement points. Average velocities are calculated from the average monthly discharge divided by the cross-sectional area of the stream channel. Stream velocities at any point are greater in the center of the channel and lower at the margins and near the channel bottom due to friction. In addition, flow conditions may vary considerably over a month, particularly during the wet season.

Figure 5.2-2 shows the distribution of the simulated average monthly flows at Freeport using the 73-year hydrologic record. The Freeport station is used to represent the point at which the Sacramento River

Figure 5.2-2. Sacramento River Flow Frequency at Freeport under Existing Conditions

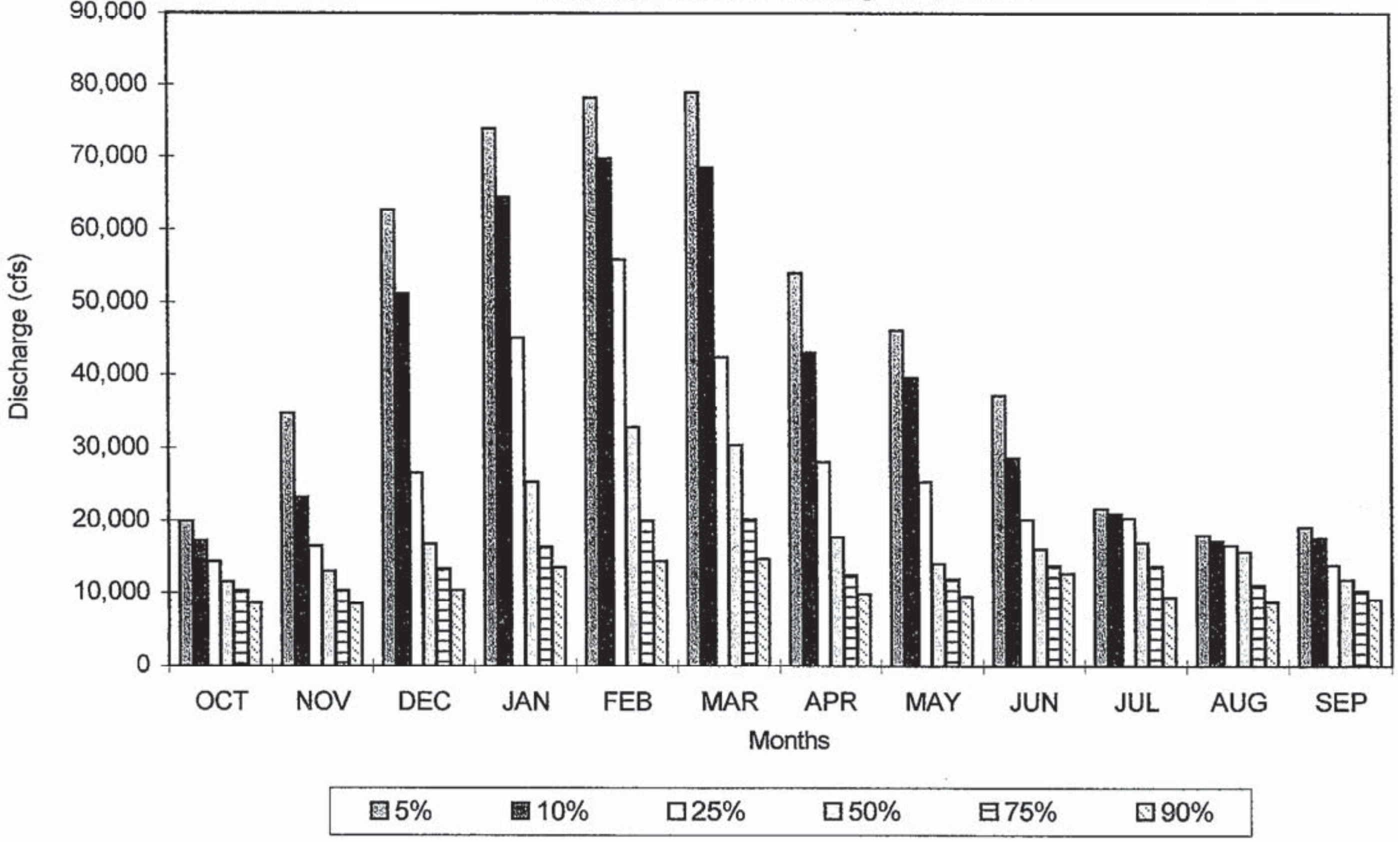
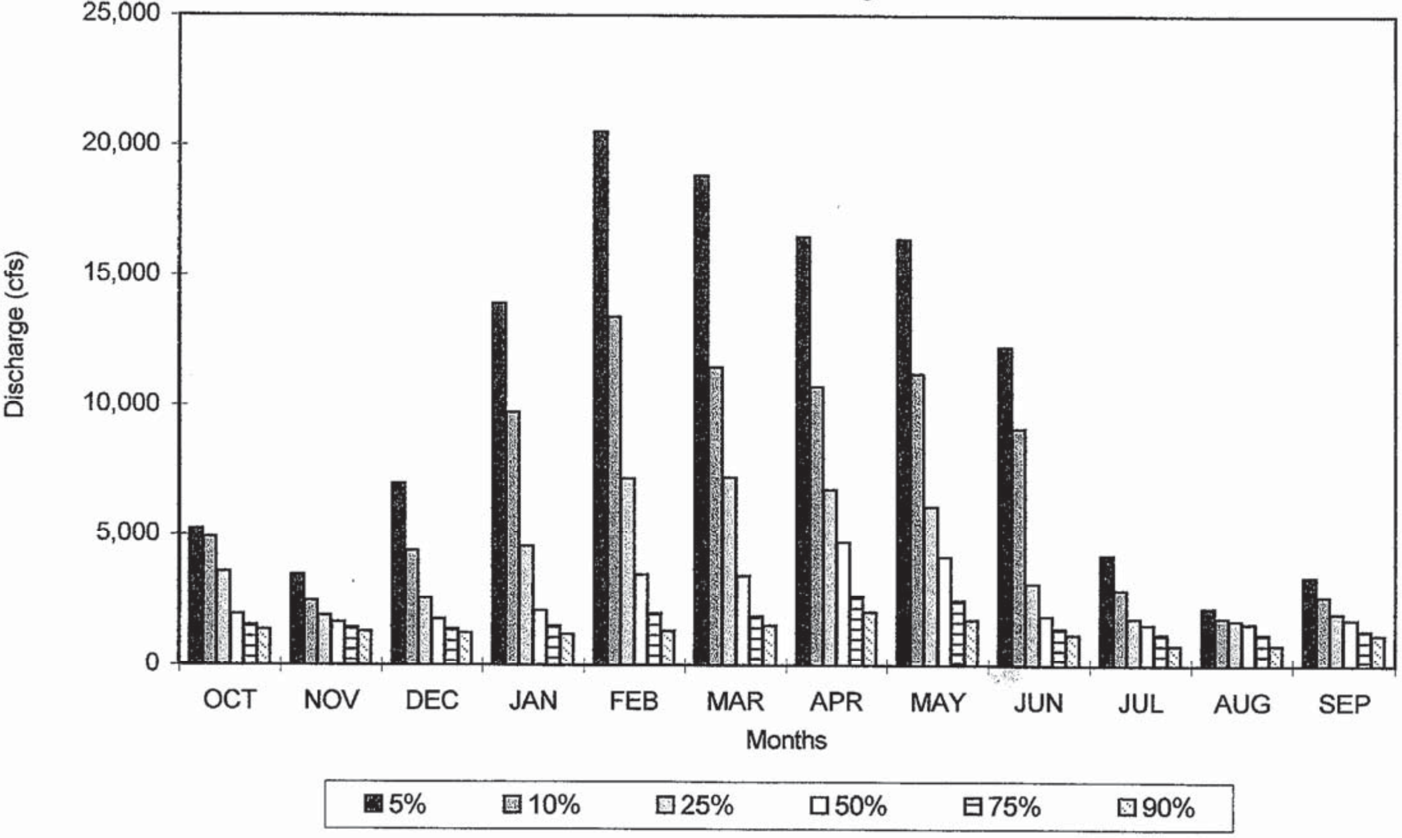


Figure 5.2-3. San Joaquin River Flow Frequency at Vernalis under Existing Conditions



enters the Delta. The heights of the bars correspond to the rate of discharge that is exceeded with the frequency shown in the Table below. The exceedance frequencies are based on the percentile ranking of the discharge values for the month. The percentile is calculated by ranking the values from smallest to largest. Since DWRSIM calculates the average monthly discharge for each month of the 73-year simulation period, 73 discharge values are associated with each month.

The maximum simulated discharge at Freeport in February is 91,000 cfs, the minimum is 10,600 cfs, and the average is 35,000 cfs. Figure 5.2-2 provides more information about the distribution of values between the extremes. Under the column representing February, the first value corresponds to the highest bar in the chart above it and is 80,000 cfs. This discharge would be exceeded in 5 out of 100 years in February at Freeport; therefore, this discharge has a 5% probability of being exceeded.

5.2.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region includes the Central Valley south of the watershed of the American River. It is generally drier than the Sacramento Valley, and flows into the Delta from the San Joaquin River are considerably lower than those from the Sacramento River. The region is also subject to extreme variations in flow, as exemplified by flooding that occurred during January 1997.

The drainage area of the San Joaquin River above Vernalis, the point at which the river enters the Delta, is 13,356 square miles, including 2,100 square miles of drainage contributed by James Bypass. Inflows from the Merced, Tuolumne, and Stanislaus Rivers historically contribute more than 60% of the flows in the San Joaquin River at Vernalis. Vernalis lies just inside the boundary of the Delta, but it is widely used as a monitoring point for Delta inflows and standards.

The USGS has operated a gaging station on the San Joaquin River near Vernalis since 1922, although complete records are available only back to 1930. The instantaneous maximum flow recorded at the station was 79,000 cfs, observed on December 9, 1950. The instantaneous minimum flow was 19 cfs, recorded on August 10, 1961. The maximum mean monthly discharge was 40,040 cfs in March 1983, and the minimum mean monthly discharge was 93 cfs in July 1977.

Three locations were selected to represent the range of existing hydraulic conditions in the San Joaquin River Region. The most important of these is the San Joaquin River at Vernalis because of its location near the Delta. The San Joaquin River at Newman was chosen to characterize the upstream portion of the river. The Stanislaus River below Goodwin Dam also was selected.

Table 5.2-2 presents the estimated range in discharge, average stream velocities, top width, and mean depth for February (high-flow period) and August (low-flow period). Figure 5.2-3 shows the frequency distribution of flows for the San Joaquin River at Vernalis, the point at which the river flows into the Delta. The data are plotted at the same scale used to plot the data for Sacramento River stations in order to illustrate the relative contributions in flows to the Delta from each river. As described for Sacramento River stations, the results indicate that the average winter flows are skewed by infrequent elevated flows. The medians in the low-flow months of July through November are nearly the same and stay within a narrow range, reflecting the effects of reservoir operations during these months.

Table 5.2-2. Range of Existing Hydraulic Conditions at Selected Stations in the San Joaquin River Region for February and August

FLOW CONDITION BASED ON 73-YEAR HYDROLOGICAL RECORD	SAN JOAQUIN RIVER AT		STANISLAUS RIVER BELOW GOODWIN DAM
	VERNALIS	NEWMAN	
February			
Discharge (cfs)			
Maximum	33,024	19,447	4,390
Minimum	911	309	211
Average	5,539	2,541	537
Mean velocity (fps)			
Maximum	3.1	3.5	4.1
Minimum	1.4	0.9	1.1
Average	2.1	1.8	1.7
Top width (feet)			
Maximum	503.7	498.7	146.7
Minimum	245.5	139.7	87.3
Average	289.9	190.7	100.1
Mean depth (feet)			
Maximum	19.5	10.7	7.3
Minimum	19.5	2.4	2.2
Average	19.5	7.8	3.1
August			
Discharge (cfs)			
Maximum	3,073	683	2,423
Minimum	618	341	114
Average	1,510	520	855
Mean velocity (fps)			
Maximum	1.8	1.2	3.4
Minimum	1.3	0.9	0.8
Average	1.6	1.1	2.2
Top width (feet)			
Maximum	274.6	157.1	130.3
Minimum	236.9	141.8	79.7
Average	257.2	150.9	107.2
Mean depth (feet)			
Maximum	5.9	3.8	5.5
Minimum	19.5	2.6	1.7
Average	19.5	3.3	3.7

Notes:

cfs = Cubic feet per second.
fps = Feet per second.

5.2.3.5 OTHER SWP AND CVP SERVICE AREAS

Surface water flows in the Other SWP and CVP Service Areas are not directly affected by the Program. Therefore, the region is not discussed further in Section 5.2.

5.2.4 ASSESSMENT METHODS

5.2.4.1 TOOLS

Refer to Section 5.1.4.1 for a description of tools used to assess potential impacts on Bay-Delta hydrodynamics and riverine hydraulics.

5.2.4.2 MODELING ASSUMPTIONS

Refer to Section 5.1.4.3 and Attachment A for a description of modeling assumptions used to assess potential impacts on Bay-Delta hydrodynamics and riverine hydraulics.

Sacramento River Diversion

Tables and figures in Section 5.1 for the Preferred Program Alternative reference a "Hood diversion." This location was used only for modeling purposes. The Preferred Program Alternative identifies a "diversion facility on the Sacramento River."

5.2.4.3 APPROACH

Delta hydrodynamic simulations were performed with DSM2, using Delta inflow hydrology resulting from the DWRSIM project operations simulations. Additionally, input to DSM2 was modified to represent different Delta geometries and export diversion locations. Flow patterns, velocities, water levels and transport processes within the Delta were evaluated reflecting the differences in input hydrology and Delta configuration. The DSM2 simulation output captures the effects of an average tide on Delta flows and water quality and also tracks the pattern of water migration from preselected points throughout the Delta (often referred to as "particle" or "mass fate" tracking).

The DSM2 simulations conducted for this evaluation assumed the south Delta channel modifications and flow control structure configurations described in Attachment A. Other south Delta channel modifications and flow control structure configurations are possible under the Program alternatives, as described in Chapter 2. Under these other configurations, flows in the south Delta would vary slightly in comparison to those described in Section 5.2. These flow differences are not expected to affect the environmental consequences associated with Bay-Delta hydrodynamics and riverine hydraulics, as described in this report. Flows in other parts of the Delta would be largely unaffected by the south Delta channel modifications and flow control structure configurations.

DSM2 Modeling

Potential Delta impacts evaluated with DSM2 include the following:

- Effects on monthly average net flows and tidal velocities in Delta channels.
- Effects on monthly average Delta flow patterns at several locations in the Delta.
- Changes in monthly average salinity.
- Changes in the fate of mass released at particular locations in the Delta.

The DSM2 simulations incorporate a 16-year hydrologic period from October 1976 to September 1991. Where modeling results were incomplete or not applicable, impacts were estimated based on other available information and professional judgment. For example, in-Delta storage is included in the Program alternatives as described in Section 2.1.4. In-Delta storage might include many different configurations, with intakes and discharges at many different locations and operated under a variety of rules. It is not practical to use DSM2 to simulate all variations. Therefore, professional judgment is used in this document to provide a quantitative description of the consequences of in-Delta storage operations. Specific in-Delta storage alternatives will be studied in greater detail prior to implementation. Other methods of analysis are documented as needed in this document.

Delta Region

Hydrodynamic impacts of Program alternatives on the Delta were evaluated based on in-Delta modifications and changes in CVP and SWP operations. The potential impacts on the Delta were evaluated with DSM2 as shown in the box.

Several Delta channel flows were evaluated and summarized in this document for each Program alternative, including: Sacramento River flow at Rio Vista, QWEST flow, cross-Delta flow, Old River flow at Bacon Island, and San Joaquin River flow at Antioch.

The DSM2 model was used to perform several mass tracking simulations for existing conditions and the Program alternatives, including the No Action Alternative. Mass tracking simulations provide an assessment of particle movement in the Delta under different hydrologic conditions. Mass tracking provides insight into relationships between Delta circulation patterns and the fate, movement, and residence time of fish eggs and larvae. The term "mass injection" is used to indicate the simulation of mass addition to the model for analysis purposes.

Mass Tracking

The transport and fate of mass released into the Delta at various locations was simulated for the following flow conditions:

- High inflow/high pumping, represented by February 1979
- Medium inflow/low pumping, represented by April 1991
- Low inflow/high pumping, represented by October 1989
- Low inflow/low pumping, represented by July 1991

These flow conditions were selected to bookend the full range of conditions expected to result from implementing Program alternatives. The months indicated were selected based on combinations of high and low events of inflows and high exports conditions.

Through simulation studies, mass was released at three discrete locations in the Delta to determine its fate under existing conditions and the Program alternatives. Mass was injected in the north Delta at Freeport, in the central Delta at Prisoner's Point, and in the south Delta at Vernalis. Differences between alternatives were evaluated for all three injection points by comparing the change in distribution of mass after 30 days.

The distribution of mass was evaluated by determining the relative percentages of mass reaching predetermined locations. These percentages consist of the amount of mass that stay in the Delta, the amount that is lost to the Delta islands, the amount that is lost to exports, and the amount that reaches

Chipps Island. Mass fate assessments were limited to water management Criterion B. Criterion B results in greater potential changes in mass fate relative to existing conditions than Criterion A.

Bay Region

The evaluation of impacts on Bay Region hydrodynamics that are associated with the Program alternatives focuses on X2 position and Delta outflow. Section 5.2 does not evaluate the potential changes of flow regimes on sediment transport from the Delta to the Bay and flow-related mixing and transport of sediments within the Bay Region. Sediment movement is a dominant transport mechanism for many contaminants.

Sacramento River and San Joaquin River Regions

DWRSIM model studies provide a preliminary assessment of the magnitude of riverine flow changes that would be expected for each Program alternative and variation. The hydraulic effects of some configurations are expected to be similar to other configurations. Differences between such configurations are discussed in qualitative terms.

The output from DWRSIM consists of calculated monthly flow volumes representing the amount of water in thousands of acre-feet (TAF) that passes a control point defined in the model. These volumes can be readily converted to an average monthly flow rate expressed in cfs. With a few exceptions, the control points generally represent actual locations along channels within the storage and conveyance system. Two locations in the Sacramento River and San Joaquin River Regions (Freeport and Vernalis) were selected as the focal points for analyzing hydraulic changes in the rivers.

DWRSIM model studies also provide a preliminary assessment of releases from existing reservoirs, as well as diversions and releases from new reservoirs. Simulation results of reservoir releases are presented from a regional perspective, consistent with a program-matic-level evaluation. While changes in reservoir release flows were estimated for each of the larger facilities in the Sacramento River and San Joaquin River Regions, results are aggregated for purposes of presentation. Sacramento River Region reservoirs include Shasta, Oroville, and Folsom. San Joaquin River reservoirs include New Melones, New Don Pedro, and McClure. The evaluation of new reservoirs in the Sacramento River Region distinguishes between releases for environmental uses and for water supply uses.

5.2.5 SIGNIFICANCE CRITERIA

Although Program-induced changes in hydraulic parameters, such as flow, velocity, stage, and related variables (for example, X2 position), are described in this section, their significance and the environmental implications of these changes are not discussed. The significance of these changes is addressed in other sections of this report in the context of each of the resources affected by the changes.

5.2.6 NO ACTION ALTERNATIVE

To assess the consequences of the various Program alternatives on Bay-Delta hydro-dynamics and riverine hydraulics in the Program study area, a preimplementation condition must be established. Typically, existing conditions provide an adequate basis for assessing the impacts of proposed projects. (See Section 5.2.3 for a description of existing conditions.) However, Program implementation is expected to occur over a 20- to 30-year period. Bay-Delta standards and management criteria, water management facilities, and other conditions are not expected to remain constant over this extended period. The actual deviation between preimplementation conditions and existing conditions is subject to a high degree of uncertainty. Section 5.2.2 elaborates on the uncertainties associated with the Program.

A 2020 No Action Alternative was defined to represent a reasonable range of uncertainty in the preimplementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta management criteria that regulate system operations.

Under Criterion A, the Program assumes that existing Bay-Delta system water demands apply throughout the Program planning horizon. Under this assumption, any future increase in demands in the Program study area would be met by alternative supply or demand management options. This bookend of the No Action Alternative also includes more protective Delta management criteria regulating flows and exports. While specific assumptions regarding Delta management criteria were made to complete the water simulation modeling, the Program's intention is to depict a general level of protection. These assumptions should not be interpreted as specific predictions of future Delta management requirements. Criterion A results in generally lower Delta exports than existing conditions.

Under Criterion B, the Program assumes an increase in Bay-Delta system water demands of about 10% over existing conditions, as projected for 2020 in DWR's Bulletin 160-98. DWR has formed a technical peer review panel to review the Bulletin's urban water forecasting methodologies; however, the Bay-Delta system demands included in Bulletin 160-98 serve as a reasonable upper boundary for 2020 conditions. This bookend of the No Action Alternative includes no change in Delta water management criteria from existing conditions. Criterion B results in generally higher Delta exports than existing conditions. Details regarding assumptions used in the evaluation of the No Action Alternative are presented in Section 5.1.4 and Attachment A.

The programmatic comparisons presented in this section differentiate Bay-Delta hydrodynamics and riverine hydraulics under the No Action Alternative and existing conditions for the Delta, Bay, and Sacramento River and San Joaquin River Regions. As discussed in previous sections, riverine hydraulics outside the Central Valley are not expected to be directly affected by any Program alternative.

Most comparisons are made based on a 73-year historical hydrologic period, a sequence of years often referred to as the "long-term" period. Similar comparisons are made using a subset of the long-term period—the dry and critical years. Over the long-term period, 28 years are classified as dry or critical by the Sacramento Valley 40-30-30 Index. Some detailed Delta hydrodynamic analyses, conducted with the Delta hydrodynamic and water quality model DSM2, were conducted using a 16-year historical hydrologic sequence. This period was selected to cover a broad range of Delta inflows and exports, including several dry and critical years, and provides a good representation of the 73-year long-term period.

Comparisons of Bay-Delta hydrodynamics and riverine hydraulics characteristics under both No Action Alternative bookends were made with those same characteristics under existing conditions. For most parameters of interest, existing conditions fall between the two No Action Alternative bookends, within the range of uncertainty associated with the No Action Alternative. This trend applies to both the long-term period and dry and critical years. Specific comparisons of Bay-Delta hydrodynamics and riverine hydraulics characteristics under the No Action Alternative and existing conditions for the Delta, Bay, and Sacramento River and San Joaquin River Regions are presented below.

5.2.6.1 DELTA REGION

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows and mass fate throughout the Delta Region. To provide a programmatic overview, channel flows are described at five locations.

Channel Flows

Sacramento River Flow at Rio Vista. The 1995 WQCP specifies minimum flow rates in the Sacramento River at Rio Vista from September through December. The DSM2 analysis shows that in most months, the No Action Alternative provides no substantial change in average monthly Rio Vista flow relative to existing conditions. The analysis does, however, show some reductions in average flow during June and July. Over the long-term period, average monthly flow could decrease by as much as 12-17%. In dry and critical years, average monthly flow could decrease by as much as 30%. A comparison of monthly average Rio Vista flow is provided in Figure 5.2-4 for the long-term period and in Figure 5.2-5 for dry and critical years.

QWEST Flow. Tidal action has a great influence on the flow of water in Delta channels. Over the tidal cycle, flows move downstream toward the Bay during ebb tides and move upstream during flood tides. QWEST is a measure of the net flow direction from the west Delta: positive QWEST values signify net flow from the west Delta downstream toward the Bay, and negative QWEST values signify net flow from the west Delta upstream toward the southern and central Delta. The range of QWEST flows predicted for the No Action Alternative generally bracket flows under existing conditions. Average monthly QWEST flow is negative during August through December over the long-term period. During dry and critical years, average monthly QWEST flow is negative in most months. A comparison of monthly average QWEST flow is provided in Figure 5.2-6 for the long-term period and in Figure 5.2-7 for dry and critical years.

Cross-Delta Flow. The DCC also has a great influence on the flow of water in Delta channels. Flows through the DCC and Georgiana Slough, collectively referred to as cross-Delta flow, allow for the conveyance of Sacramento River water directly from the north Delta to the central and south Delta. Higher cross-Delta flows generally allow for more positive QWEST flows and improved water quality in the central and south Delta. However, operation of the DCC is regulated by the 1995 WQCP and the CVPIA to provide fishery protections. Except during June and July, no substantial change in average monthly cross-Delta flow is expected under the No Action Alternative relative to existing conditions.

Figure 5.2-4. Average Monthly Sacramento River Flow at Rio Vista under the No Action Alternative for the Long-Term Period

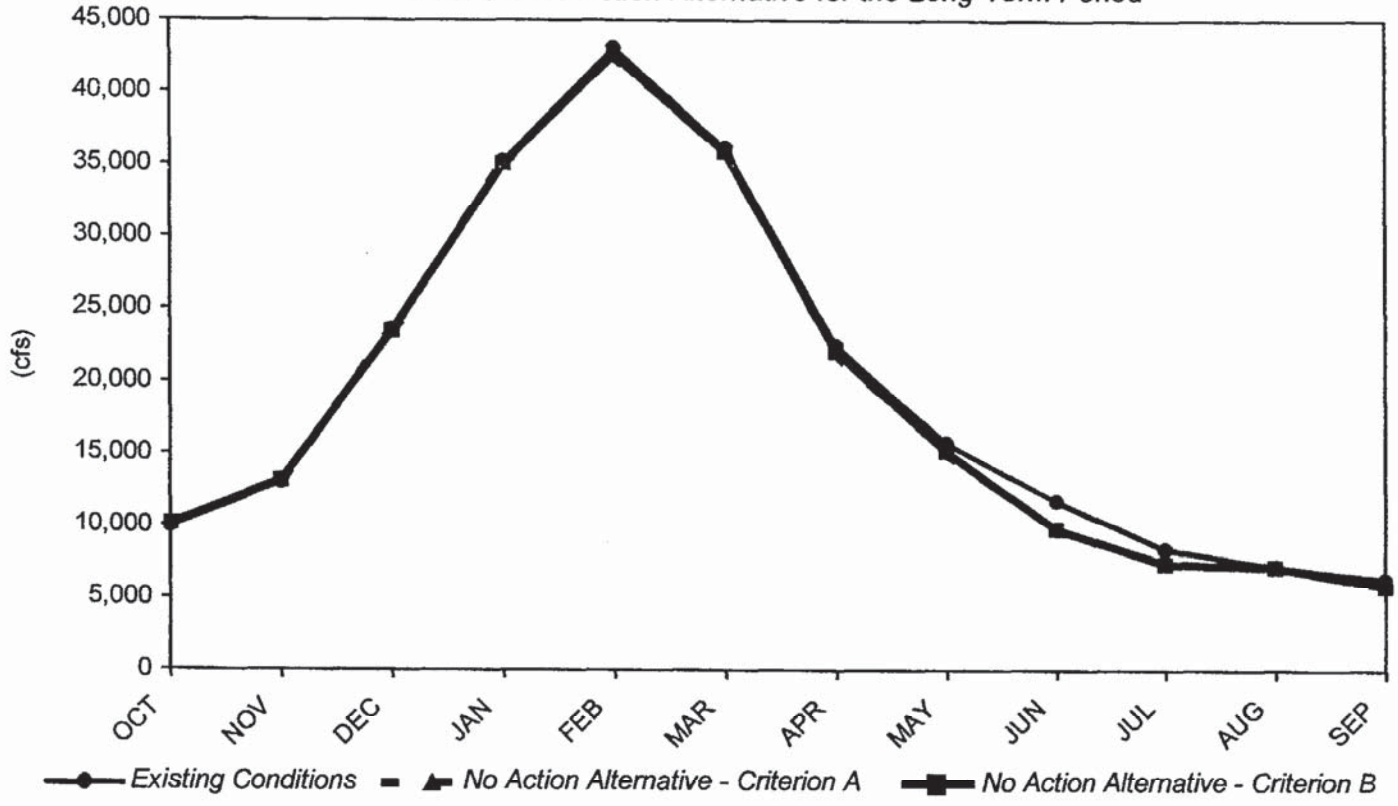


Figure 5.2-5. Average Monthly Sacramento River Flow at Rio Vista under the No Action Alternative for Dry and Critical Years

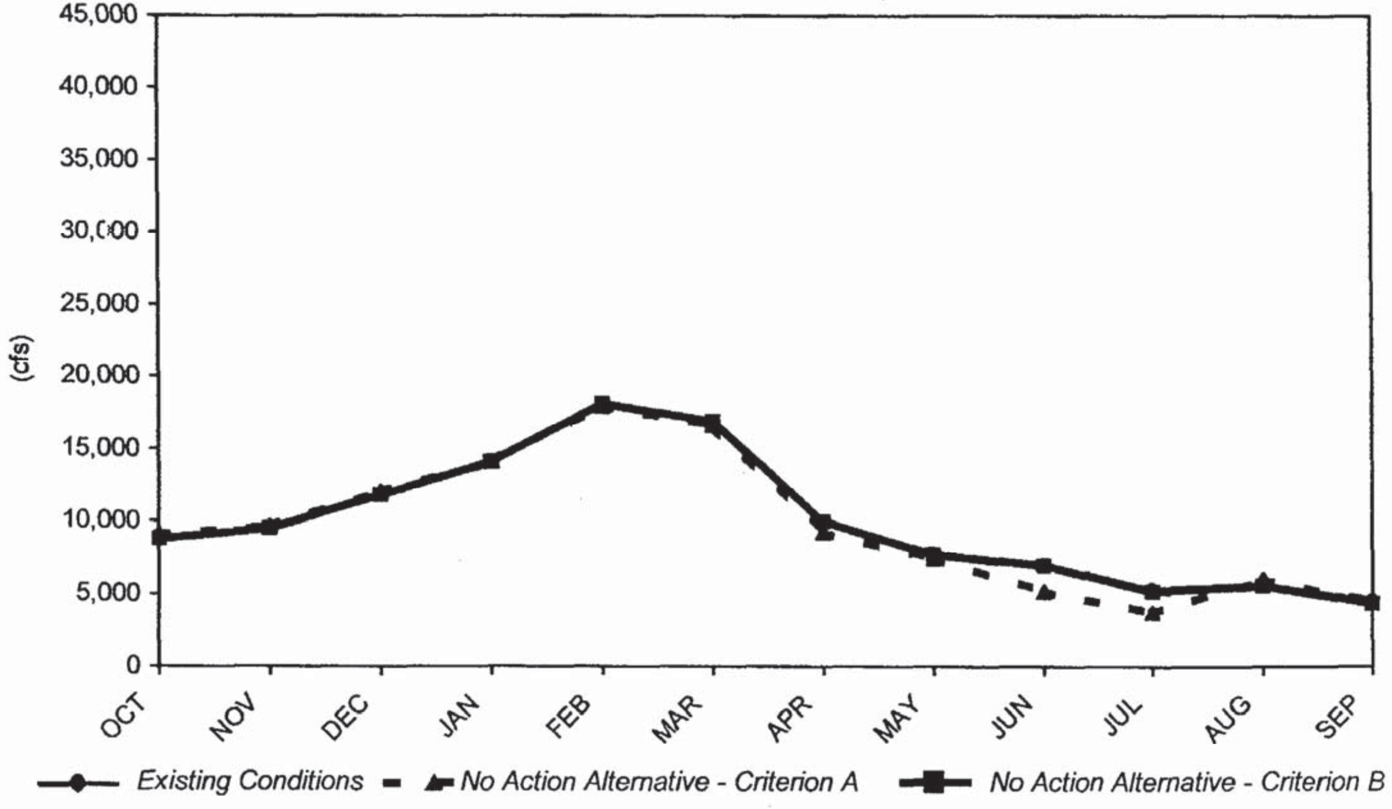


Figure 5.2-6. Average Monthly QWEST Flow under the No Action Alternative for the Long-Term Period

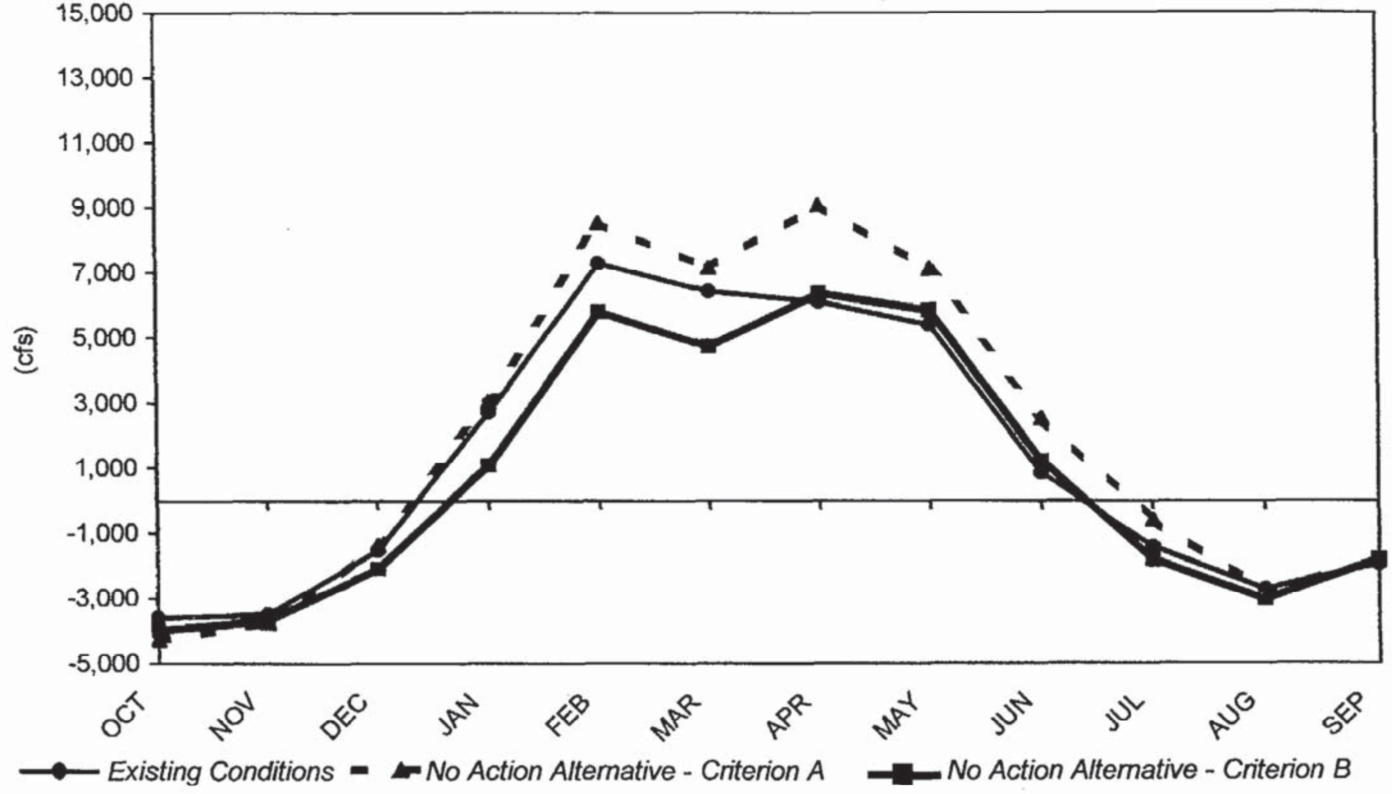
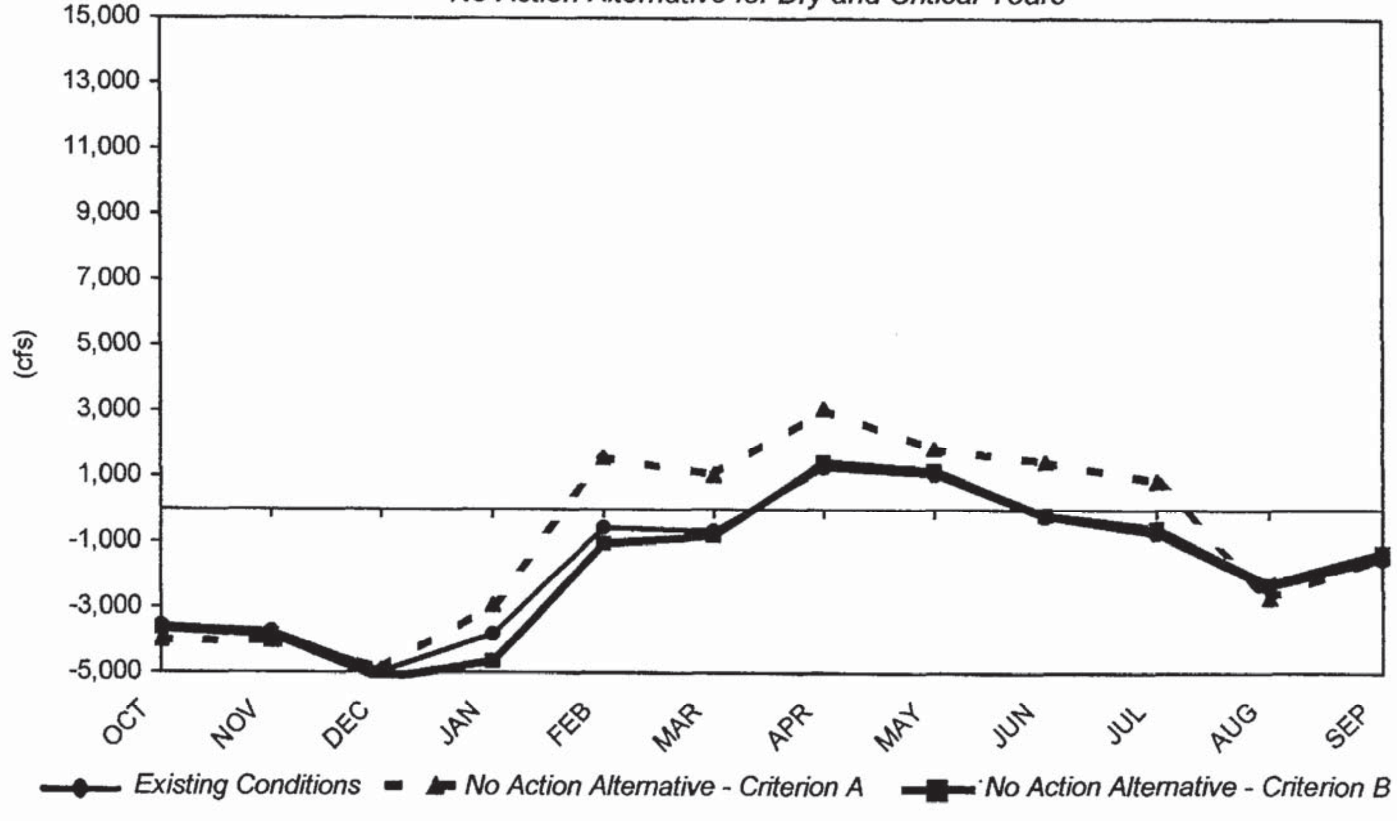


Figure 5.2-7. Average Monthly QWEST Flow under the No Action Alternative for Dry and Critical Years



Over the long-term period, average monthly flow during these months could increase by as much as 7% or could decrease by as much as 10%. In dry and critical years, average monthly flow could decrease by as much as 19%. A comparison of monthly average cross-Delta flow is provided in Figure 5.2-8 for the long-term period and in Figure 5.2-9 for dry and critical years.

Old River Flow at Bacon Island. The flow of water in Old River at Bacon Island is often used as an indicator of hydraulic conditions in the south Delta. Average monthly flow is generally negative over the long-term period, ranging from (-3,500) to (-3,400) cfs in August and from (-1,100) to (-100) cfs in April. Average monthly flow is always negative in dry and critical years, ranging from (-3,600) to (-3,000) cfs in August and from (-1,000) to (-100) cfs in April. The range of Old River flows predicted for the No Action Alternative at Bacon Island generally brackets flows under existing conditions.

San Joaquin River Flow at Antioch. Similar to QWEST, the net flow in the San Joaquin River at Antioch is a measure of tidal interactions between the west Delta and the interior Delta. The range of San Joaquin River flows predicted for the No Action Alternative at Antioch generally brackets flows under existing conditions. Average monthly flow is generally positive over the long-term period, ranging from (-1,200) to (-1,000) cfs in October and from 10,800 to 12,900 cfs in February. Average monthly flow ranges from (-2,400) to (-2,100) cfs in December and from 2,200 to 3,600 cfs in April of dry and critical years.

Mass Fate. The DSM2 model was used to perform several mass tracking simulations for existing conditions and the No Action Alternative. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

5.2.6.2 BAY REGION

The 1995 WQCP established fishery protection measures related to X2 position. The CVPIA provides water supplies to further enhance X2 position for environmental benefits. Under the No Action Alternative, monthly average X2 position over the long-term period ranges from a maximum downstream position of 65.3 km in March to a maximum upstream position of 87.0 km in September. The ranges of X2 position predicted for the No Action Alternative generally bracket values under existing conditions.

A comparison of monthly average X2 position is provided in Figure 5.2-10 for the long-term period and in Figure 5.2-11 for dry and critical years. As shown in the figures, the greatest deviations in monthly average values occur in winter. For the long-term period, X2 position could vary by (-0.5) to 0.6 km in January and could vary by (-0.6) to 0.5 km in February. In dry and critical years, X2 position could decrease by as much as 1.2 km or increase as much as 0.1 km in March relative to existing conditions.

5.2.6.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Programmatic comparisons of river flows and reservoir releases in the Sacramento River and San Joaquin River Regions were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative.

Figure 5.2-8. Average Monthly Cross-Delta Flow under the No Action Alternative for the Long-Term Period

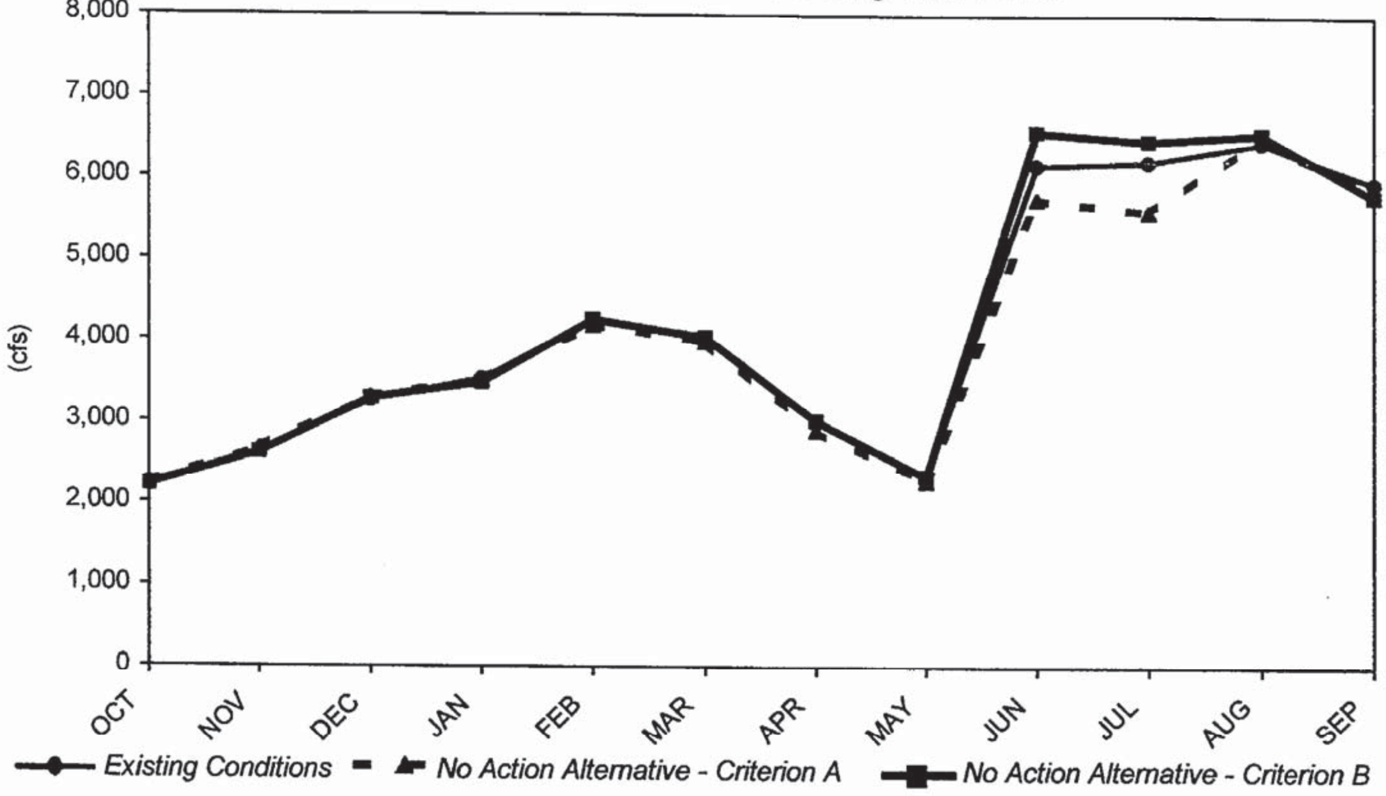


Figure 5.2-9. Average Monthly Cross-Delta Flow under the No Action Alternative for Dry and Critical Years

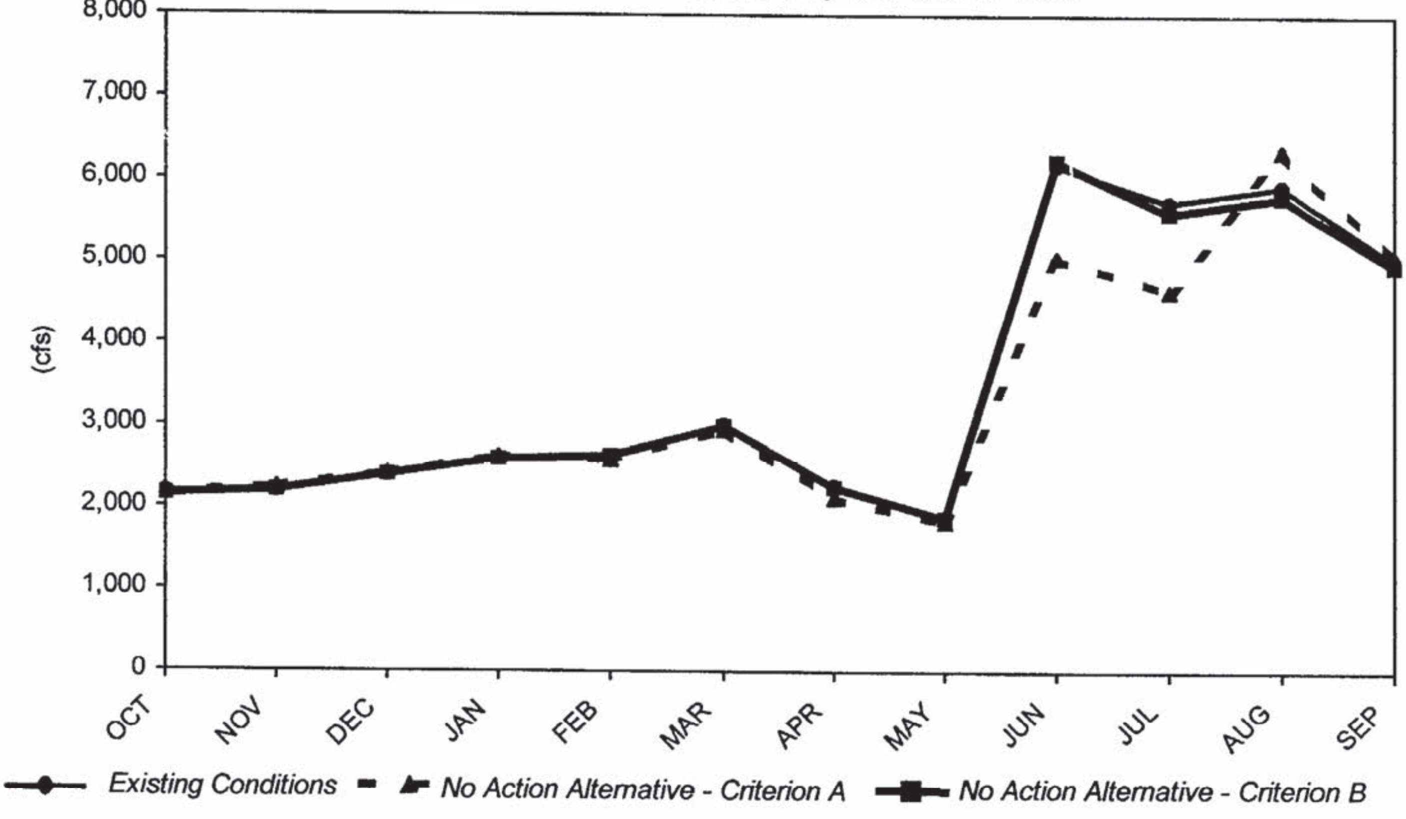


Figure 5.2-10. Average Monthly X2 Position under the No Action Alternative for the Long-Term Period

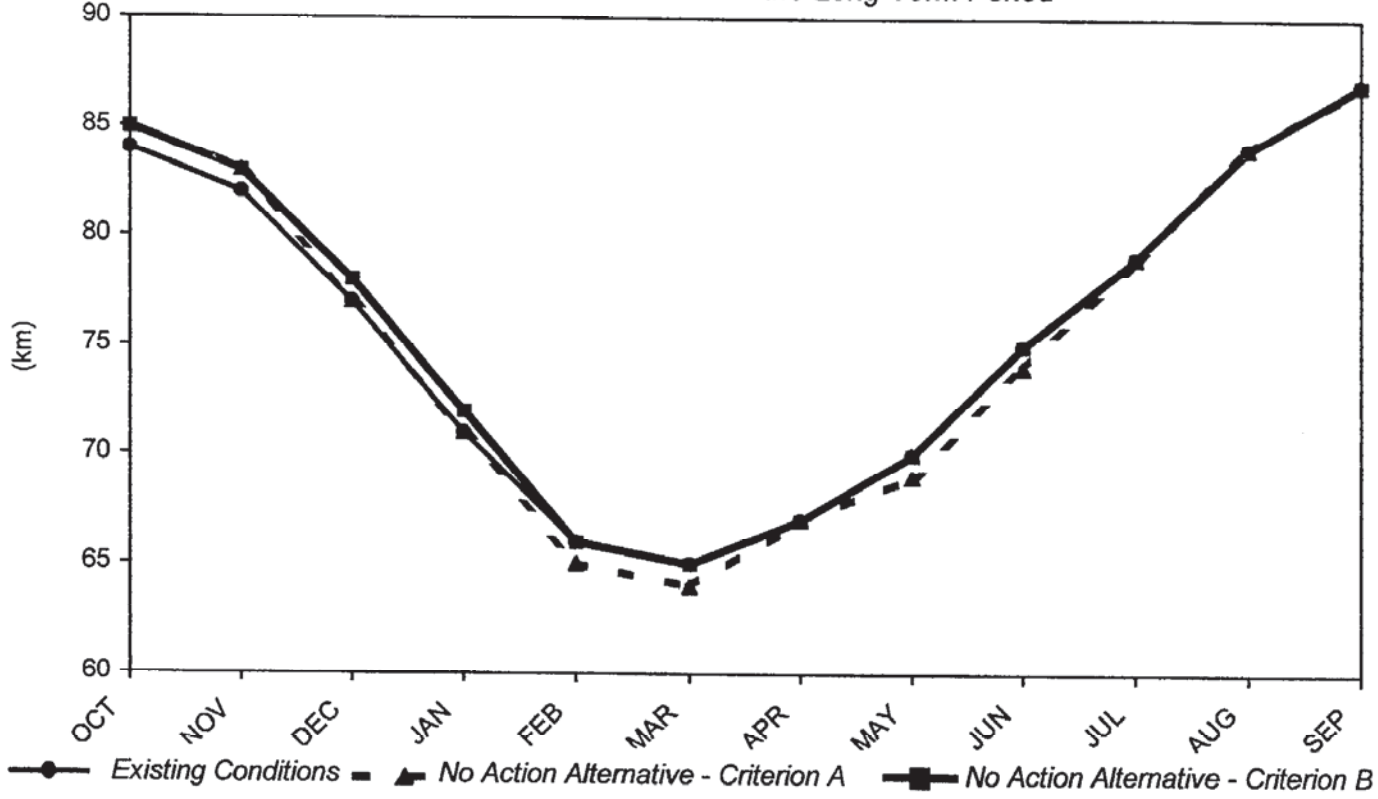
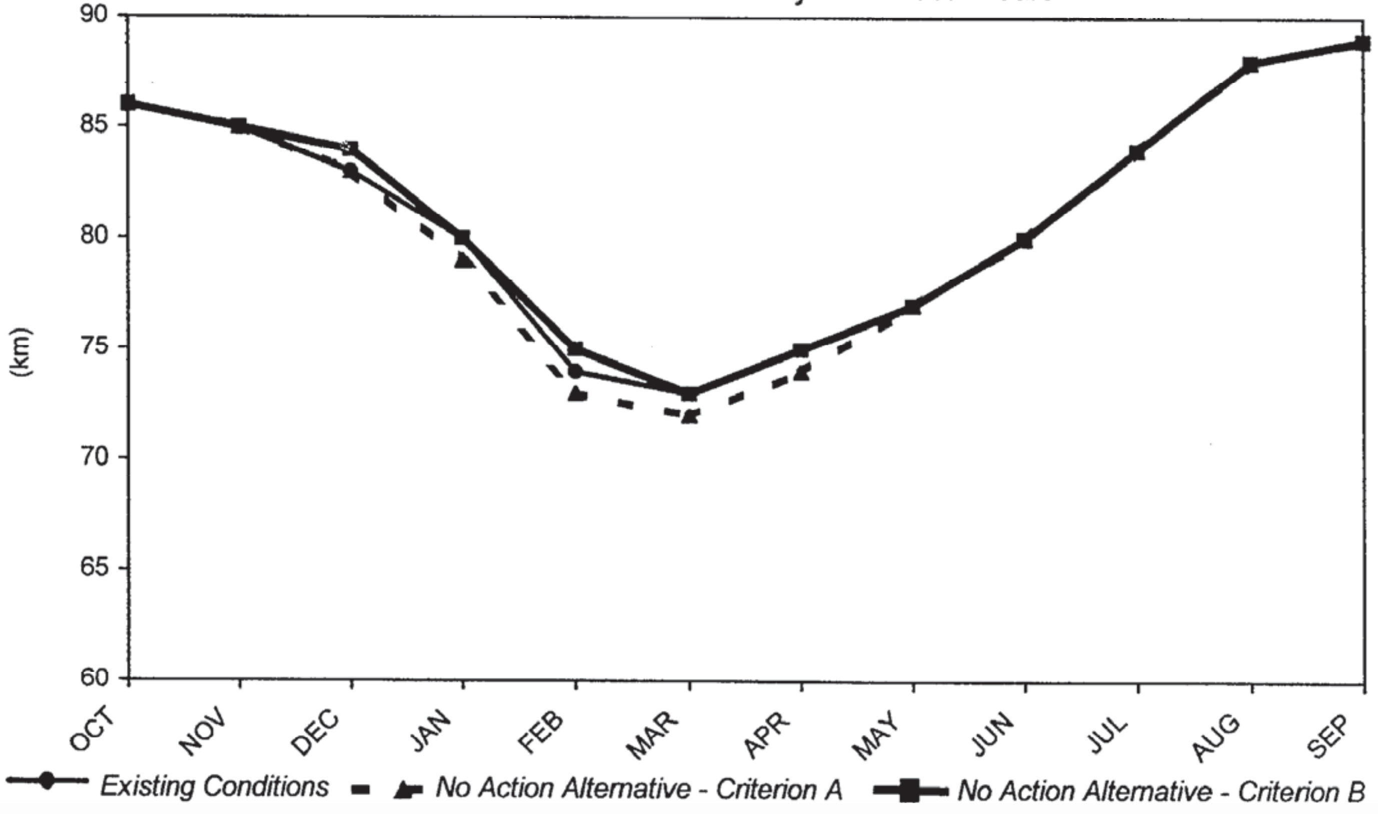


Figure 5.2-11. Average Monthly X2 Position under the No Action Alternative for Dry and Critical Years



River Flows. Flows from the Sacramento River Region enter the Delta just south of Sacramento at Freeport. Under the No Action Alternative, average monthly flow in the Sacramento River at Freeport is expected to vary seasonally between 11,900 cfs in September and 38,100 cfs in February over the long-term period. Average monthly flow is expected to vary seasonally between 9,800 cfs in September and 20,700 cfs in February for dry and critical years. In most months, no substantial change in average flow is expected under the No Action Alternative relative to existing conditions. However, some reductions in average flow could occur during June and July. Over the long-term period, average monthly flow could decrease by about 12% in these months. In dry and critical years, average monthly flow could decrease by about 18%. A comparison of monthly average Sacramento River flow at Freeport is provided in Figure 5.2-12 for the long-term period and in Figure 5.2-13 for dry and critical years.

Flows from the San Joaquin River Region enter the Delta at Vernalis. Under the No Action Alternative, average monthly flow in the San Joaquin River at Vernalis is expected to vary between 1,600 cfs in August and 6,200 cfs in April over the long-term period. Average monthly flow is expected to vary between 1,100 cfs in August and 2,900 cfs in April for dry and critical years. Although average annual San Joaquin River flow at Vernalis is expected to be similar under existing conditions and the No Action Alternative, some changes in monthly flow patterns are predicted by the analysis. Over the long-term period relative to existing conditions, the No Action Alternative is expected to result in lower average Vernalis flow in January through March (by about 4%) and higher average Vernalis flow in April through June (by about 8%). In dry and critical years, the No Action Alternative is expected to result in somewhat higher flows relative to existing conditions in December through April. During these months, average flows may increase in the range of 3-9%. A comparison of monthly average San Joaquin River flow at Vernalis is provided in Figure 5.2-14 for the long-term period and in Figure 5.2-15 for dry and critical years.

Existing Reservoir Releases. Average monthly releases from Sacramento River Region surface reservoirs are similar under existing conditions and the No Action Alternative. Average releases vary between 9,400 cfs in October and 22,600 cfs in July over the long-term period. In dry and critical years when winter flood control releases are not typically made, average releases vary between 7,000 cfs in January and 18,300 cfs in July.

Average monthly releases from San Joaquin River Region surface reservoirs are expected to vary somewhat between the No Action Alternative and existing conditions. While monthly releases are similar in dry and critical years, the programmatic analysis shows small variations occurring between January and June over the long-term period. No Action Alternative reservoir releases are about 1% lower during winter and 3-5% higher during spring. Average releases vary between 1,600 cfs in November and 8,500 cfs in May over the long-term period. In dry and critical years, average flows vary between 800 cfs in January and 6,100 cfs in May.

5.2.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For Bay-Delta hydrodynamics and riverine hydraulics, the environmental consequences of the Ecosystem Restoration, Levee System Integrity, Water Use Efficiency, and Water Transfer Program elements are similar under all Program alternatives and are described by study area in this section. South Delta components of the Conveyance element that result in similar environmental consequences under all

Figure 5.2-12. Average Monthly Sacramento River Flow at Freeport under the No Action Alternative for the Long-Term Period

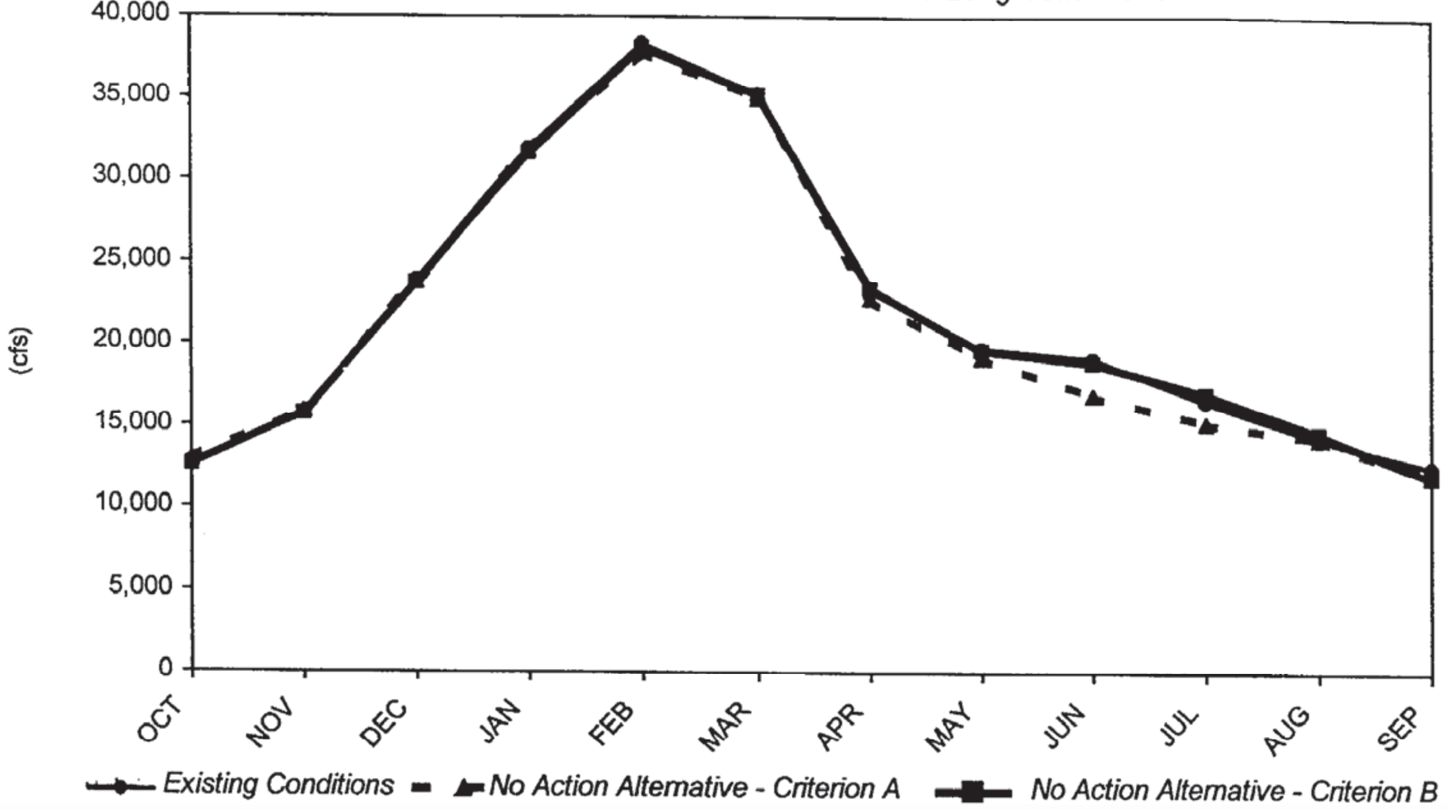


Figure 5.2-13. Average Monthly Sacramento River Flow at Freeport under the No Action Alternative for Dry and Critical Years

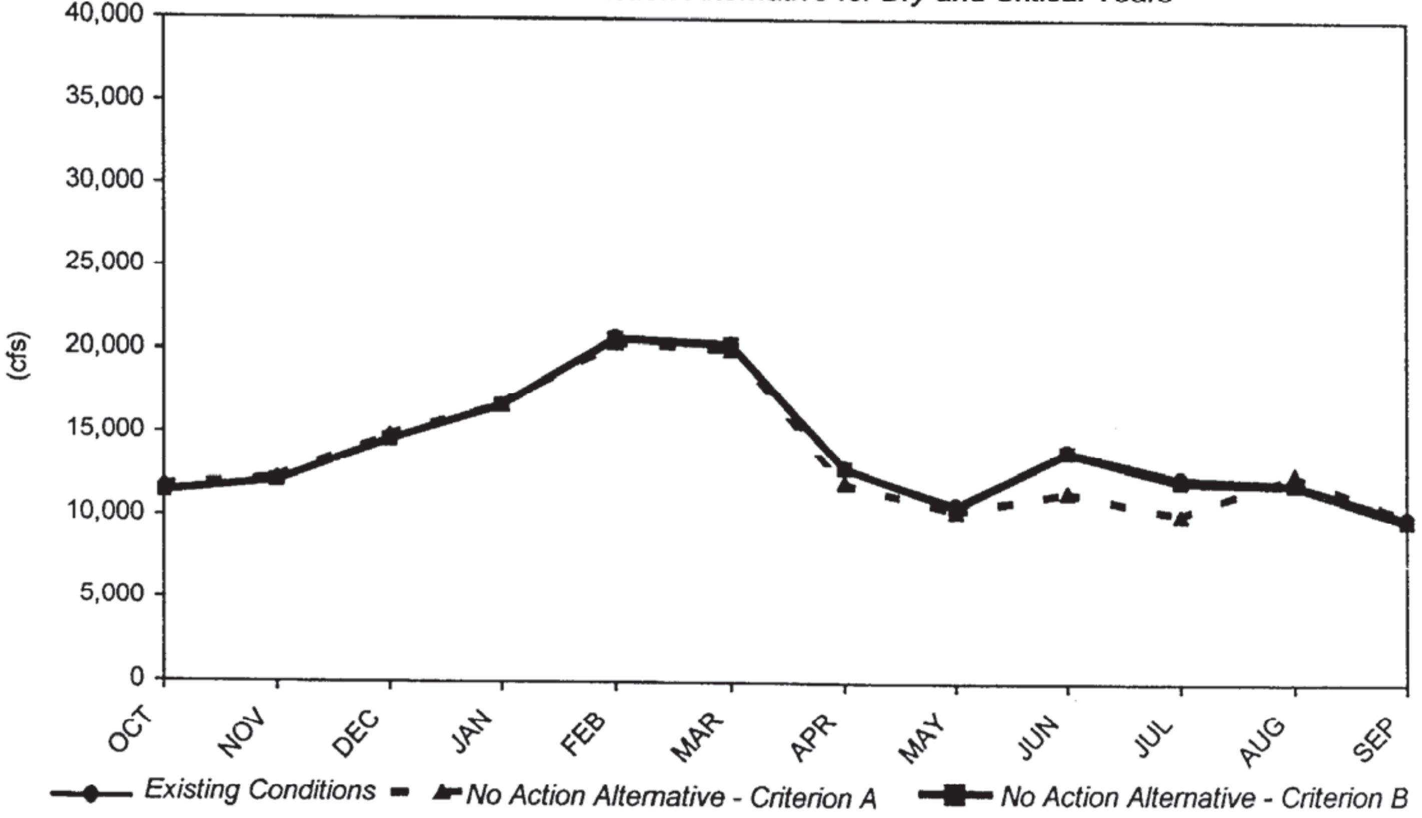


Figure 5.2-14. Average Monthly San Joaquin River Flow at Vernalis under the No Action Alternative for the Long-Term Period

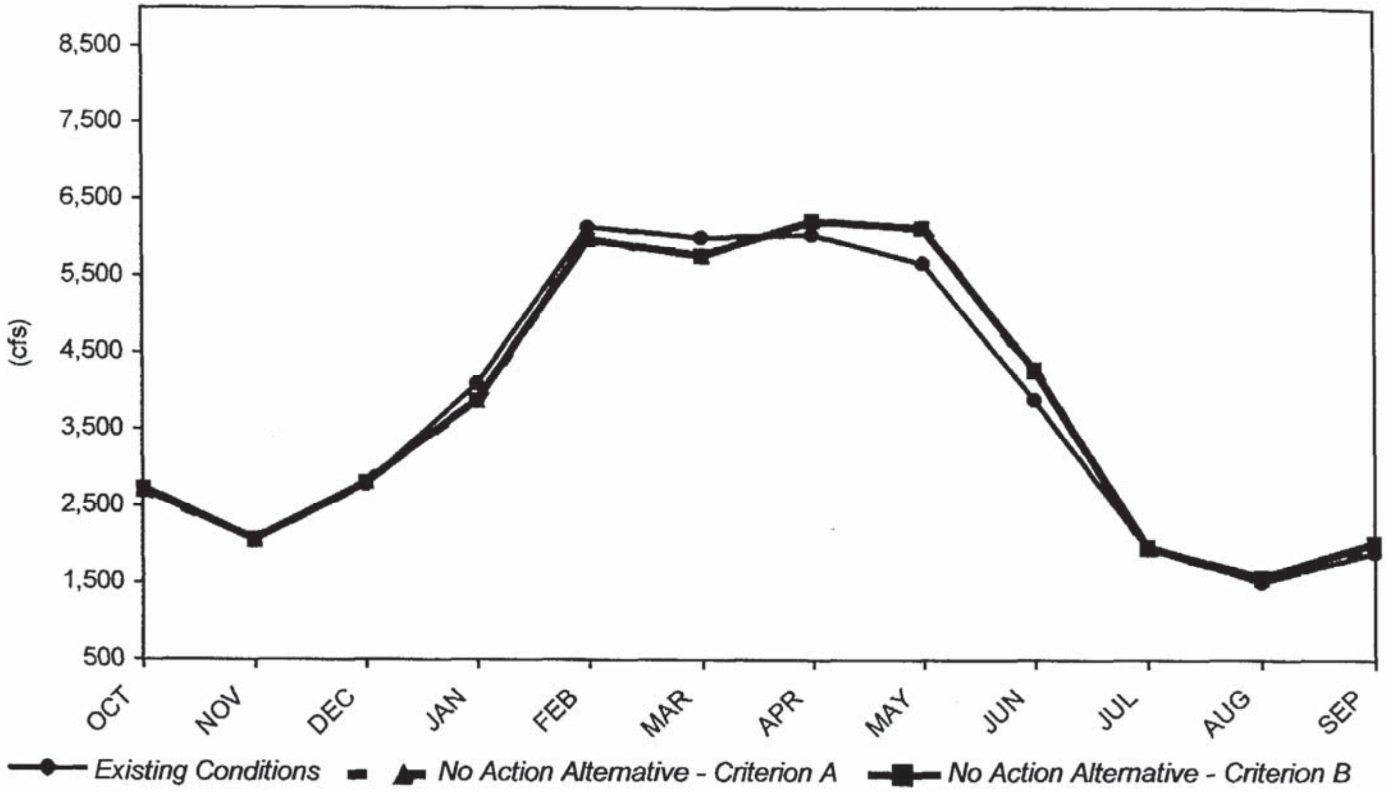
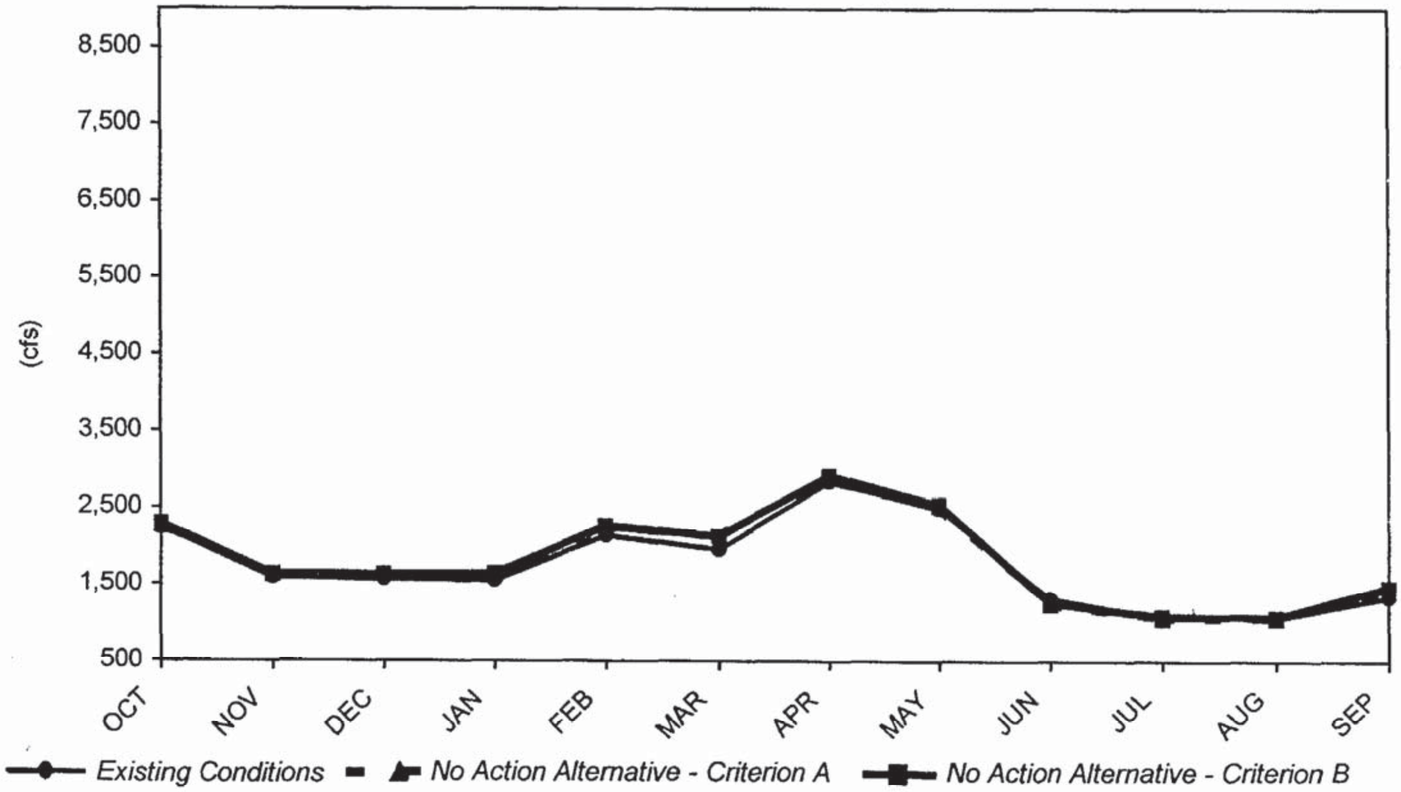


Figure 5.2-15. Average Monthly San Joaquin River Flow at Vernalis under the No Action Alternative for Dry and Critical Years



Program alternatives are described in Section 5.2.7.1. The environmental consequences of the in-Delta storage component of the Storage element were evaluated qualitatively, are similar under all Program alternatives, and are described in Sections 5.2.7.1 and 5.2.7.2. The environmental consequences of the Storage and Conveyance elements that vary among Program alternatives are described in Section 5.2.8. The Water Quality and Watershed Program elements would not substantially affect hydraulics and hydrodynamics in the Program study area, as discussed below.

The Water Quality Program would not directly affect river hydraulics or hydrodynamics. However, where timed releases are made to dilute harmful constituent loadings, small changes in streamflow patterns and hydraulic characteristics may result. The effects of the Water Quality Program are not discussed further in this section.

The various possible watershed projects proposed under the Watershed Program would alter flow regimes in specific areas. Effects of these flow changes in the Delta and the Bay Regions should be negligible. Vegetation and habitat restoration projects may increase retention of surface water in the watershed, but the effects on hydrodynamics also should be very small. The effects of the Watershed Program in the Delta and Bay Regions are not discussed further in this section.

5.2.7.1 DELTA REGION

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would increase spring flows during 10-day pulse flow periods within rivers of the Central Valley and the Delta. Under the Ecosystem Restoration Program, Delta outflow would be augmented by a pulse flow originating in the Sacramento River watershed in March and again by a pulse flow originating in the San Joaquin River watershed in late April or early May. Flows would be augmented primarily in above-normal, below-normal, and dry water years. Over the long-term period, Delta outflow would be increased during these pulse flow periods (in total) by an average of about 300 TAF.

Levee System Integrity Program

Channel geometry may be altered by creating setback levees, dredging channels for levee construction material, or increasing the height of levees. Increased levee heights, channel widening and deepening, and bank stabilization could result in increased channel capacities. Channel widening would reduce stream and channel velocities at the selected sites. This would create the potential for more sediment deposition, with both positive and negative environmental consequences.

Since the Levee System Integrity Program focuses on levee improvements and modifica-tions within the Delta, any potential adverse impacts on channel hydraulic characteristics outside the Delta are expected to be minor. Therefore, this program is discussed only for the Delta Region.

Water Use Efficiency Program

Increasing water use efficiency could affect Delta hydrodynamics by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. These effects are expected to be insignificant and were included within the range of assumptions considered in the Program alternatives system operations modeling.

Water Transfer Program

Water transfers would affect Delta hydrodynamics primarily through changes to Delta inflows. Increased water transfers could change the timing of diversions and alter the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. Water transfers from areas upstream of the Delta to areas south of the Delta would affect Delta hydrodynamics by increasing diversions from the Delta and/or modifying water diversion schedules. Management of the EWA may magnify the effects of this program.

Conveyance

South Delta water levels are highly influenced by Delta inflow, tidal action, diversions, and Delta exports. During times of high Delta exports, in combination with tidal effects, water levels in the south Delta drop significantly, making it difficult to operate existing agricultural diversions. Under each Program alternative, actions would be implemented to ensure availability of water of adequate quantity and quality to agricultural diverters within the south Delta, and to contribute to restoring ecological health of aquatic resources in the lower San Joaquin River and south Delta. These actions may include channel dredging, extension and screening of agricultural intakes, consolidation of agricultural intakes, operable barriers, levee setbacks, and levee improvements. Actions will be staged with appropriate monitoring and testing to guide the implementation process. While south Delta water levels would depend on the specific actions taken, adequate availability of water supplies would be provided under each Program alternative.

Storage

Diversions to in-Delta storage could result in changes in flow patterns toward the direction of the in-Delta storage intakes. These diversions could increase flow velocities and reduce stage in channels near the intakes. In-Delta storage variations that release water back to Delta channels could change flow patterns away from the release points. In-Delta storage variations that release water directly to Bay Region diversion facilities or South-of-Delta SWP and CVP Service Areas export facilities could substitute for some diversions from those existing facilities, diminishing the environmental consequences of the operations of those existing facilities. Appropriate operational rules would be required to ensure that diversions and releases from in-Delta storage do not result in substantial negative effects on Delta hydrodynamics.

5.2.7.2 BAY REGION

Ecosystem Restoration Program

Under the Ecosystem Restoration Program, the acreage of shallow-water aquatic habitat and saline emergent wetlands would be increased adjacent to Suisun Bay and Marsh, San Pablo Bay, the Napa and Petaluma Rivers, and Sonoma Creek. The proposed lands for conversion are currently used for agriculture. These changes could result in a small effect on Bay hydrodynamics.

Water Use Efficiency Program

Increasing water use efficiency could affect Bay hydrodynamics by changing the timing of diversions and reducing the amounts of water diverted from the Delta for agricultural, municipal, industrial, and ecosystem purposes. This change would alter inflows from the Delta. Implementation of the Water Use Efficiency Program also would reduce the water returns from agricultural and urban users. These effects are expected to be insignificant.

Water Transfer Program

Water transfers would affect Bay hydrodynamics primarily through changes to Delta inflows. Increased water transfers could change the timing of diversions and alter the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. Water transfers from areas upstream of the Delta to areas south of the Delta could affect Bay hydrodynamics by increasing diversions from the Delta and/or modifying Delta water diversion schedules, thereby affecting outflows to the Bay. Management of the EWA may magnify the effects of this program.

Storage

Diversions to in-Delta storage could result in direct decreases in outflow to the Bay. In-Delta storage operations for water supply purposes could affect Bay hydrodynamics by increasing total diversions from the Delta and/or modifying Delta water diversion schedules, thereby affecting outflows to the Bay. Appropriate operational rules would be required to ensure that diversions and releases from in-Delta storage for all water management purposes do not result in substantial negative effects on Bay hydrodynamics. Releases from in-Delta storage to Delta channels for ecosystem benefit could increase outflow to the Bay during times critical to fisheries, moving the X2 position closer to the Bay.

5.2.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would increase spring flows during 10-day pulse flow periods within rivers of the Central Valley and the Delta. Under the Ecosystem Restoration Program, pulse flows would occur in the Sacramento River watershed in March and in the San Joaquin River watershed in late April or early May. Flows would be augmented primarily in above-normal, below-normal, and dry water years. Over the long-term period, Sacramento River flows would be increased during these pulse flow periods by an average of about 110 TAF, while San Joaquin River flows would be increased by an average of about 95 TAF.

The Ecosystem Restoration Program could result in short-term adverse impacts from increased sediment loading during construction activities. Conversion of cultivated land to habitat could increase water use. Reductions in channel velocities in some Delta reaches that are widened to encourage meanders could result in increases in water temperature.

Water Use Efficiency Program

Improved water use efficiency could alter the timing and reduce the amount of water diverted to supply agricultural, urban, and ecosystem uses. These changes could affect riverine hydraulics by reducing the number and size of diversions, and result in the redistribution of reservoir releases. Increased conservation and water recycling in the urban sector could reduce or eliminate the need for increased diversions as populations increase and demand grows. These changes would benefit streamflows overall, but detrimental instream flow reductions could occur in cases where streams are partially or entirely fed by return flows. These impacts are expected to be insignificant.

Water Transfer Program

Water transfers can modify the timing and/or increase or decrease streamflows in channels. The timing and magnitude of the changes in flows would be constrained by facility conveyance capacities such as those of the Delta export pumps and canals south of the Delta, by system operating rules, and by individual water transfers (as defined through future buying and selling). Management of the EWA may magnify the effects of this program.

Watershed Program

Coordination of watershed activities, as proposed in the Watershed Program, would help facilitate projects that could lead directly or indirectly to changes in channel hydraulics. Two goals of such changes would be improvements to watershed hydrology and to in-stream flow conditions. Effects in the watersheds should be beneficial, and various secondary impacts could occur. Flow changes in trunk streams downstream of most watershed improvement projects generally would be minor. Any residual effects should be moderated by reservoir operations.

Depending on the size and scale of the watershed projects, effects could range from very limited changes in flows in nearby stream reaches, to large-scale changes in flow regimes. Vegetation and habitat restoration projects may increase retention of surface water in the watershed, resulting in less variable runoff (reduced peak flows and increased base flows in streams).

Improvements in timber harvest practices could reduce peak flows from affected forested areas. Total annual runoff could be reduced if net evapotranspiration (ET) increases in the target watersheds. Reforestation could produce increases in net ET and reduce annual stream discharges. Other hydrologic variables that could interact to alter stream hydrographs include interception and infiltration of precipitation, surface runoff, groundwater recharge, and stream accretions and depletions. In areas where snowmelt plays an important role in the flow regime, reduced timber harvesting would increase shading and reduce evaporation and sublimation of snow packs to maintain snow packs longer, which would increase net runoff and retard spring runoff peaks. Improved management of grazing activities on rangelands could improve vegetative cover in watersheds, promote vegetative diversity, and help to reestablish riparian habitat. Overall effects on watershed hydrologic characteristics would be improved by reducing runoff velocities and increasing water retention. However, annual stream discharges could decrease.

Erosion control efforts could result in reductions and retardation of runoff and sediment transport into tributaries and reservoirs. Because many erosion control efforts are expected to be local and small-scale, efforts would slightly reduce peak flows but would not substantially alter the timing of those flows. Large-scale watershed improvements, such as revegetation of large tracts in steep, denuded watersheds, would result in more substantial beneficial effects.

Stream restoration projects, such as the removal of logs and debris from stream channels to improve their fish passage capacities, could result in local increases in flow velocities and erosion while the stream gradient and banks become stable. These impacts would decrease with time and distance downstream, and generally would be negligible.

5.2.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

Quantitative methods were used to predict changes in Bay-Delta hydrodynamics and riverine hydraulics as a result of the implementation of Program elements. The impacts of Program alternatives were analyzed with DWR's operations planning model (DWRSIM) and Bay-Delta hydrodynamic model (DSM2).

Because of the inherent difficulty in projecting conditions that will influence future water management decisions, the Program considered a reasonable range of uncertainty in this programmatic evaluation of alternatives. This range of uncertainty was quantified by formulating two distinct bookend water management criteria assumption sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export and outflow patterns in the No Action Alternative and Program alternatives. Further details regarding the modeling assumptions are presented in Section 5.1.4.

The programmatic comparisons presented in this section differentiate Bay-Delta hydrodynamics and riverine hydraulics resulting under the Program alternatives and the No Action Alternative. These comparisons are made in consideration of ranges of assumptions regarding future water management actions affecting the Bay-Delta system. The water management criteria for the No Action Alternative include ranges of water demands and protective Delta management criteria. The range of water demands represents uncertainty in the future need for Bay-Delta water supplies due to uncertainty in projections of population, land use, implementation of water use efficiency measures, and the effects of water marketing. The range of protective Delta management criteria represents uncertainty related to future actions required to assure recovery of the Bay-Delta ecosystem. It is anticipated that the future conditions will be within the range of water demands and Delta management criteria used to predict impacts.

This section describes Program-induced changes in hydraulic parameters, including flow and other variables such as X2 position. However, the significance or environ-mental implications of these changes are not described here. The significance of these changes is addressed in other sections of this report in the context of each of the resources affected by the changes. This section differentiates conditions for the Delta, Bay, Sacramento River, and San Joaquin River planning regions. As discussed previously, riverine hydraulics outside the Central Valley are not expected to be directly affected by any Program alternatives. Changes in streamflows in these service areas would be the result of local interagency operations, were not evaluated by the Program, and are not discussed further in this section.

5.2.8.1 ALTERNATIVE 1

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross-Delta, Old River at Bacon Island, and San Joaquin River at Antioch) and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, channel flows are described at five locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs. Under Alternative 1, average monthly Rio Vista flow decreases by as much as 1,000 cfs in February. Alternative 1 modifies flow by (-100) to 300 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, Alternative 1 decreases flow in February by about 150 cfs. In September, Alternative 1 increases flow by as much as 900 cfs. Figures 5.2-16 and 5.2-17 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

Figure 5.2-16. Average Monthly Sacramento River Flow at Rio Vista under Alternative 1 for the Long-Term Period

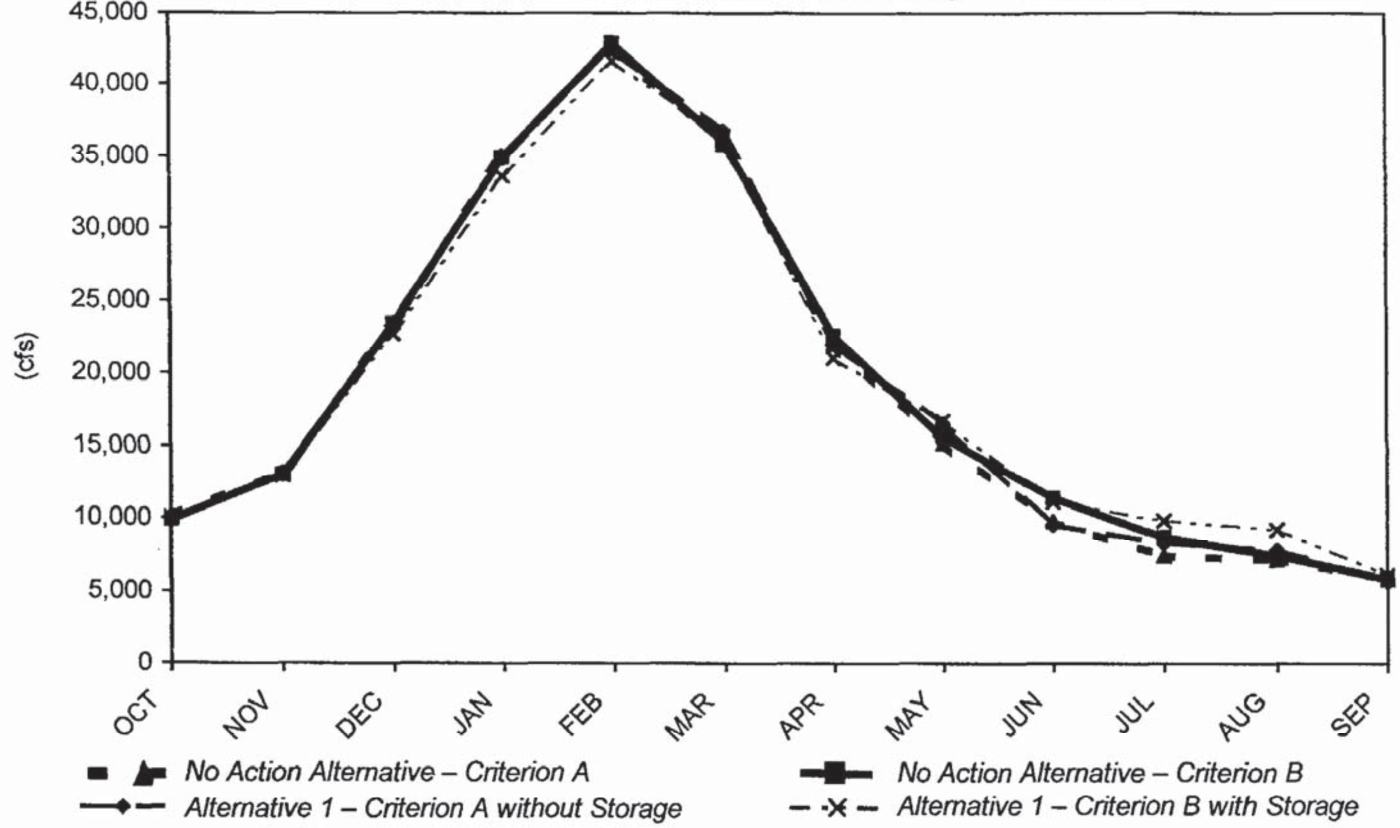
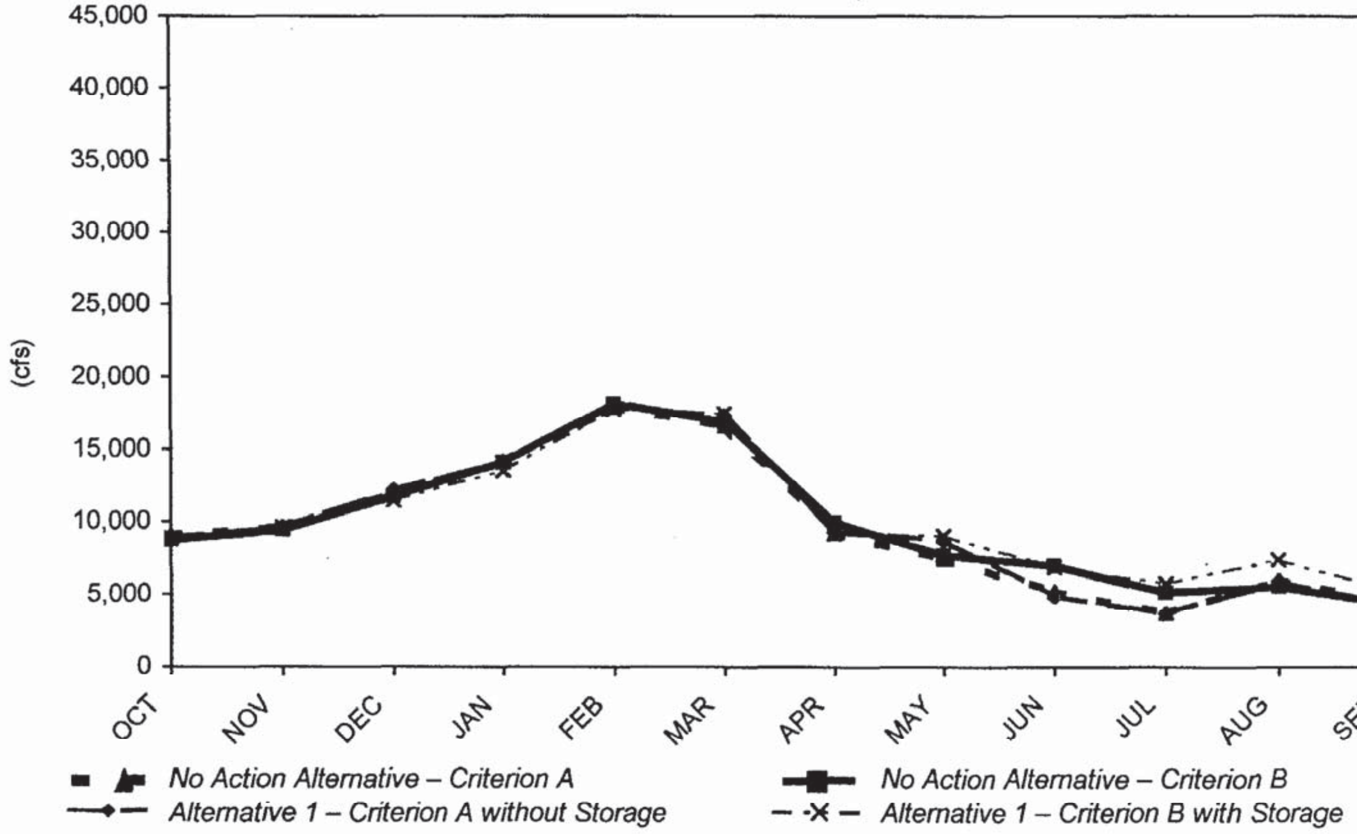


Figure 5.2-17. Average Monthly Sacramento River Flow at Rio Vista under Alternative 1 for Dry and Critical Years



QWEST Flow. QWEST flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about (-4,300) to (-4,000) cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from (-5,200) to (-4,900) cfs.

Alternative 1 decreases average monthly positive QWEST flow over the long-term period in April by as much as 500 cfs and increases average monthly reverse QWEST flow in October by as much as 600 cfs. During dry and critical years, Alternative 1 increases average monthly positive QWEST flow in April by only about 10 cfs and increases average monthly reverse QWEST flow in December by as much as 1,000 cfs. Figures 5.2-18 and 5.2-19 compare average monthly QWEST flow for the long-term period and dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Differences in cross-Delta flow are best summarized by flows occurring in August, December, and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December, and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 1, over the long-term period and in dry and critical years, cross-Delta flow typically increases in August and May, whereas cross-Delta flow in December may slightly increase or decrease. Over the long-term period under Alternative 1, cross-Delta flow may increase by as much as 600 cfs in August and by about 30 cfs in May relative to the No Action Alternative. Cross-Delta flow in December varies by (-30) to 10 cfs relative to the No Action Alternative. During dry and critical years under Alternative 1, cross-Delta flow may increase by about 200 cfs in August and by about 80 cfs in May relative to the No Action Alternative. Cross-Delta flow in December varies by (-10) to 10 cfs relative to the No Action Alternative. Figures 5.2-20 and 5.2-21 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about (-3,400) cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from (-3,600) to (-3,000) cfs.

Over the long-term period under Alternative 1, increases in reverse flow in Old River at Bacon Island in August range from 600 to 1,100 cfs, resulting in flow ranging from (-4,600) to (-4,000) cfs. In dry and critical years under Alternative 1, reverse flow in August may decrease by 100 cfs or may increase by 500 cfs, resulting in flow ranging from (-4,000) to (-3,400) cfs.

Figure 5.2-18. Average Monthly QWEST Flow under Alternative 1 for the Long-Term Period

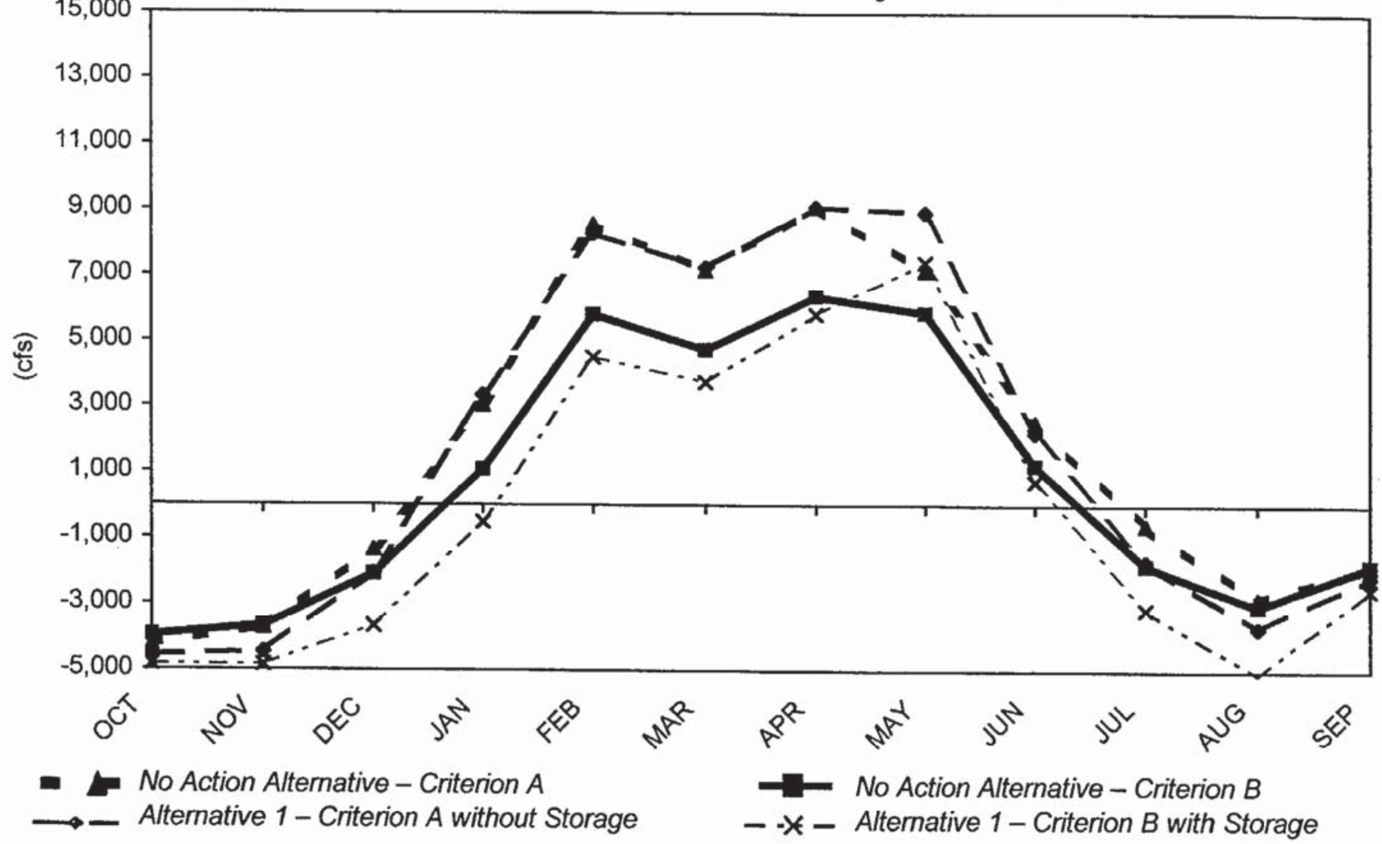


Figure 5.2-19. Average Monthly QWEST Flow under Alternative 1 for Dry and Critical Years

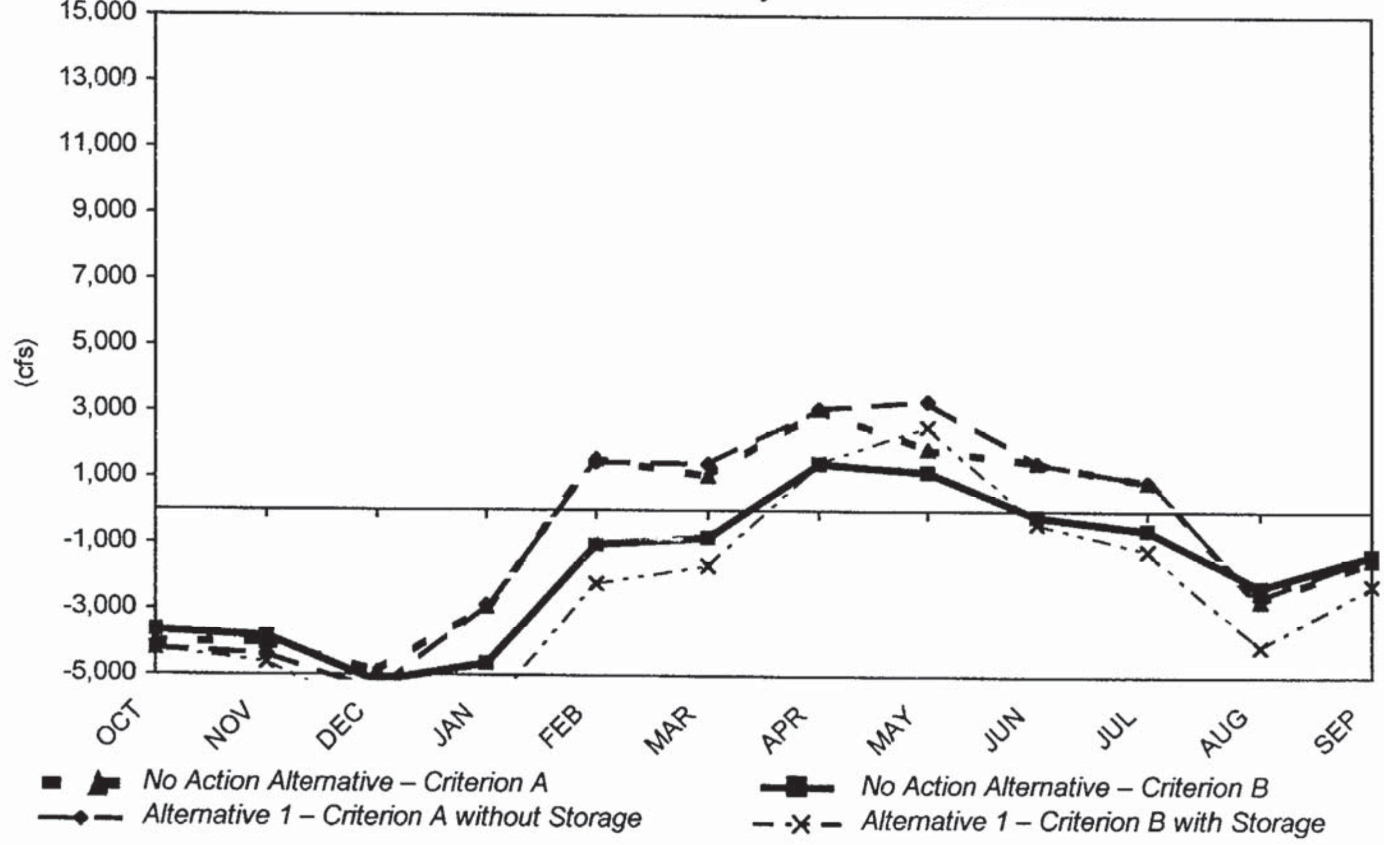


Figure 5.2-20. Average Monthly Cross-Delta Flow under Alternative 1 for the Long-Term Period

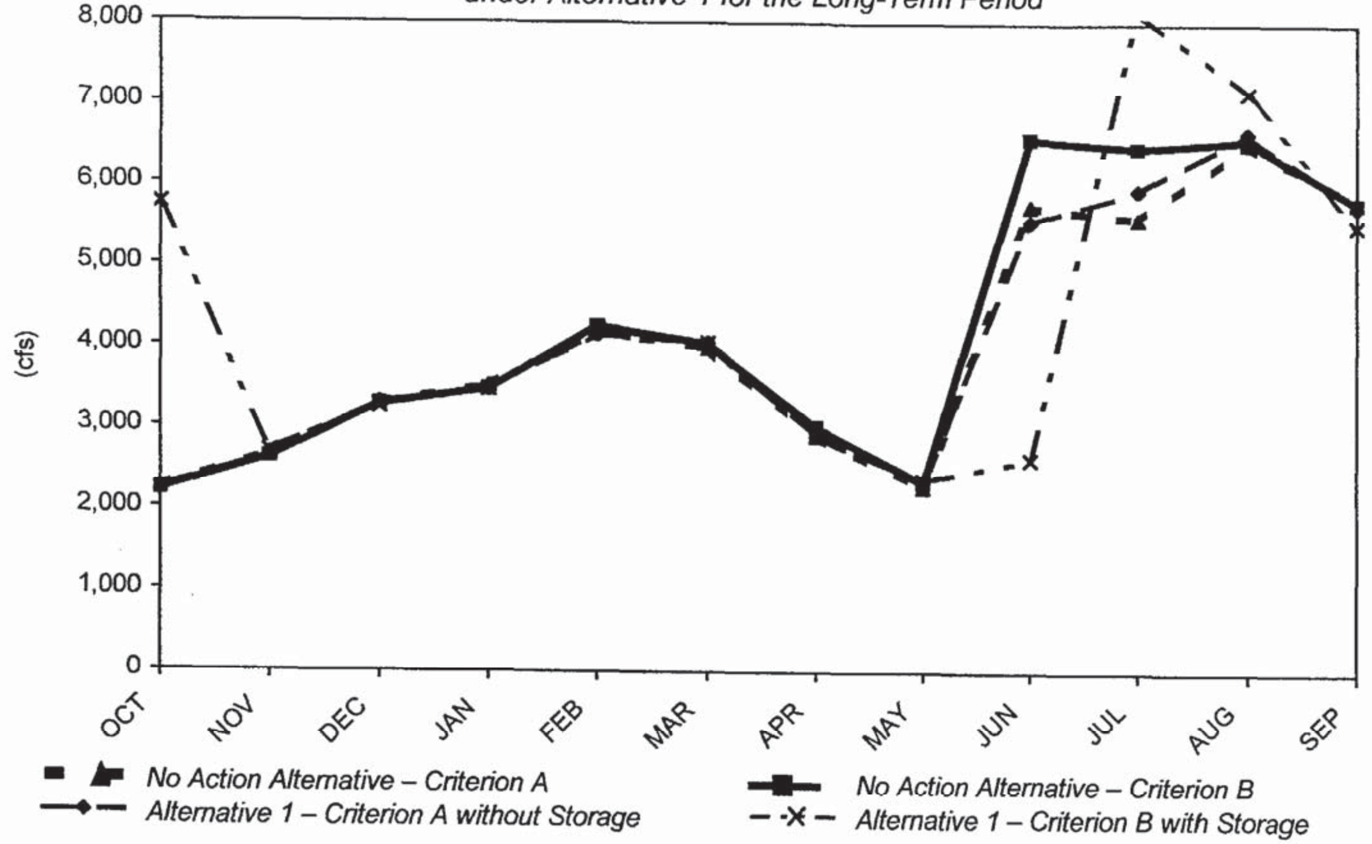
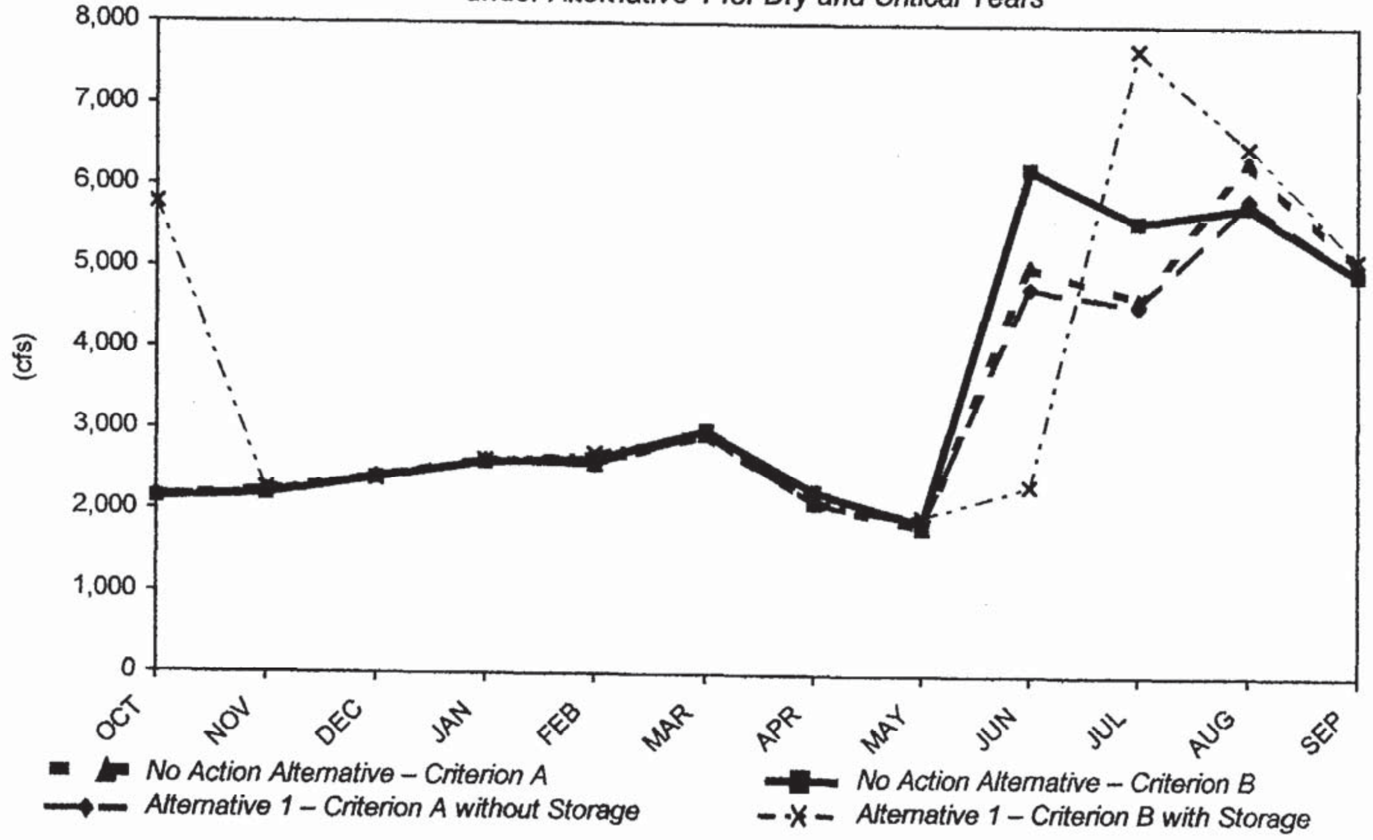


Figure 5.2-21. Average Monthly Cross-Delta Flow under Alternative 1 for Dry and Critical Years



San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from (-1,200) to (-1,000) cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from (-2,400) to (-2,100) cfs.

Average monthly San Joaquin River flow at Antioch ranges from (-1,300) to (-600) cfs in August over the long-term period under Alternative 1. In dry and critical years under Alternative 1, reverse flow in August may vary by (-300) to 400 cfs relative to the No Action Alternative, resulting in flow ranging from (-1,200) to (-500) cfs. Increases in reverse flow in December range from 60 to 700 cfs under Alternative 1 in dry and critical years, resulting in flow ranging from (-3,100) to (-2,500) cfs.

Mass Fate. The DSM2 model was used to perform several mass tracking simulations for Alternative 1. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 1 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 1 increases average monthly X2 position by about 0.6 km in September. Alternative 1 could increase X2 position by about 0.2 km or decrease X2 position by about 0.3 km in March. During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. Alternative 1 does not affect X2 position in September. However, X2 position may increase by 0.3 km or decrease by 0.4 km in March. Figures 5.2-22 and 5.2-23 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 1 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 1. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an in-stream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B under the modeling analysis.

River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 1 and the No Action Alternative. Figures 5.2-24 and 5.2-25 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

Figure 5.2-22. Average Monthly X2 Position under Alternative 1 for the Long-Term Period

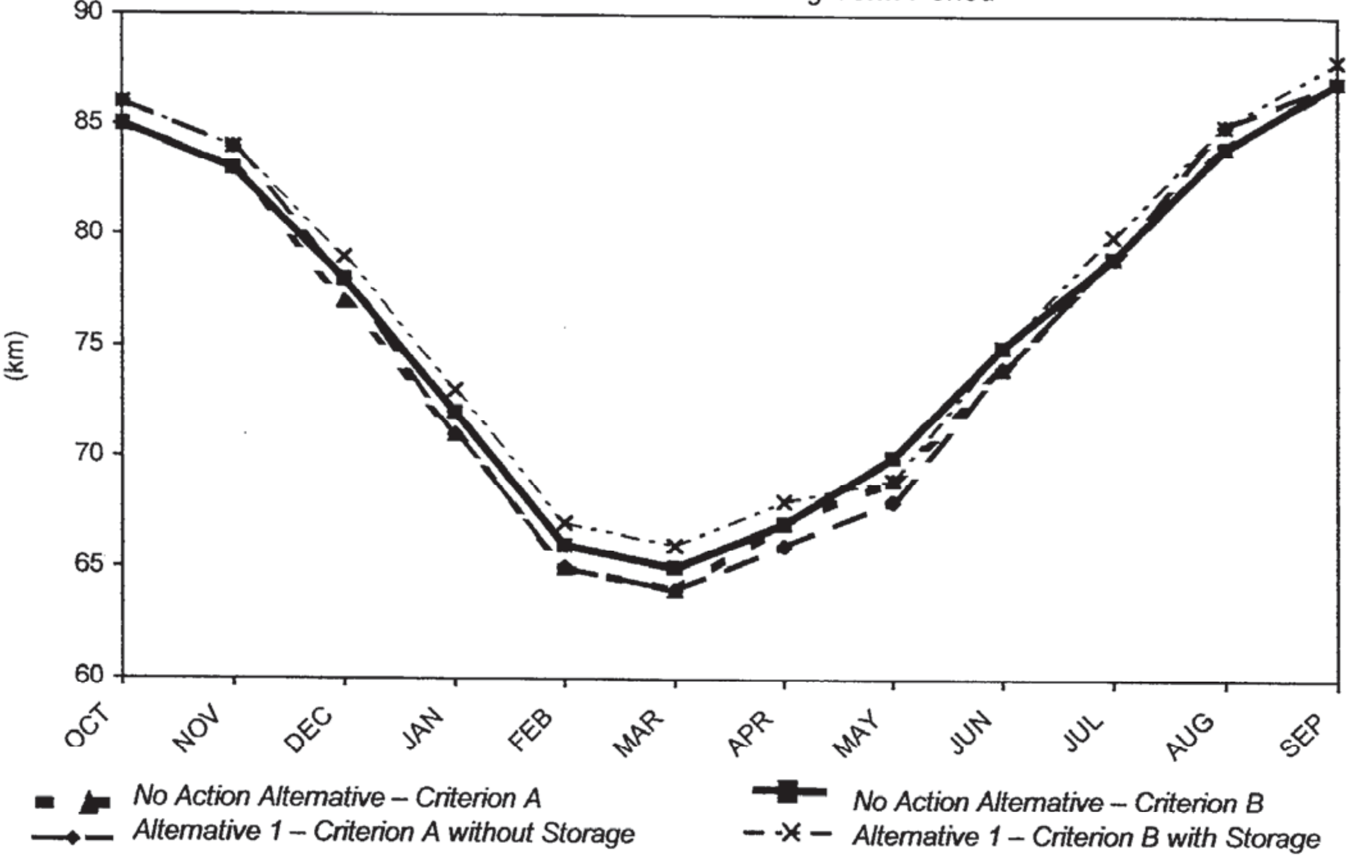


Figure 5.2-23. Average Monthly X2 Position under Alternative 1 for Dry and Critical Years

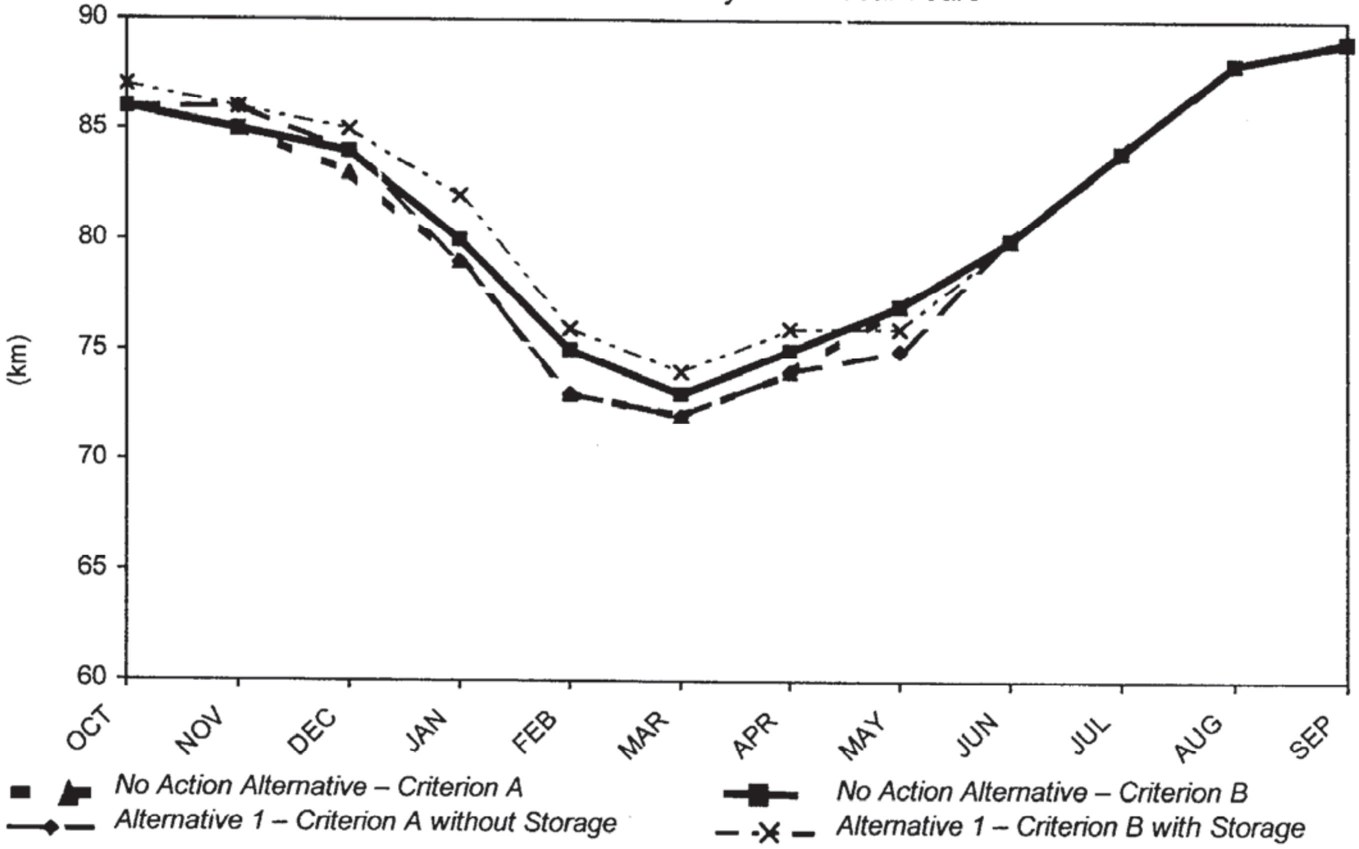


Figure 5.2-24. Average Monthly Sacramento River Flow at Freeport under Alternative 1 for the Long-Term Period

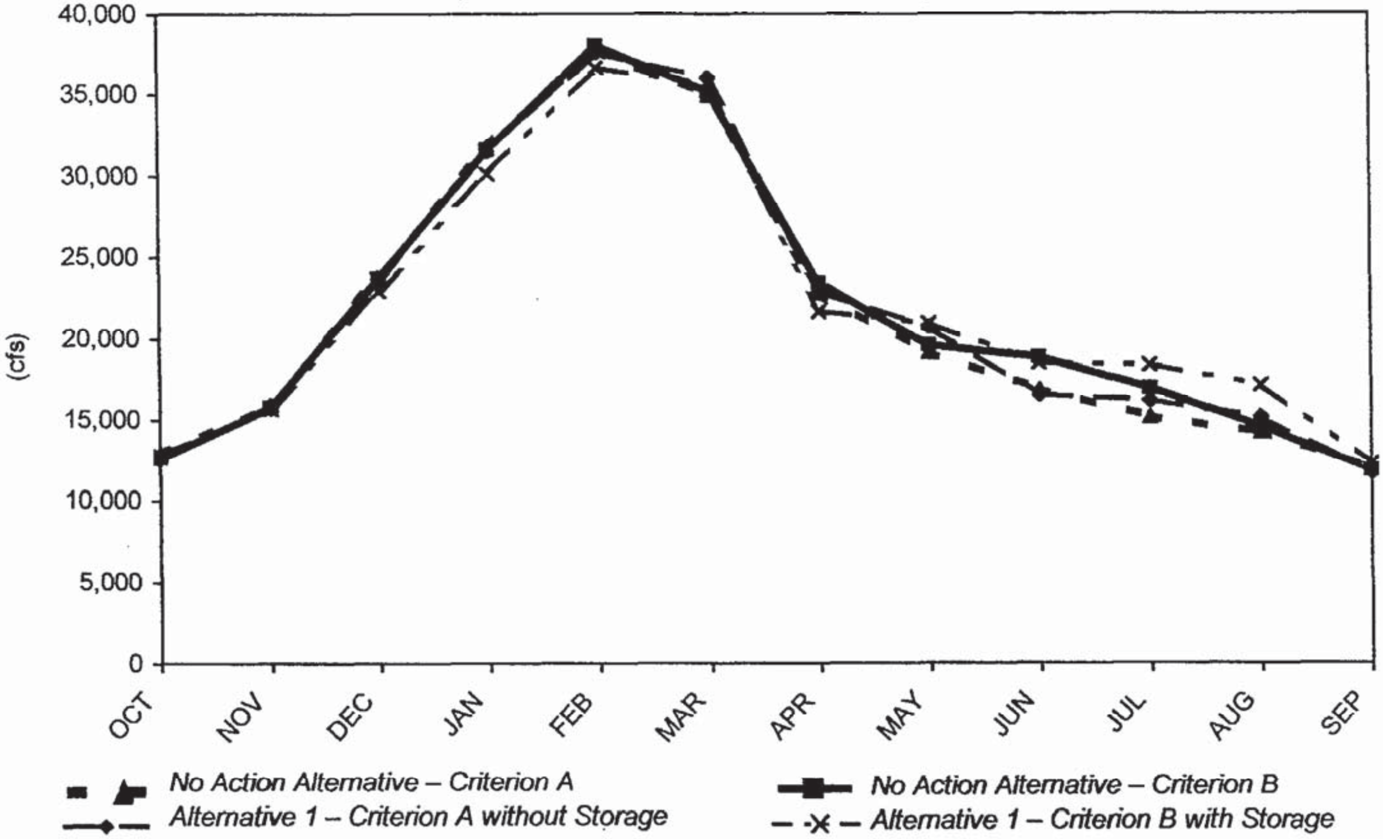
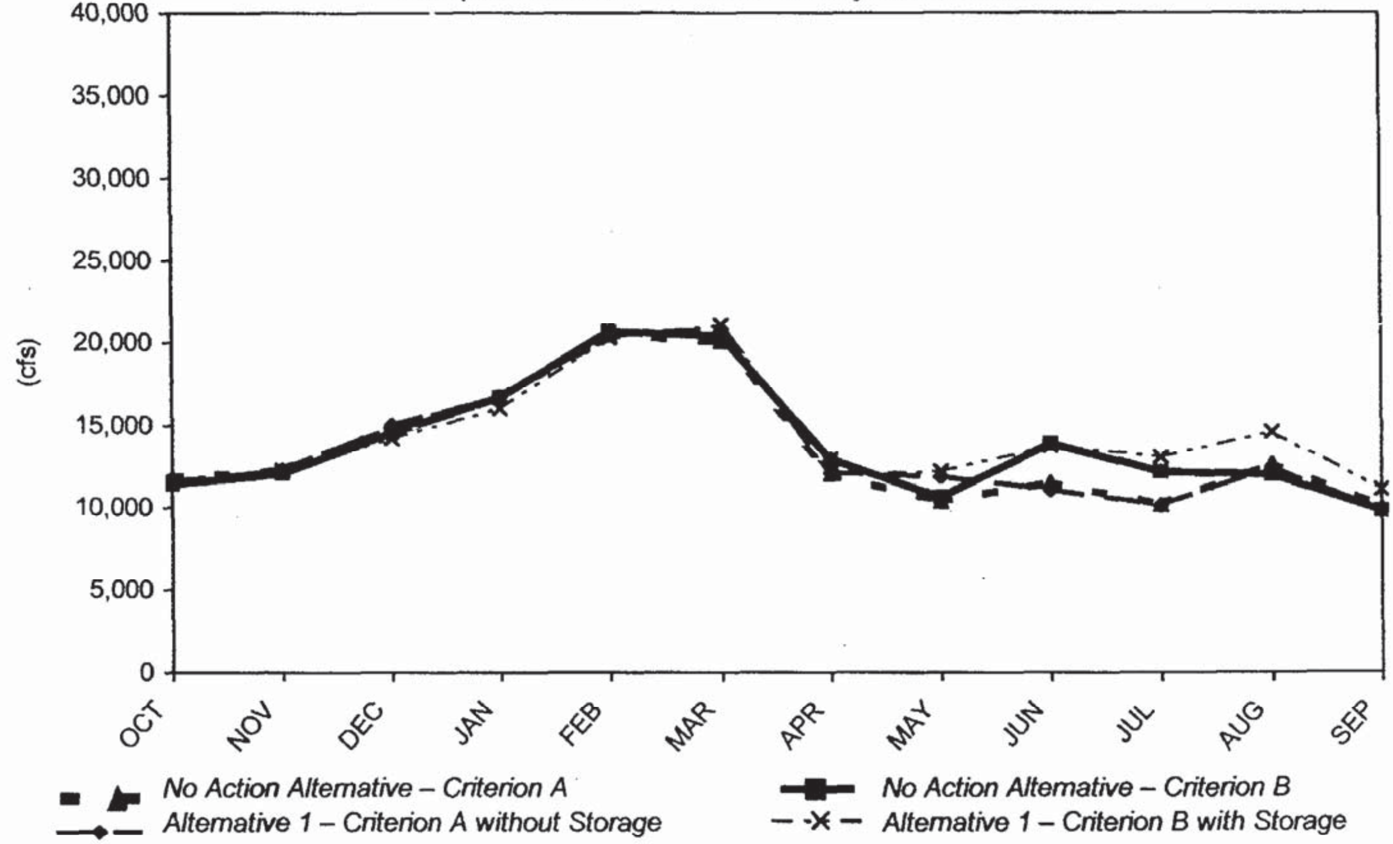


Figure 5.2-25. Average Monthly Sacramento River Flow at Freeport under Alternative 1 for Dry and Critical Years



In the absence of new storage facilities, Alternative 1 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer under all hydrologic conditions. Alternative 1 increases average monthly flow by as much as 1,400 cfs during summer. Even with new storage facilities, Alternative 1 has little impact on average monthly flow in most months. Anticipated flow increases are most pronounced during summers of dry and critical years—up to 900 cfs in July.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alternative 1 and the No Action Alternative. Figures 5.2-26 and 5.2-27 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 1, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. Alternative 1 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 1 increases average monthly flow in spring by as much as 1,300 cfs.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer under the No Action Alternative as well as under Alternative 1. This pattern is consistent for the long-term period and for dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 1, the lowest long-term period summer releases are generally associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity.

New storage would provide increased operational flexibility and would supplement releases from existing facilities. If no new storage is implemented under Alternative 1, summer releases from existing facilities may increase up to 1,300 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 1, summer releases may decrease as much as 1,400 cfs or increase up to 600 cfs relative to the No Action Alternative. During winter, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 1, necessitates increased flood control releases in winter.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of Alternative 1. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

New Reservoir Diversions and Releases. Figures 5.2-28 and 5.2-29 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 1. Under Alternative 1, new surface storage diversions typically occur during winter and spring, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is 1,400-2,300 cfs. For dry and critical years, the range of peak average monthly diversions is 200-1,400 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B.

Figure 5.2-26. Average Monthly San Joaquin River Flow at Vernalis under Alternative 1 for the Long-Term Period

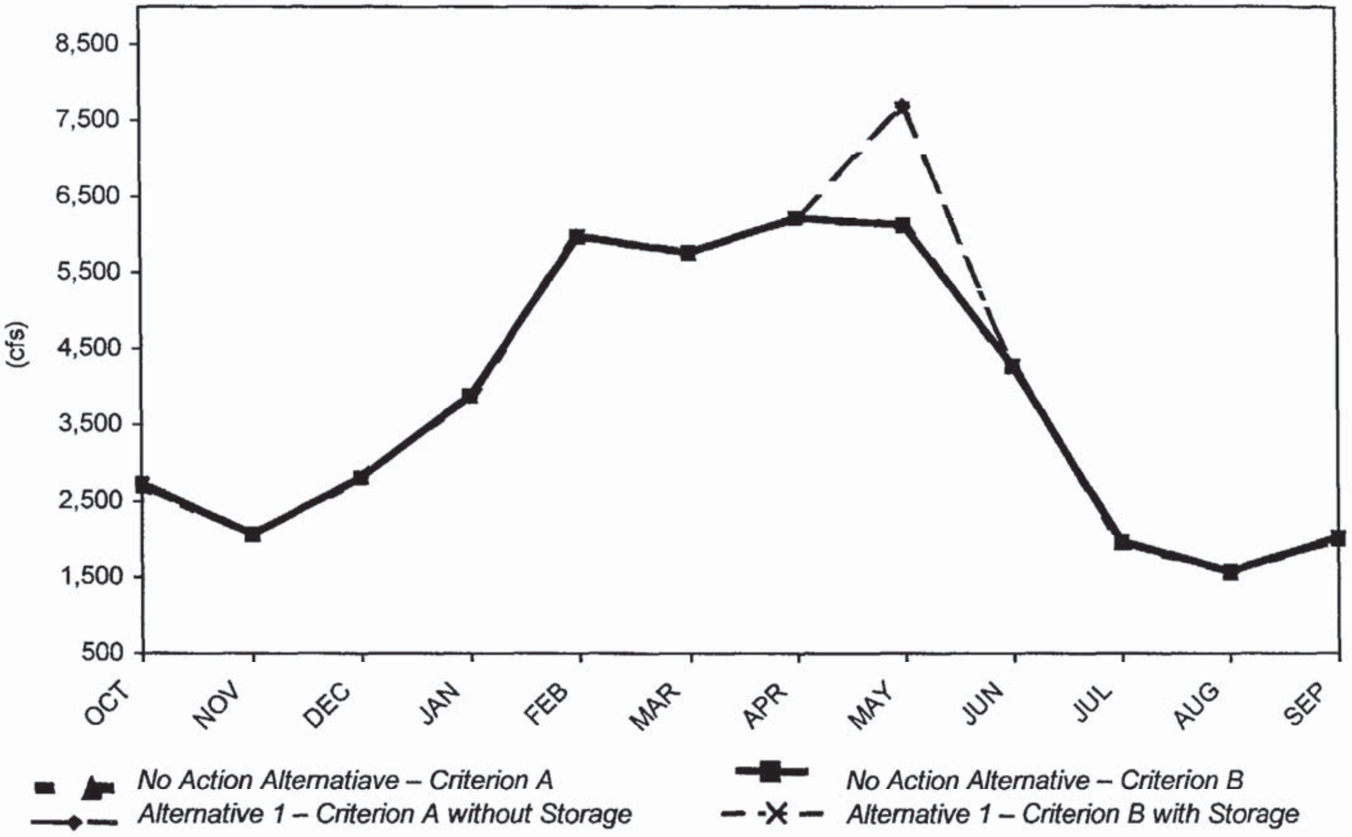


Figure 5.2-27. Average Monthly San Joaquin River Flow at Vernalis under Alternative 1 for Dry and Critical Years

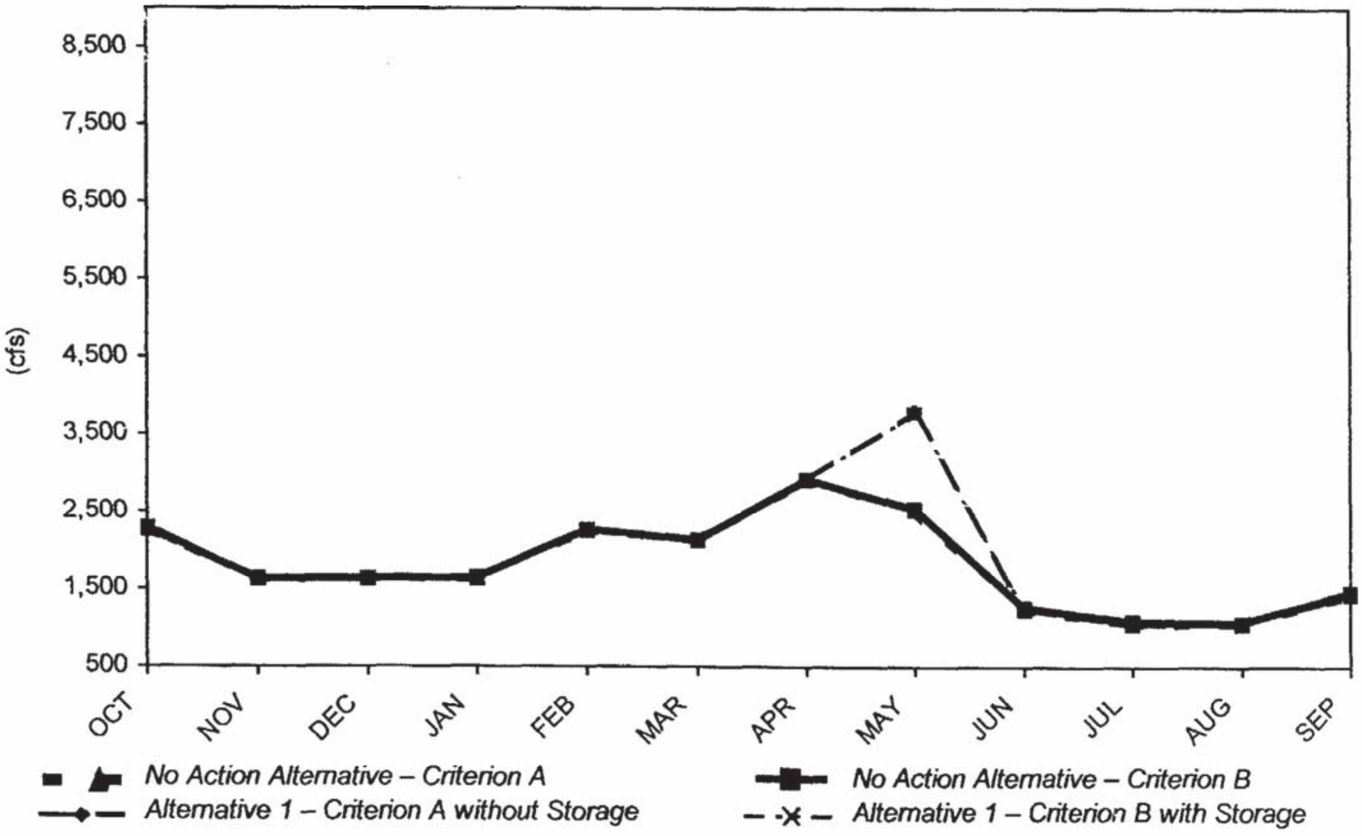


Figure 5.2-28. New Surface Storage Diversions in the Sacramento River Region under Alternative 1 for the Long-Term Period

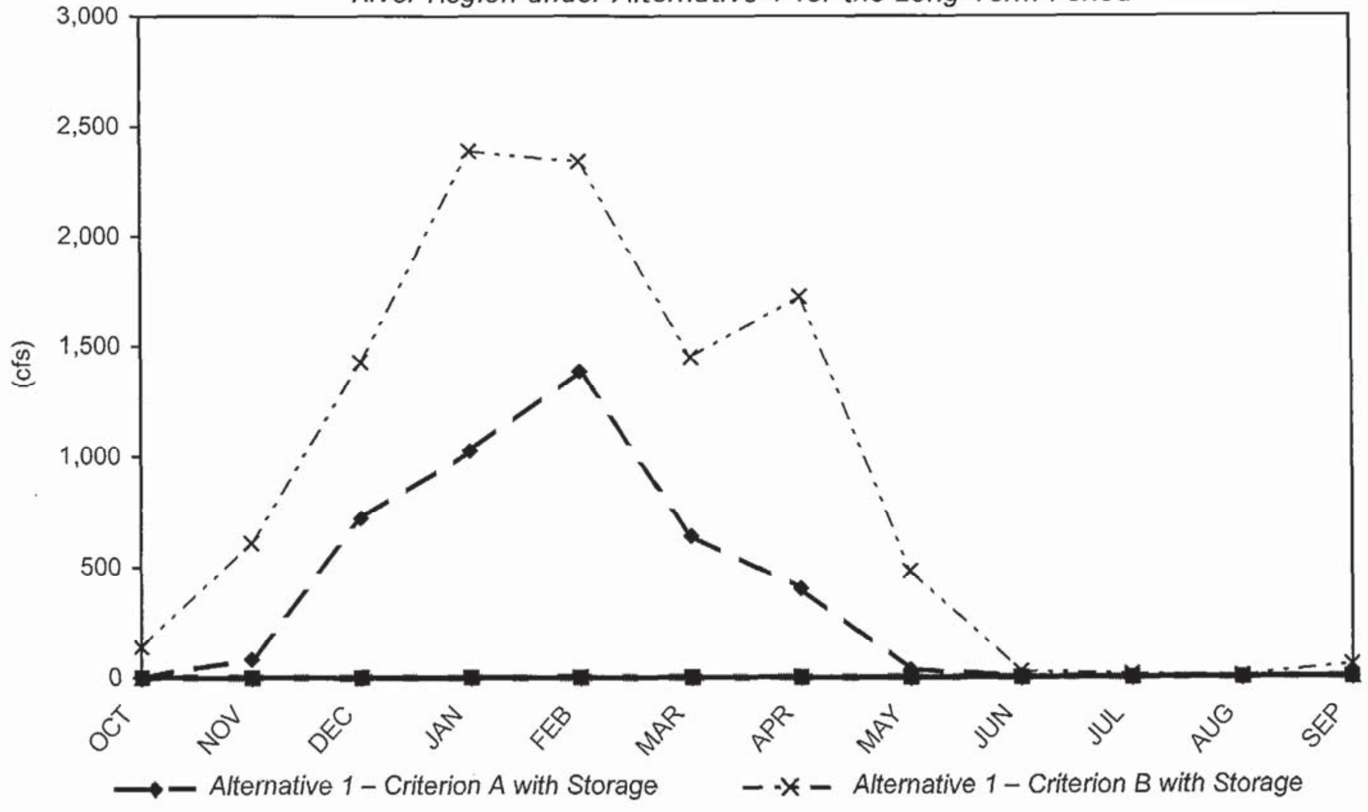
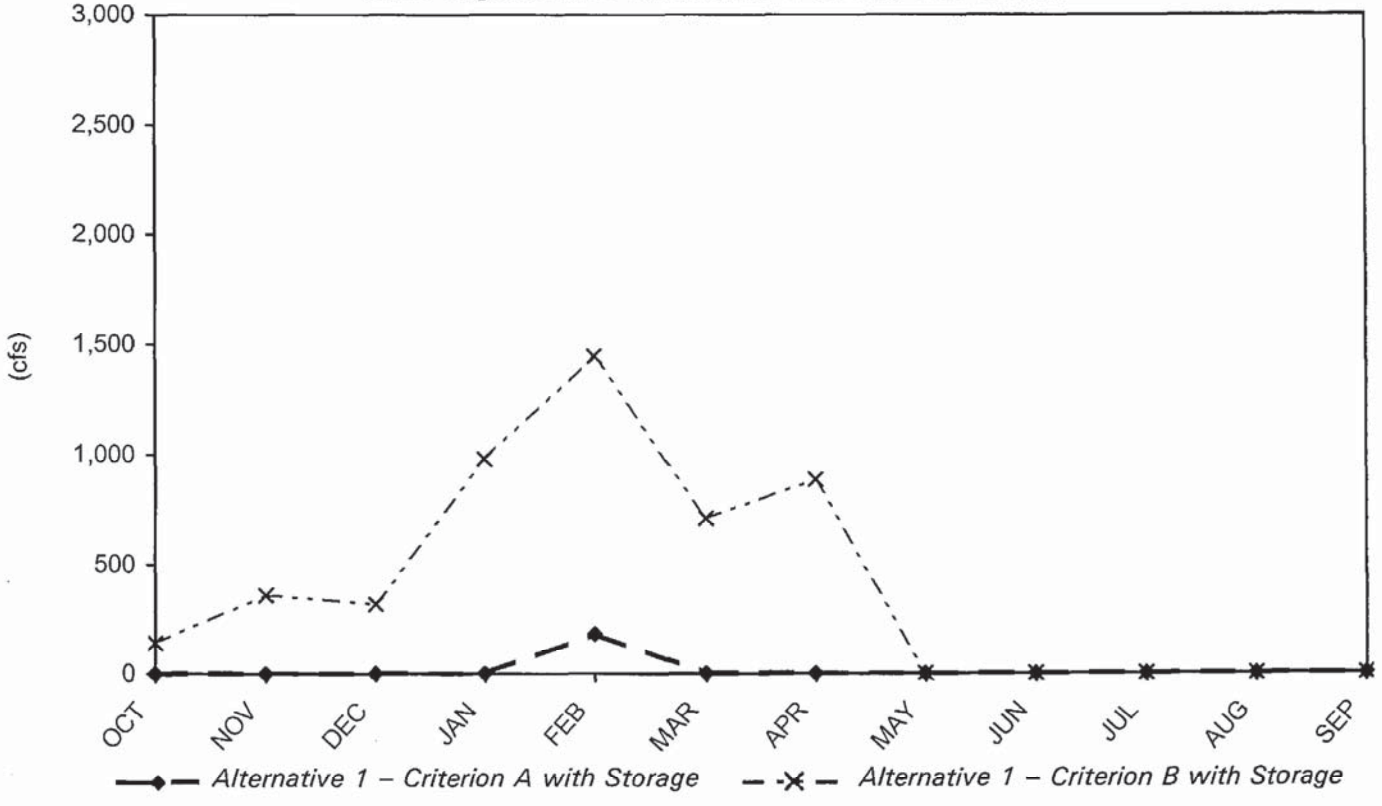


Figure 5.2-29. New Surface Storage Diversions in the Sacramento River Region under Alternative 1 for Dry and Critical Years



Under Alternative 1, maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Peak average monthly releases range from 700 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,100 to over 2,100 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (140 cfs), while average monthly diversions over the long-term period are greatest in late winter (170 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 1. Maximum average monthly releases range from 550 to 560 cfs for the long-term period and from 340 to 350 cfs for dry and critical years.

5.2.8.2 ALTERNATIVE 2

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch) and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, channel flows are described at five locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs.

Alternative 2 decreases flow by as much as 8,500 cfs in February and by as much as 2,600 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, Alternative 2 decreases flow in February by as much as 7,000 cfs. In September, Alternative 2 modifies flow by (-1,300) to 300 cfs. Figures 5.2-30 and 5.2-31 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

QWEST Flow. QWEST flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400

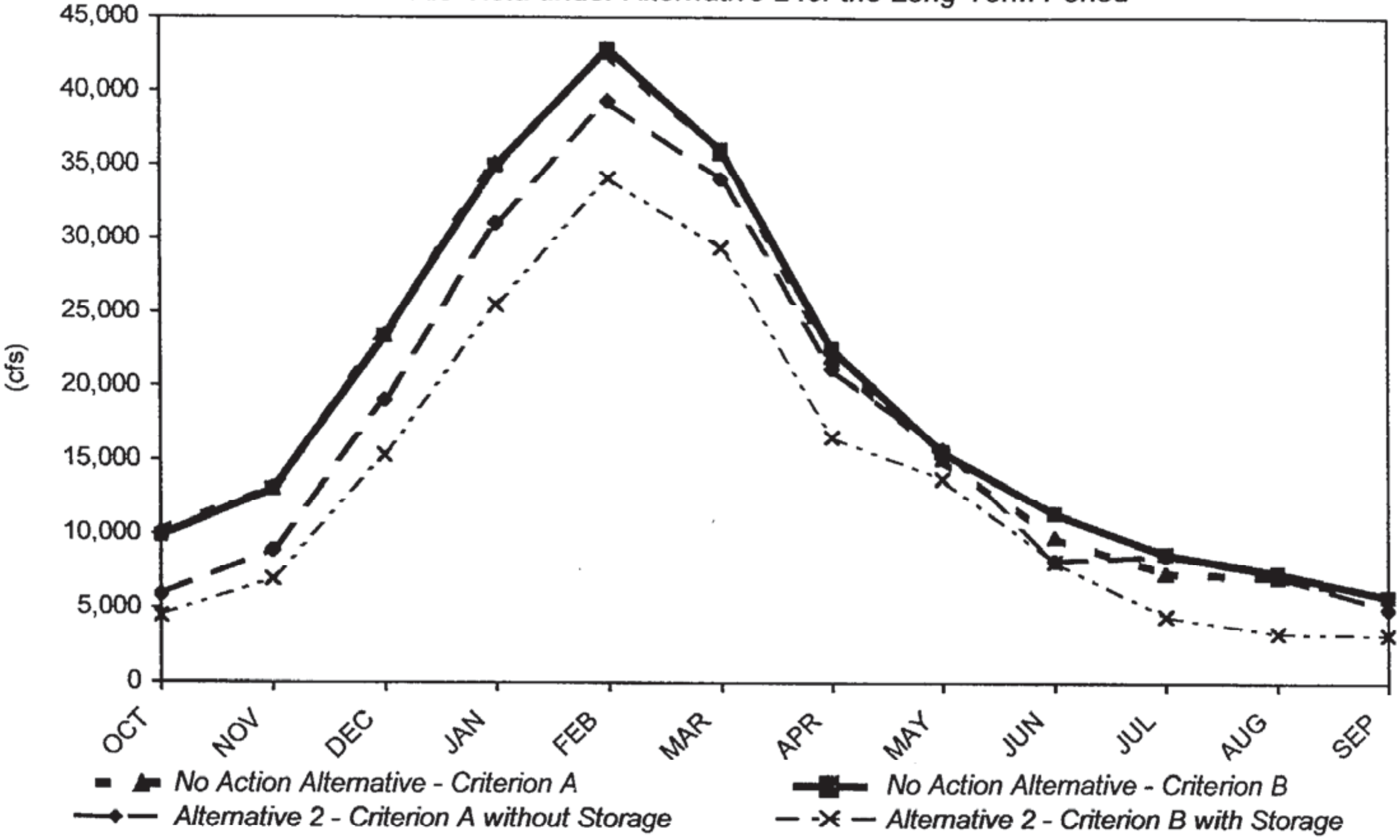


Figure 5.2-30. Average Monthly Sacramento River Flow at Rio Vista under Alternative 2 for the Long-Term Period

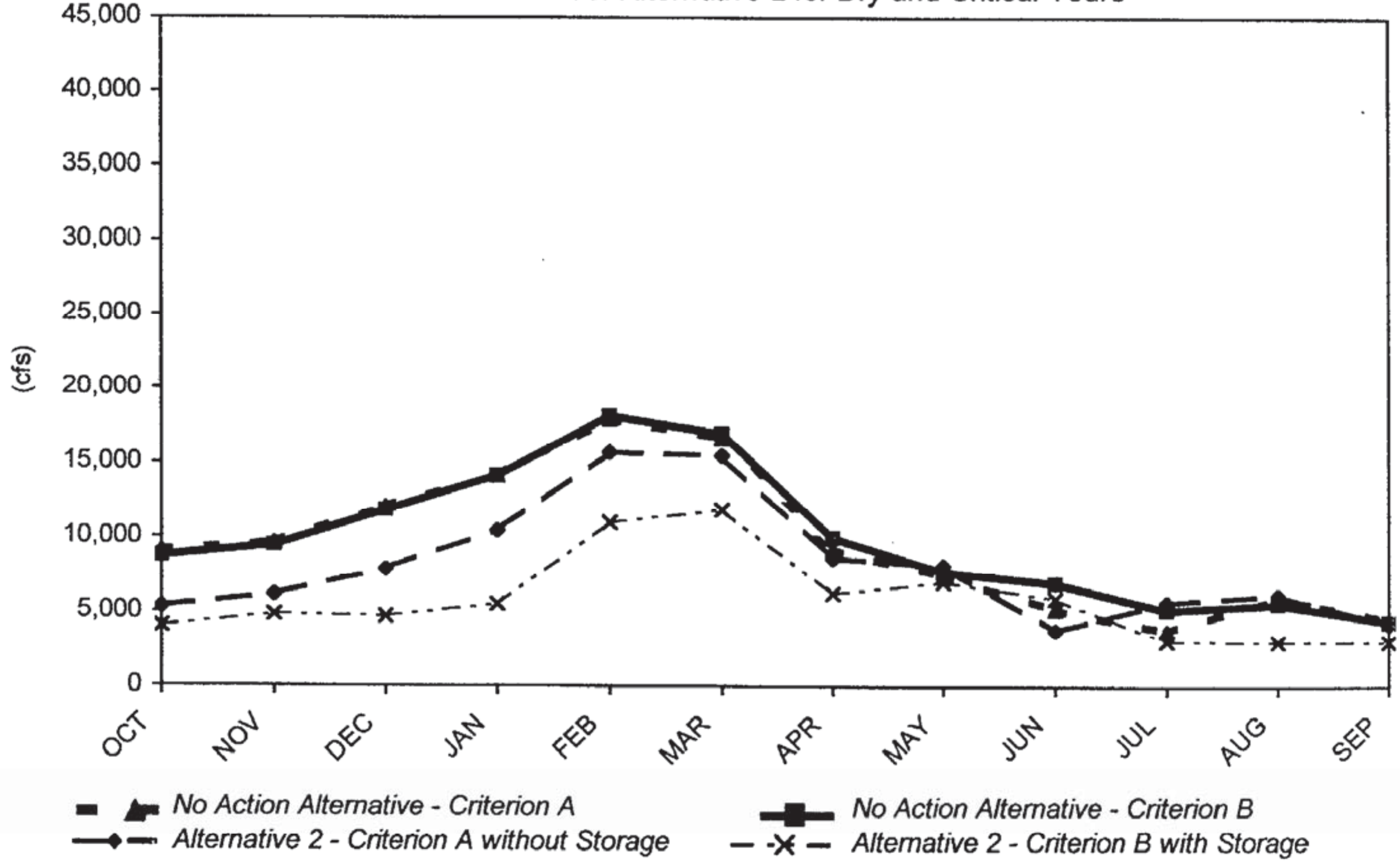


Figure 5.2-31. Average Monthly Sacramento River Flow at Rio Vista under Alternative 2 for Dry and Critical Years

to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about (-4,300) to (-4,000) cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from (-5,200) to (-4,900) cfs.

Alternative 2 increases average monthly positive QWEST flow over the long-term period in April by as much as 1,300 cfs and decreases average monthly reverse QWEST flow in October by as much as 4,700 cfs. During dry and critical years, Alternative 2 increases average monthly positive QWEST flow in April by as much as 1,300 cfs and decreases average monthly reverse QWEST flow in December by as much as 5,600 cfs. Figures 5.2-32 and 5.2-33 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December, and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December, and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 2, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas cross-Delta flow in December and May typically increases. Over the long-term period under Alternative 2, cross-Delta flow in August may vary by (-150) to 3,800 cfs relative to the No Action Alternative. Increases in cross-Delta flows over the long-term period range from 4,000 to 6,400 cfs in December and from 600 to 2,400 cfs in May. During dry and critical years under Alternative 2, cross-Delta flow in August may vary by (-300) to 3,000 cfs relative to the No Action Alternative. Increases in cross-Delta flow during dry and critical years range from 3,800 to 5,900 cfs in December and from 500 to 1,700 cfs in May. Figures 5.2-34 and 5.2-35 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about (-3,400) cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from (-3,600) to (-3,000) cfs.

Over the long-term period under Alternative 2, increases in reverse flow in Old River at Bacon Island in August range from 700 to 1,600 cfs, resulting in flow ranging from (-5,000) to (-4,100) cfs. In dry and critical years under Alternative 2, increases in reverse flow in August range from 30 to 900 cfs, resulting in flow ranging from (-4,400) to (-3,600) cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from (-1,200) to (-1,000) cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from (-2,400) to (-2,100) cfs.

Figure 5.2-32. Average Monthly QWEST Flow under Alternative 2 for the Long-Term Period

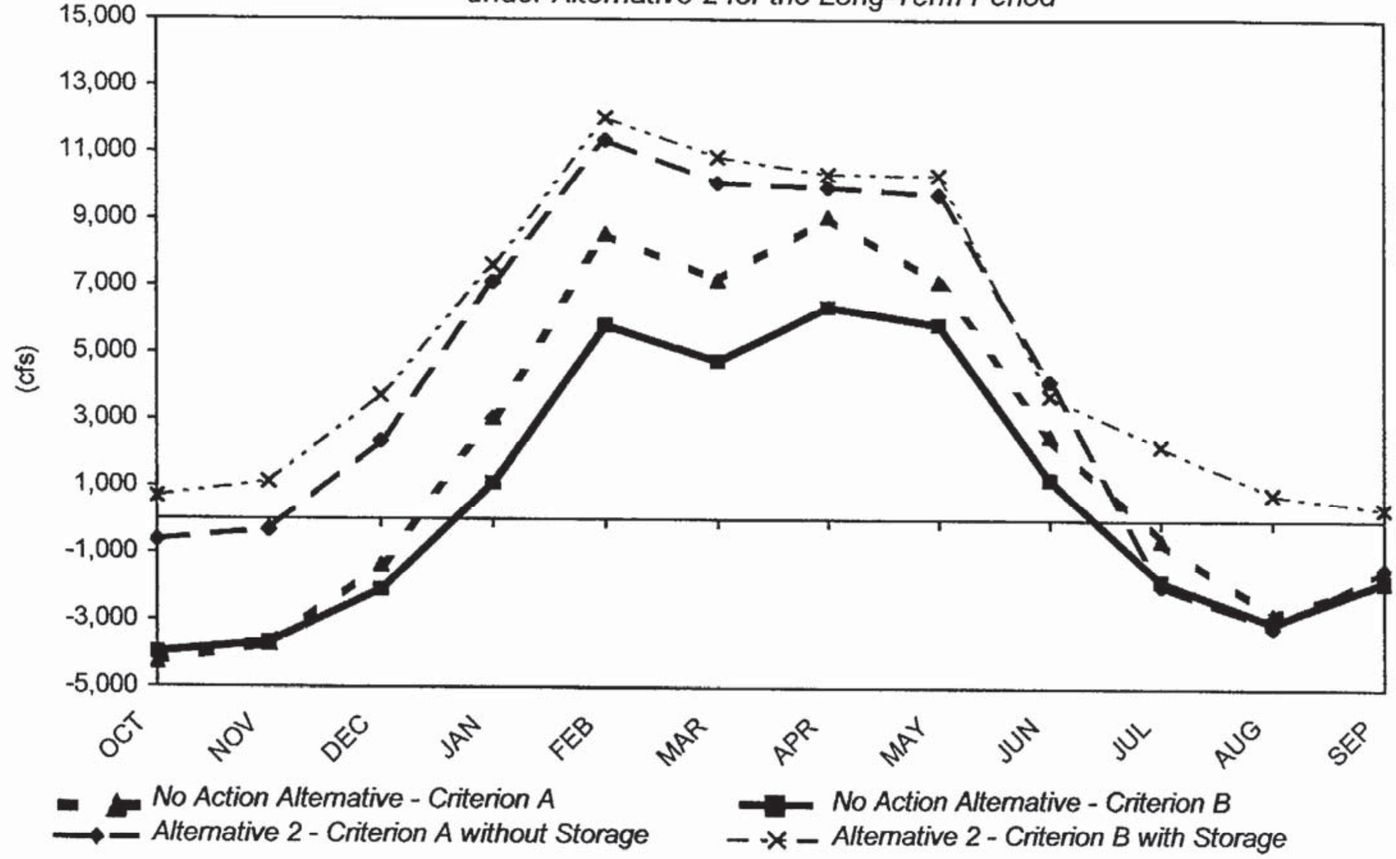


Figure 5.2-33. Average Monthly QWEST Flow under Alternative 2 for Dry and Critical Years

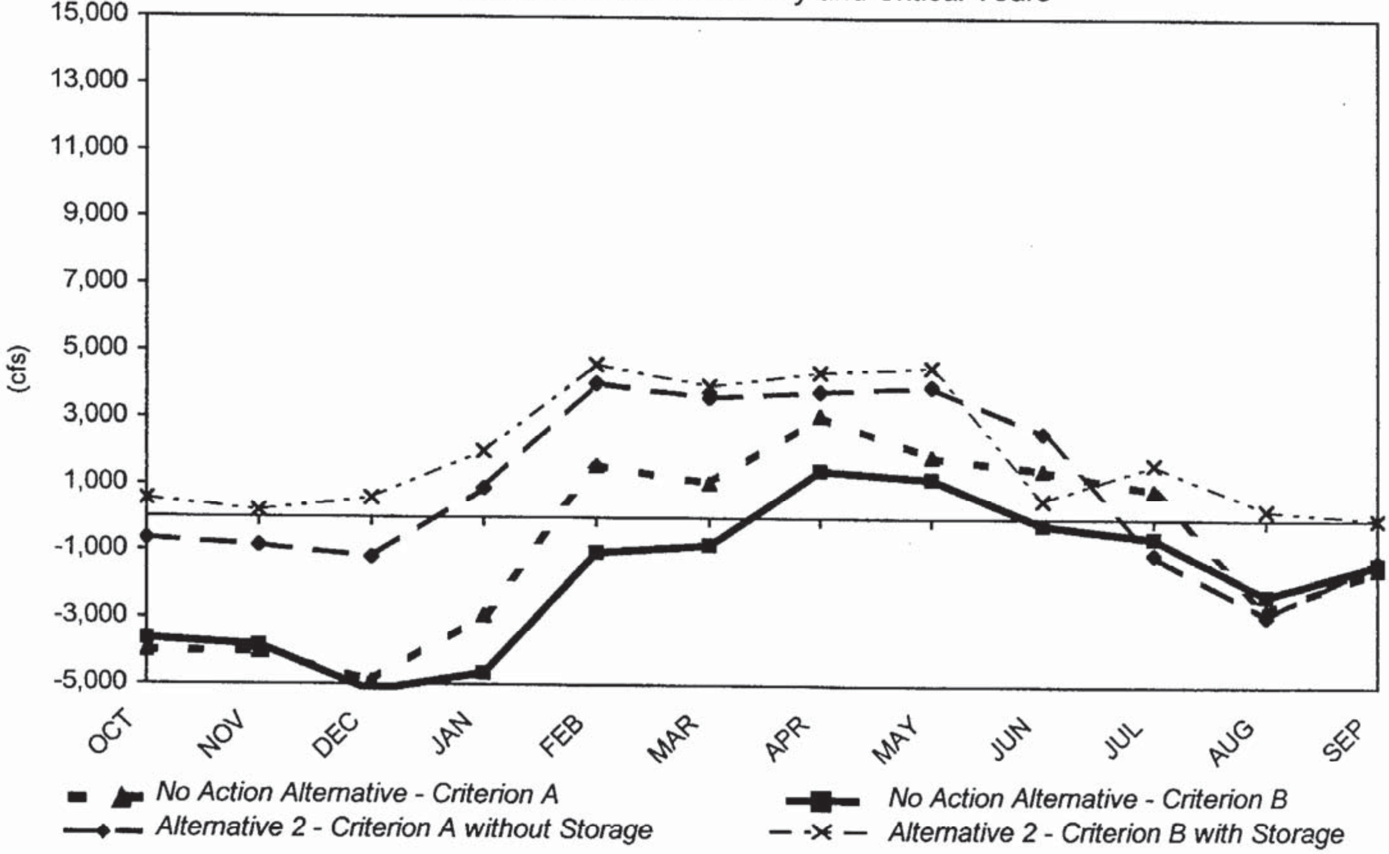


Figure 5.2-34. Average Monthly Cross-Delta Flow under Alternative 2 for the Long-Term Period

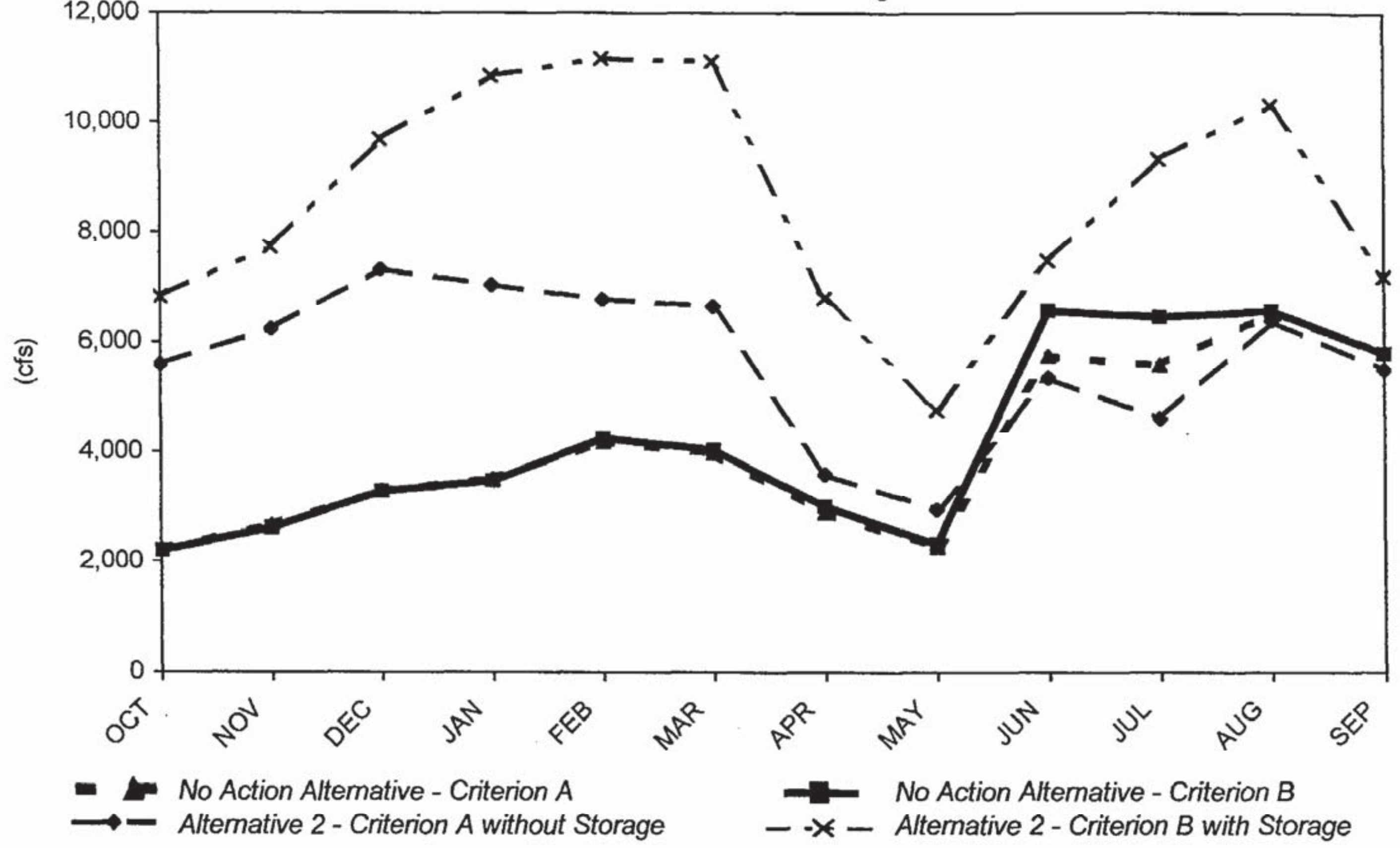
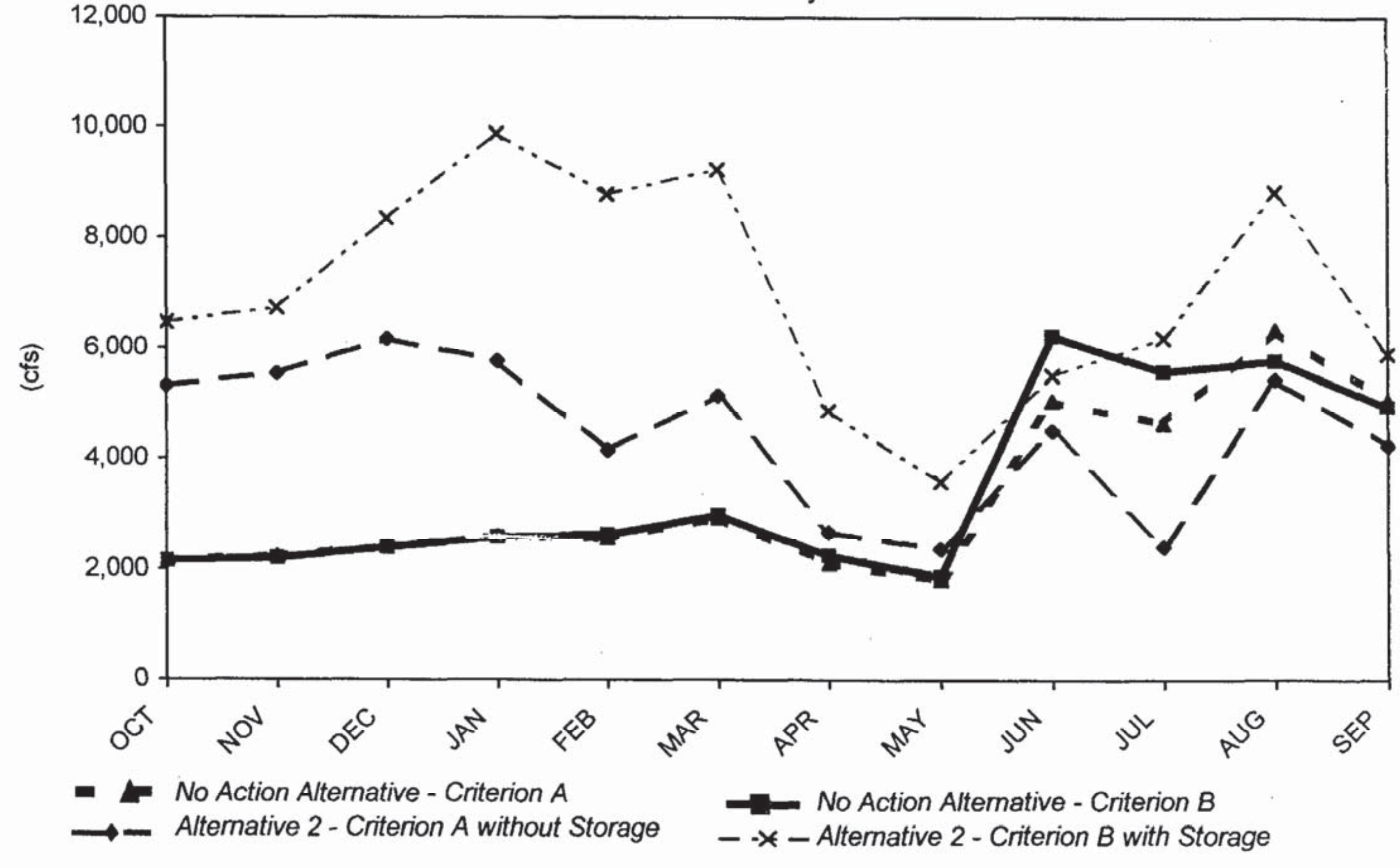


Figure 5.2-35. Average Monthly Cross-Delta Flow under Alternative 2 for Dry and Critical Years



Average monthly San Joaquin River flow at Antioch ranges from (-900) to 500 cfs in August over the long-term period under Alternative 2. In dry and critical years under Alternative 2, reverse flow in August may vary by (-500) to 200 cfs relative to the No Action Alternative, resulting in flow ranging from (-1,000) to 200 cfs. Decreases in reverse flow in December range from 2,500 to 3,400 cfs under Alternative 2 in dry and critical years, resulting in flow ranging from 500 to 1,400 cfs.

Mass Fate. The DSM2 model was used to perform several mass tracking simulations for Alternative 2. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 2 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 2 increases average monthly X2 position by about 0.6 km in September. Alternative 2 could increase X2 position by about 0.2 km or decrease X2 position by 0.4 km in March.

During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. During dry and critical years, Alternative 2 decreases average monthly X2 position by about 0.1 km in September. Alternative 2 may increase X2 position by 0.4 km or decrease X2 position by 0.6 km in March. Figures 5.2-36 and 5.2-37 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 2 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 2. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an in-stream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B in the modeling analysis.

River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 2 and the No Action Alternative. Figures 5.2-38 and 5.2-39 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, Alternative 2 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer under all hydrologic conditions. Alternative 2 increases average monthly flow by as much as 1,400 cfs during summer. Even with new storage facilities, Alternative 2 has little impact on average

Figure 5.2-36. Average Monthly X2 Position under Alternative 2 for the Long-Term Period

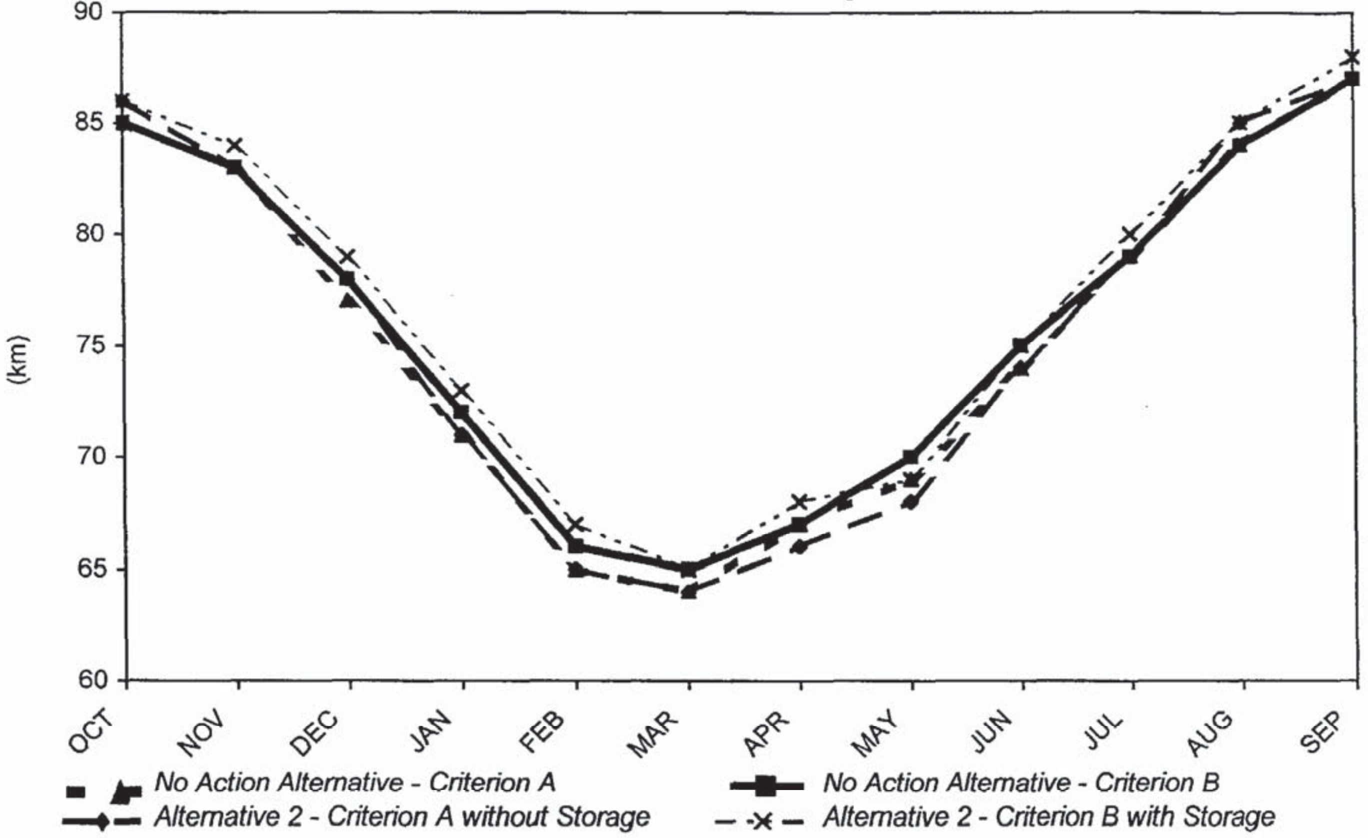


Figure 5.2-37. Average Monthly X2 Position under Alternative 2 for Dry and Critical Years

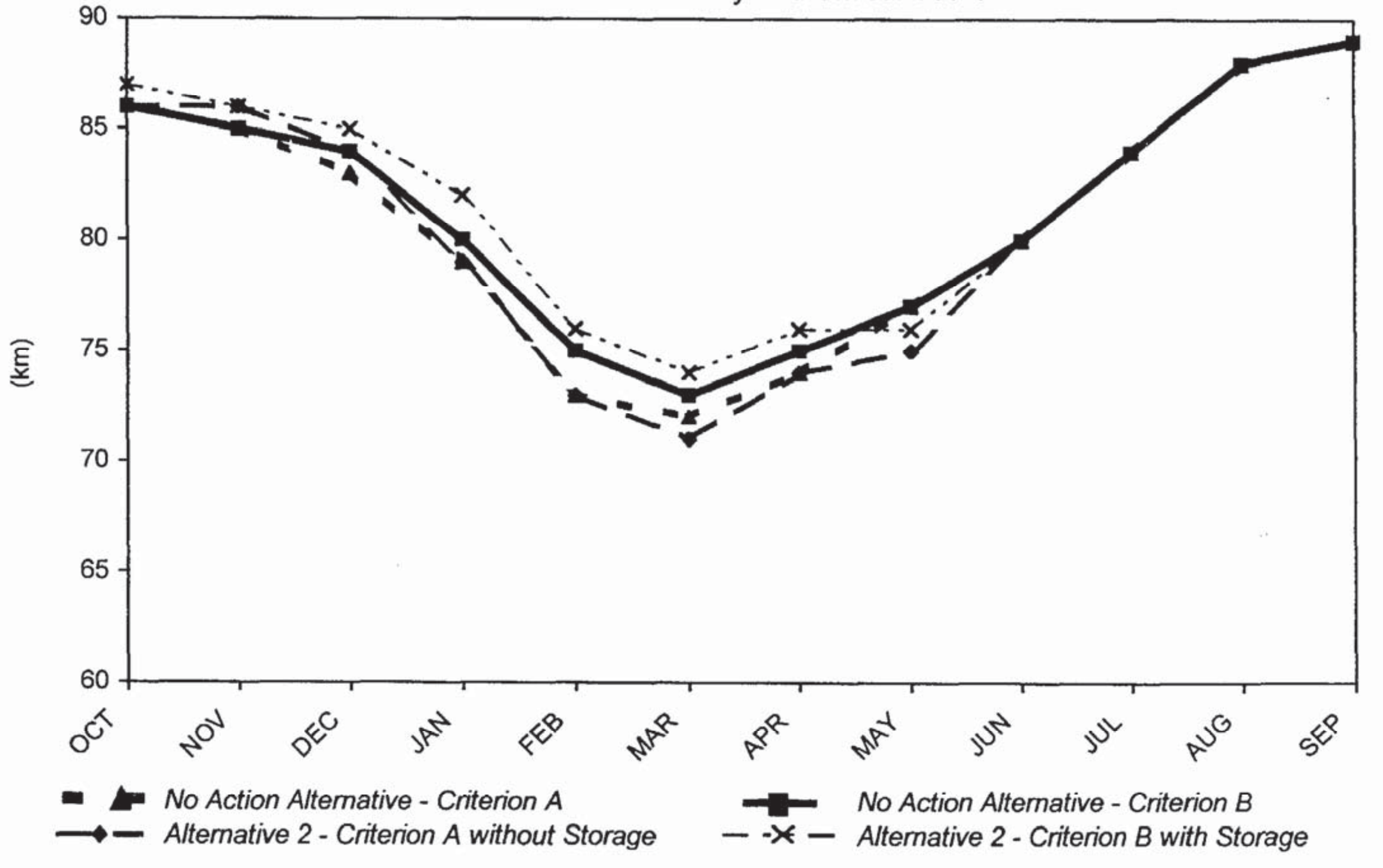


Figure 5.2-38. Average Monthly Sacramento River Flow at Freeport under Alternative 2 for the Long-Term Period

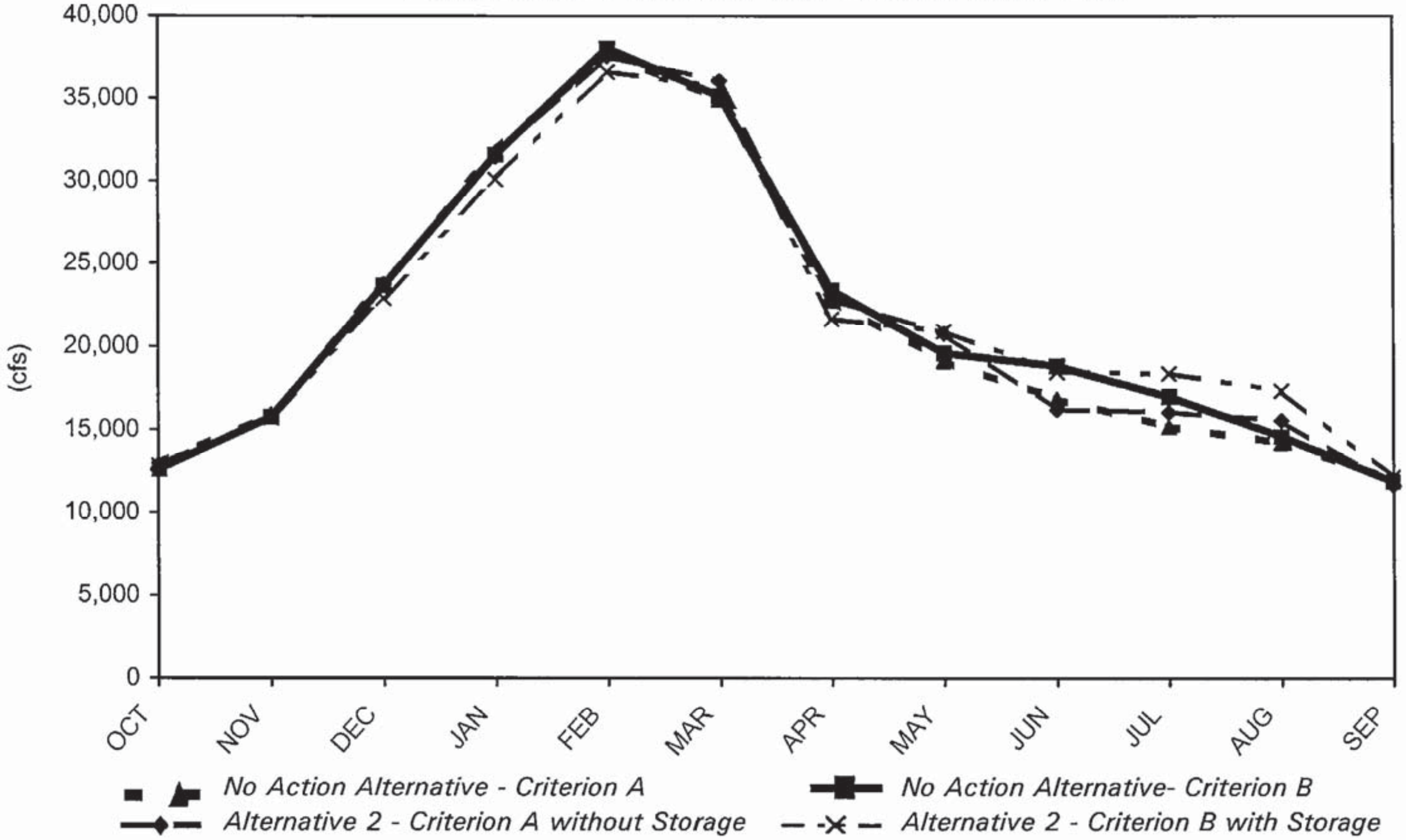
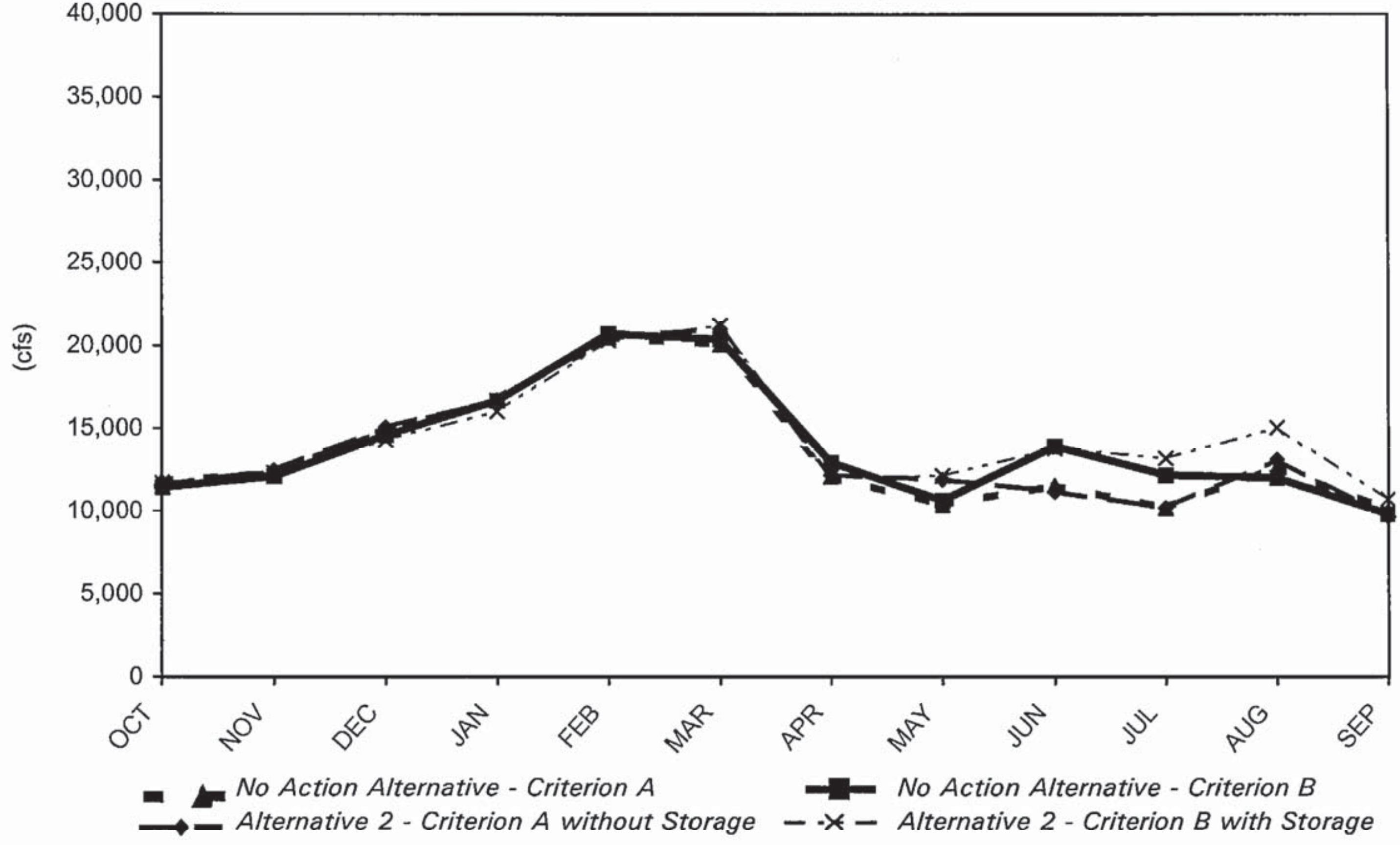


Figure 5.2-39. Average Monthly Sacramento River Flow at Freeport under Alternative 2 for Dry and Critical Years



monthly flow in most months. Anticipated flow increases are most pronounced during summers of dry and critical years—up to 1,000 cfs.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alterna-tive 2 and the No Action Alternative. Figures 5.2-40 and 5.2-41 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 2, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except in early spring. Alternative 2 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 2 increases average monthly flow in spring by as much as 1,400 cfs.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer under the No Action Alternative as well as under Alternative 2. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 2, the lowest long-term period summer releases generally are associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under Alternative 2, summer releases from existing facilities may increase up to 1,400 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 2, releases may decrease as much as 1,300 cfs or increase up to 300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 2, necessitates increased flood control releases in winter months.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of Alternative 2. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

New Reservoir Diversions and Releases. Figures 5.2-42 and 5.2-43 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 2. Under Alternative 2, new surface storage diversions typically occur during winter and spring, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is 1,400-2,300 cfs. For dry and critical years, the range of peak average monthly diversions is 200-1,400 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer when the greatest environmental benefits are anticipated—with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Figure 5.2-40. Average Monthly San Joaquin River Flow at Vernalis under Alternative 2 for the Long-Term Period

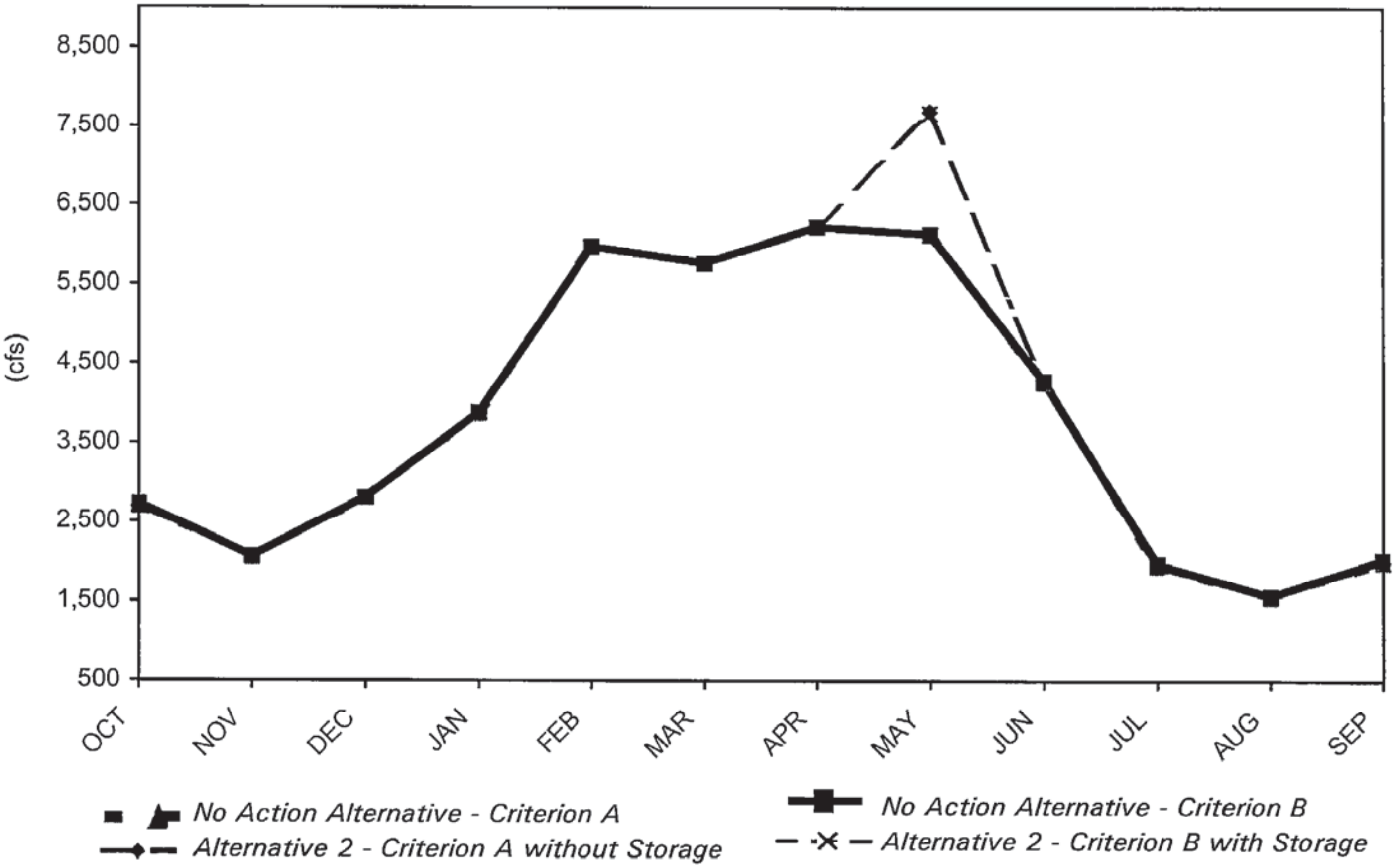


Figure 5.2-41. Average Monthly San Joaquin River Flow at Vernalis under Alternative 2 for Dry and Critical Years

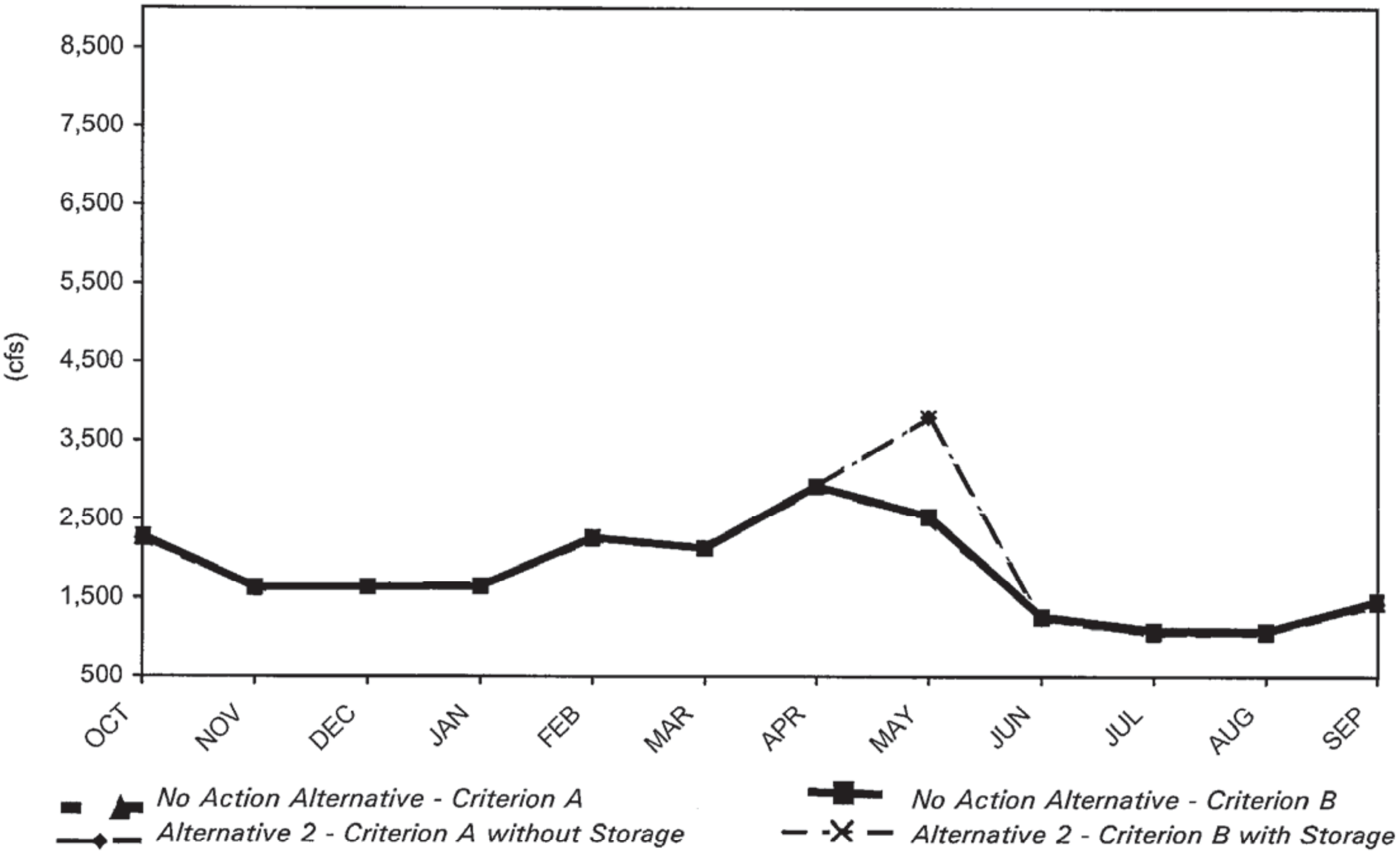


Figure 5.2-42. New Surface Storage Diversions in the Sacramento River Region under Alternative 2 for the Long-Term Period

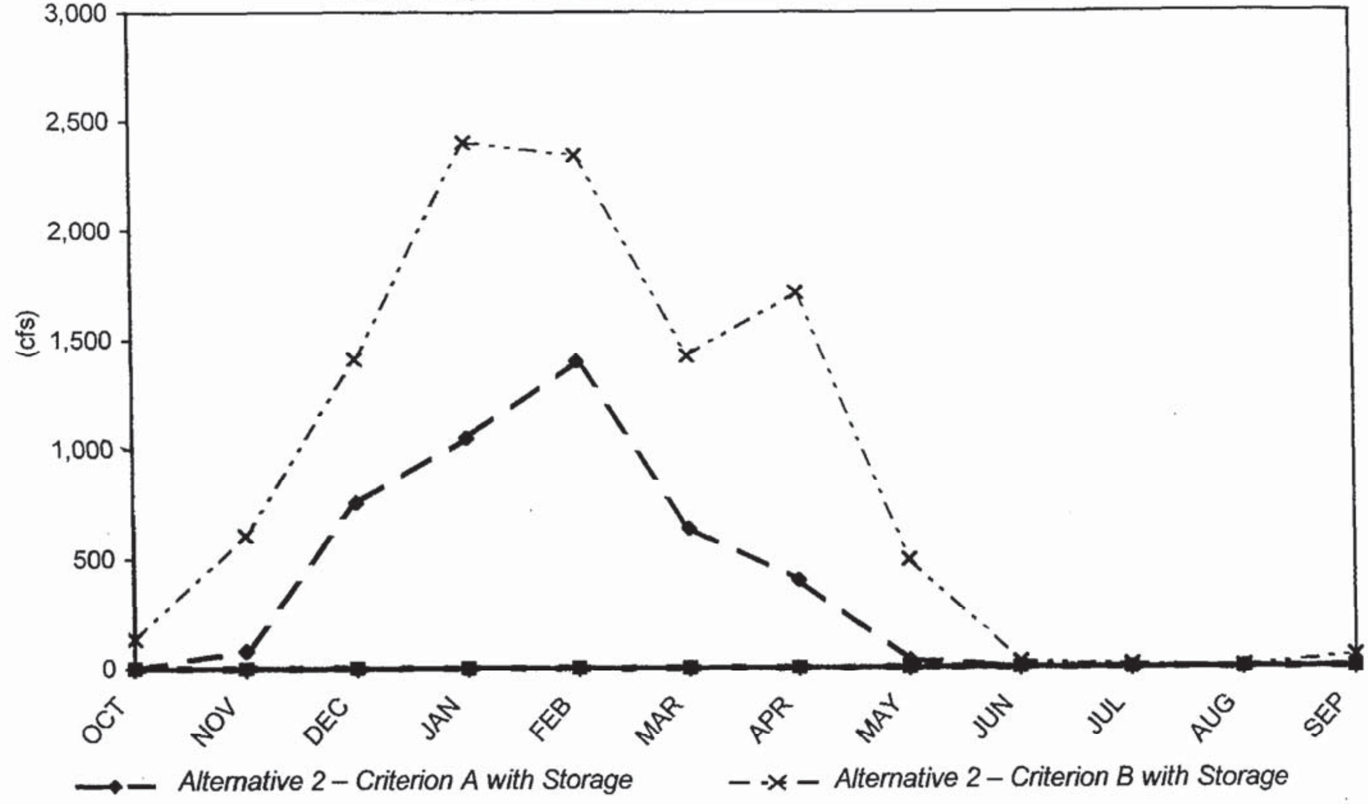
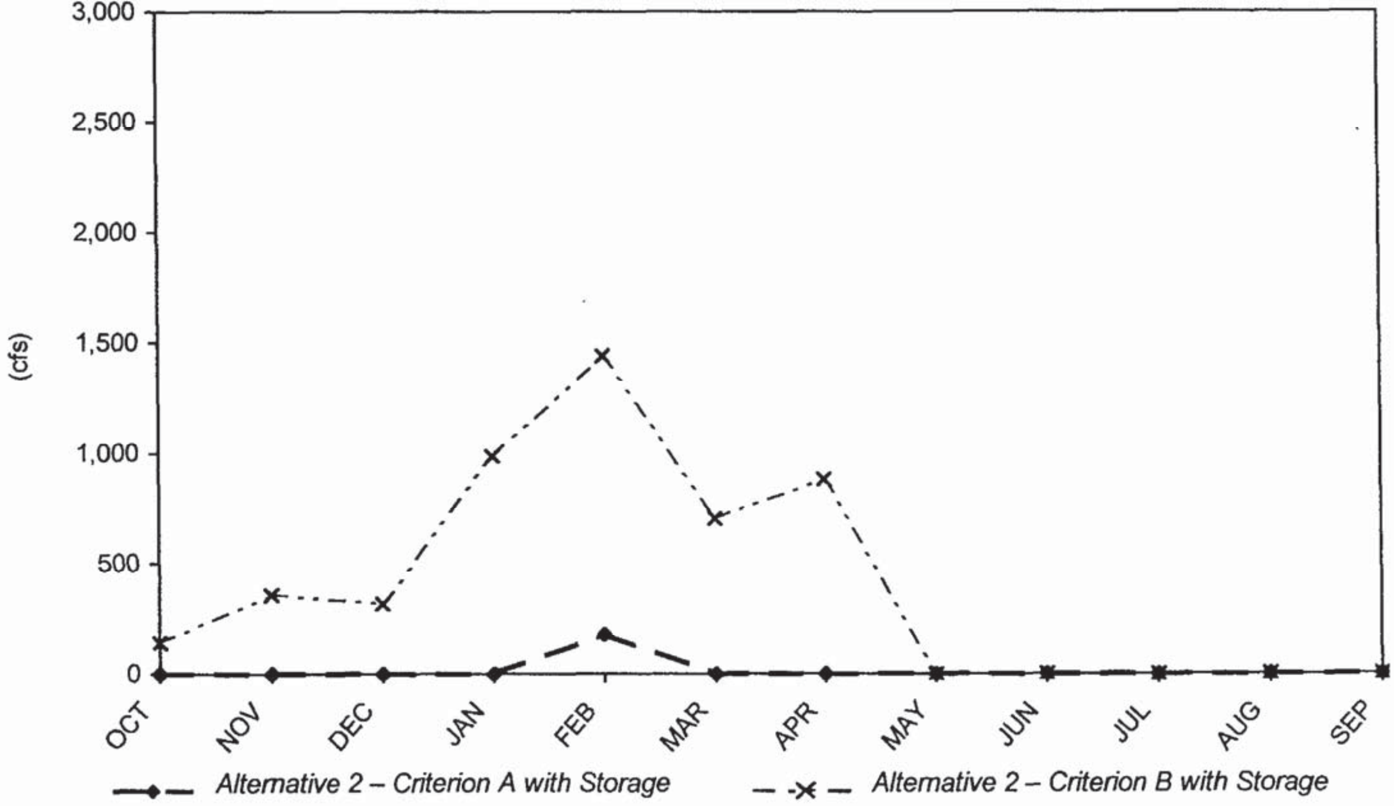


Figure 5.2-43. New Surface Storage Diversions in the Sacramento River Region under Alternative 2 for Dry and Critical Years



Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Under Alternative 2, peak average monthly releases range from 1,700-2,600 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200-2,200 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Under Alternative 2, maximum diversions during dry and critical years occur in early summer (120 cfs), while average monthly diversions over the long-term period are greatest in late winter (170 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 2. Under Alternative 2, maximum average monthly releases range from 550 to 560 cfs for the long-term period, from 340-350 cfs for dry and critical years.

5.2.8.3 ALTERNATIVE 3

For evaluation purposes, Alternative 3 was simulated with a 5,000- and 15,000-cfs isolated conveyance facility. Evaluation of the smaller configuration assumes that full south Delta improvements are in place. Evaluation of the larger configuration assumes a subset of the south Delta improvements are in place and includes service to Delta islands along the route of the canal. To fully describe potential consequences of Alternative 3, the 15,000-cfs isolated conveyance facility is evaluated under Criterion A assumptions and the 5,000-cfs isolated conveyance facility is evaluated under Criterion B assumptions. See Attachment A for further details.

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch) and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, channel flows are described at five locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs.

Alternative 3 decreases flow by as much as 7,400 cfs in February and by as much as 2,800 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, Alternative 3 decreases flow by as much as 4,400 cfs in February and by as much as 1,400 cfs in September. Figures 5.2-44 and 5.2-45 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

QWEST Flow. QWEST flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about (-4,300) to (-4,000) cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400-3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from (-5,200) to (-4,900) cfs.

Alternative 3 increases average monthly positive QWEST flow over the long-term period in April by as much as 2,100 cfs and decreases average monthly reverse QWEST flow in October by as much as 5,700 cfs. During dry and critical years, Alternative 3 increases average monthly positive QWEST flow in April by as much as 1,900 cfs and decreases average monthly reverse QWEST flow in December by as much as 6,700 cfs. Figures 5.2-46 and 5.2-47 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 3, over the long-term period and in dry and critical years, cross-Delta flow typically decreases in August, December and May. Over the long-term period under Alternative 3, decreases in cross-Delta flow range from 1,700 to 2,800 cfs in August, from 800 to 1,300 cfs in December and from 200 to 400 cfs in May. During dry and critical years under Alternative 3, decreases in cross-Delta flow range from 1,700 to 2,000 cfs in August, from 800 to 1,300 cfs in December and from 200 to 500 cfs in May. Figures 5.2-48 and 5.2-49 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about (-3,400) cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from (-3,600) to (-3,000) cfs.

Over the long-term period under Alternative 3, decreases in reverse flow in Old River at Bacon Island in August range from 1,700 to 3,000 cfs, resulting in flow ranging from (-1,700) to (-400) cfs. In dry and critical years under Alternative 3, decreases in reverse flow in August range from 2,100 to 2,400 cfs, resulting in flow ranging from (-1,000) to (-600) cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin

Figure 5.2-44. Average Monthly Sacramento River Flow at Rio Vista under Alternative 3 for the Long-Term Period

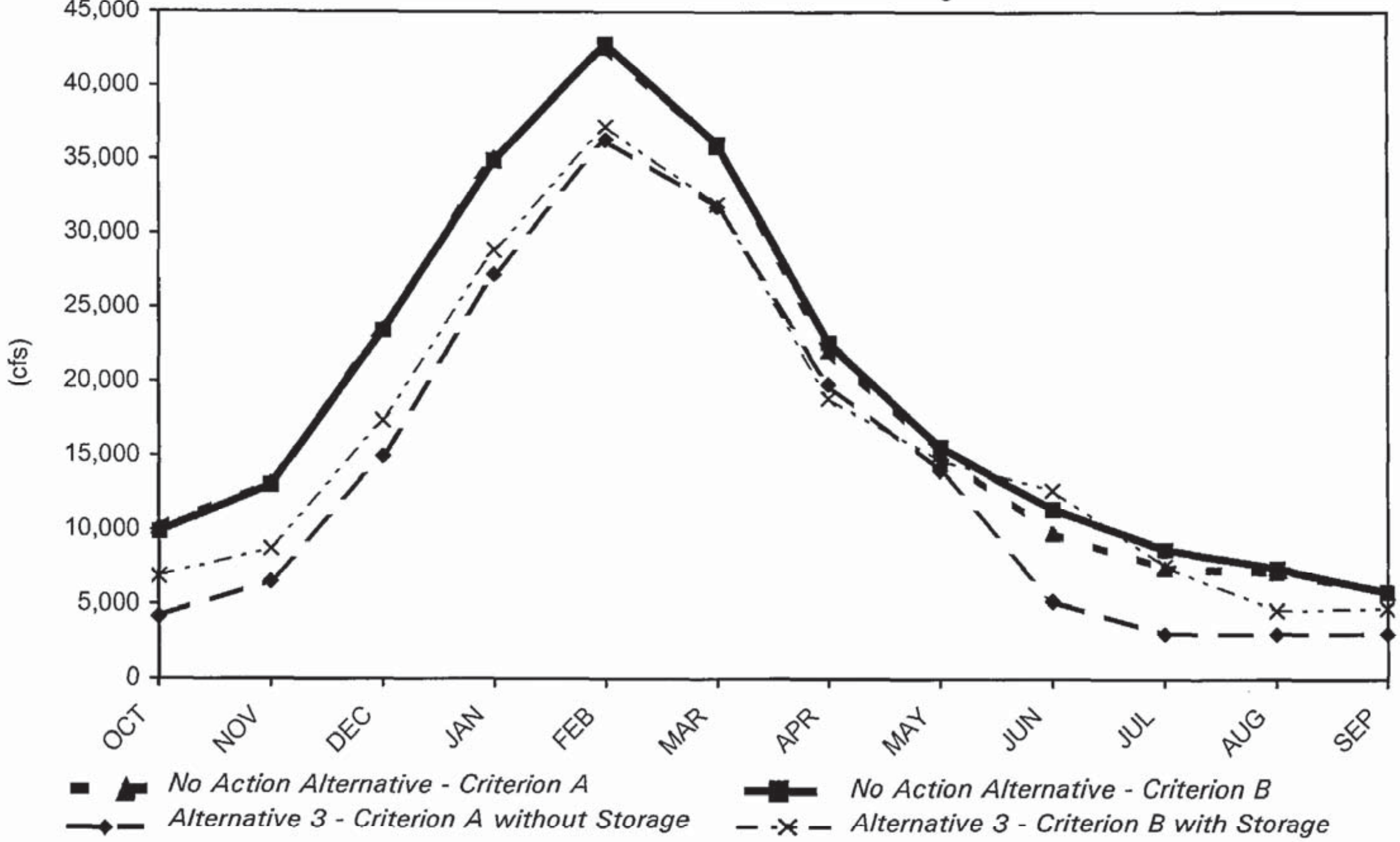


Figure 5.2-45. Average Monthly Sacramento River Flow at Rio Vista under Alternative 3 for Dry and Critical Years

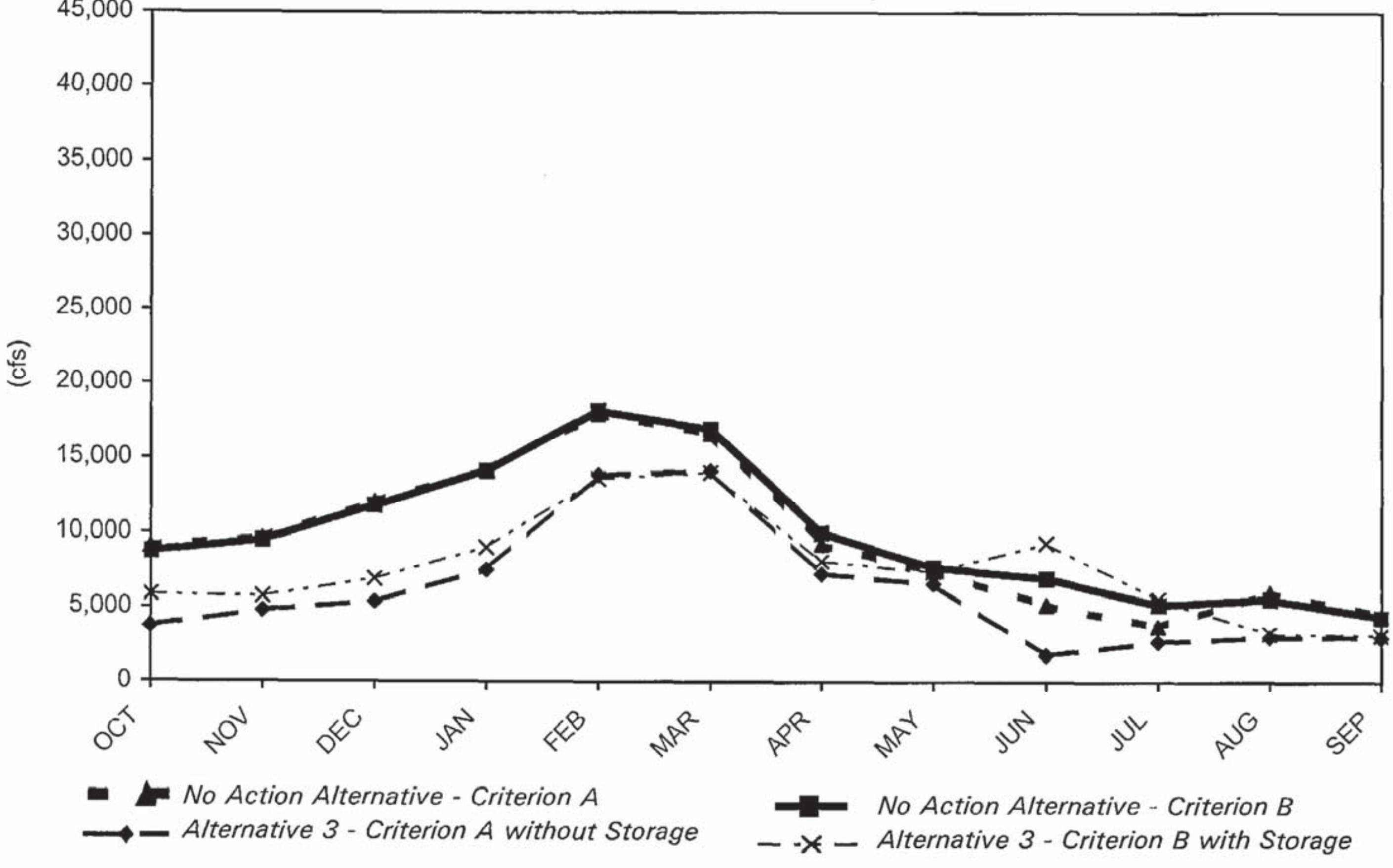


Figure 5.2-46. Average Monthly QWEST Flow under Alternative 3 for the Long-Term Period

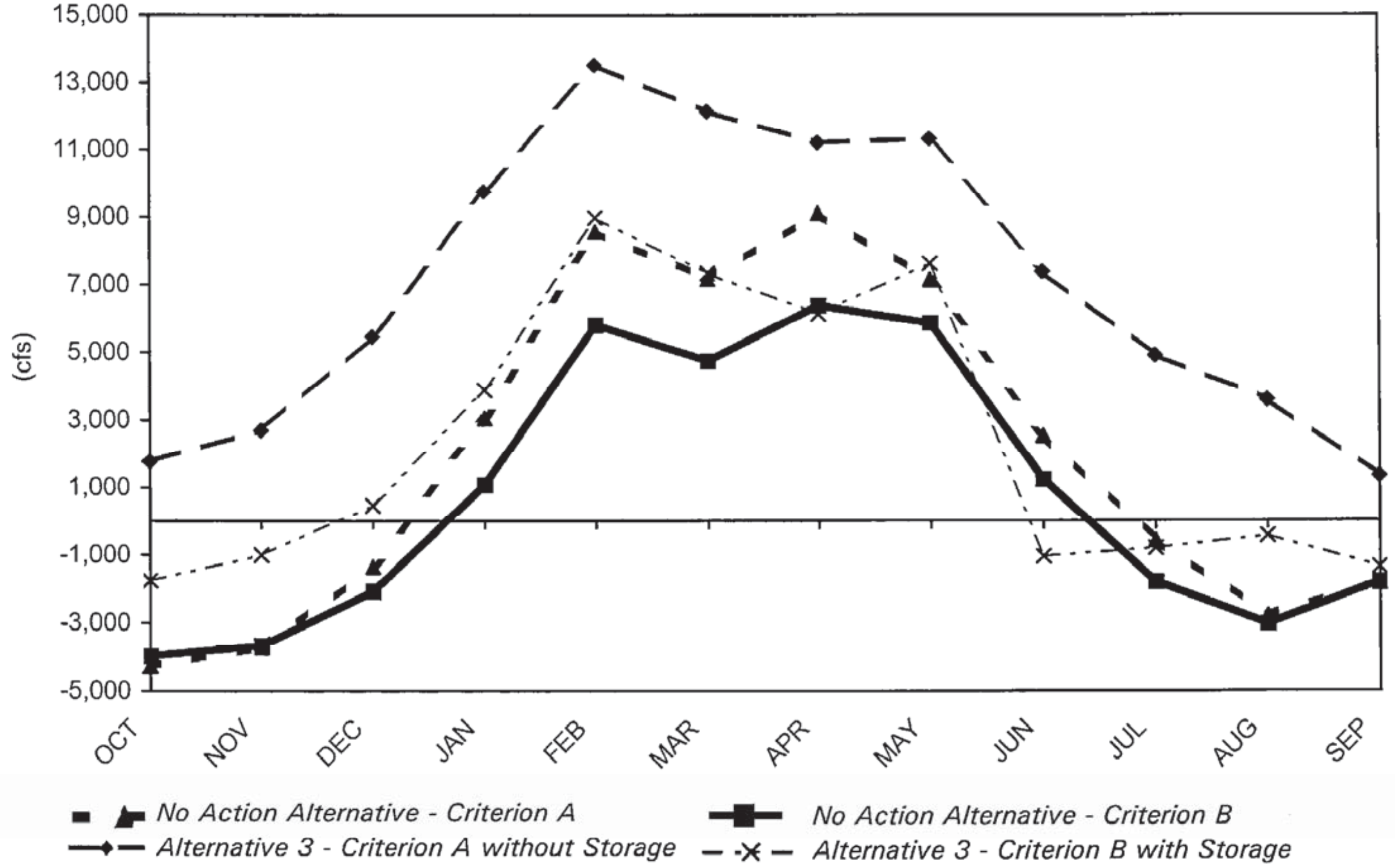


Figure 5.2-47. Average Monthly QWEST Flow under Alternative 3 for Dry and Critical Years

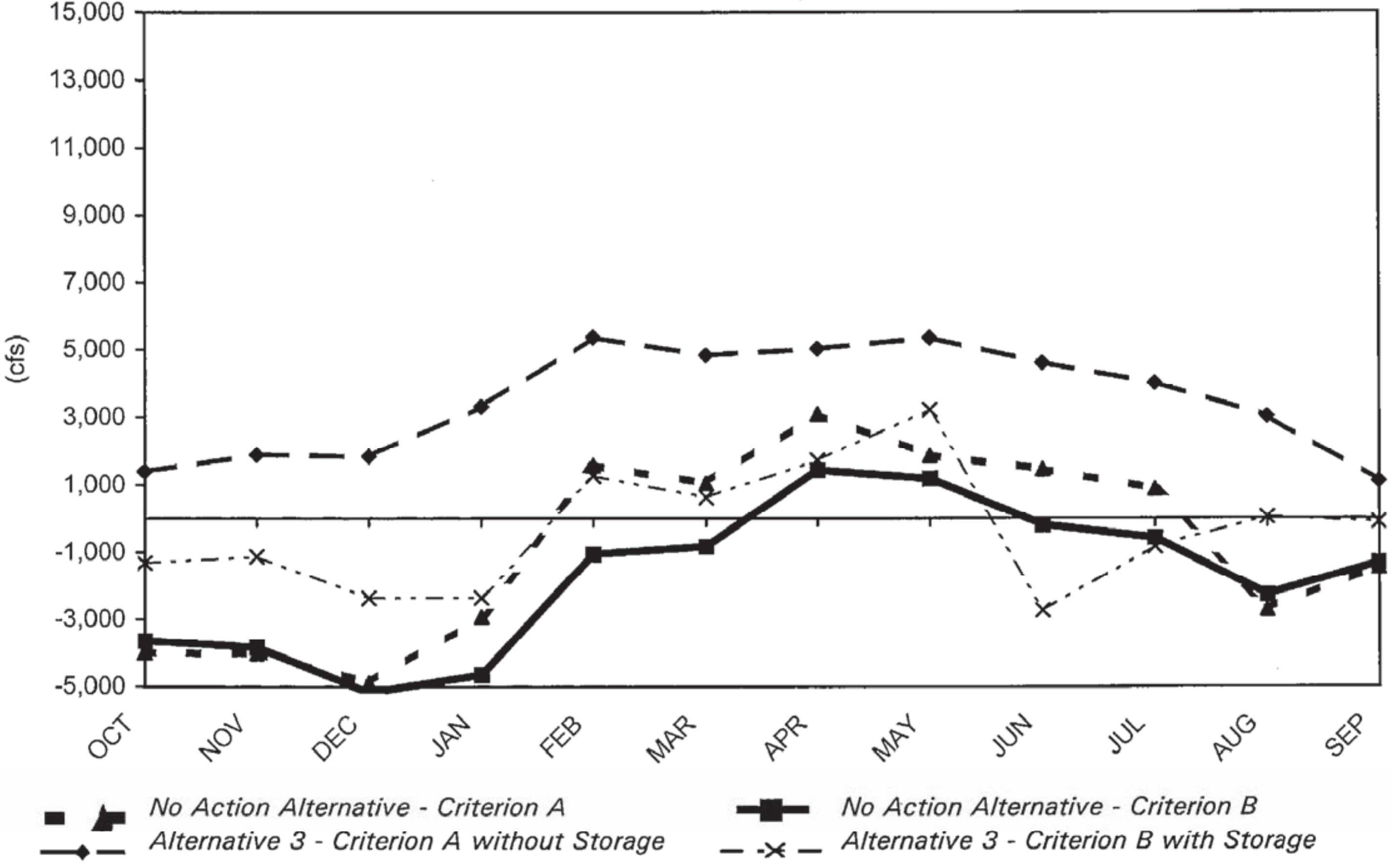


Figure 5.2-48. Average Monthly Cross-Delta Flow under Alternative 3 for the Long-Term Period

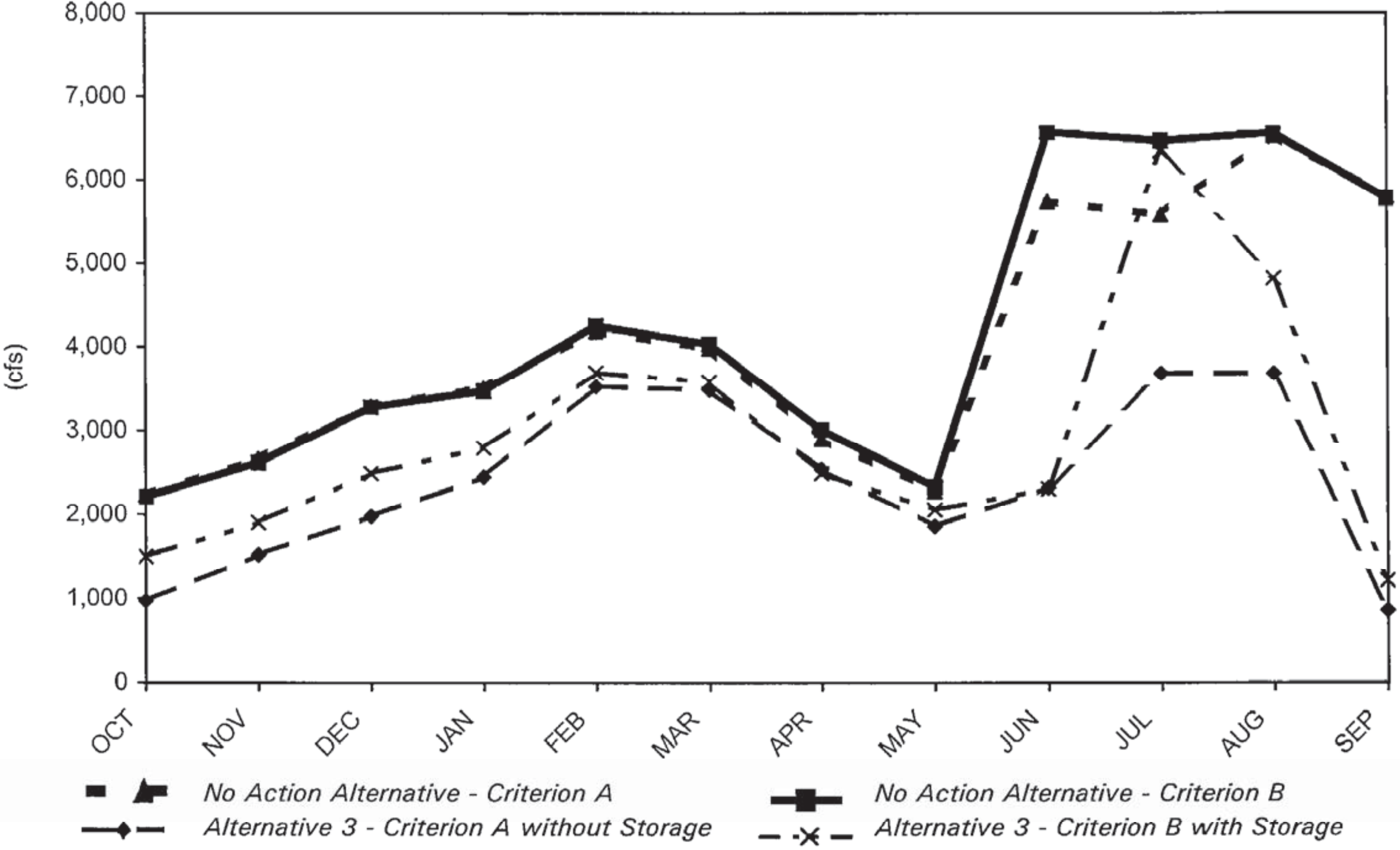
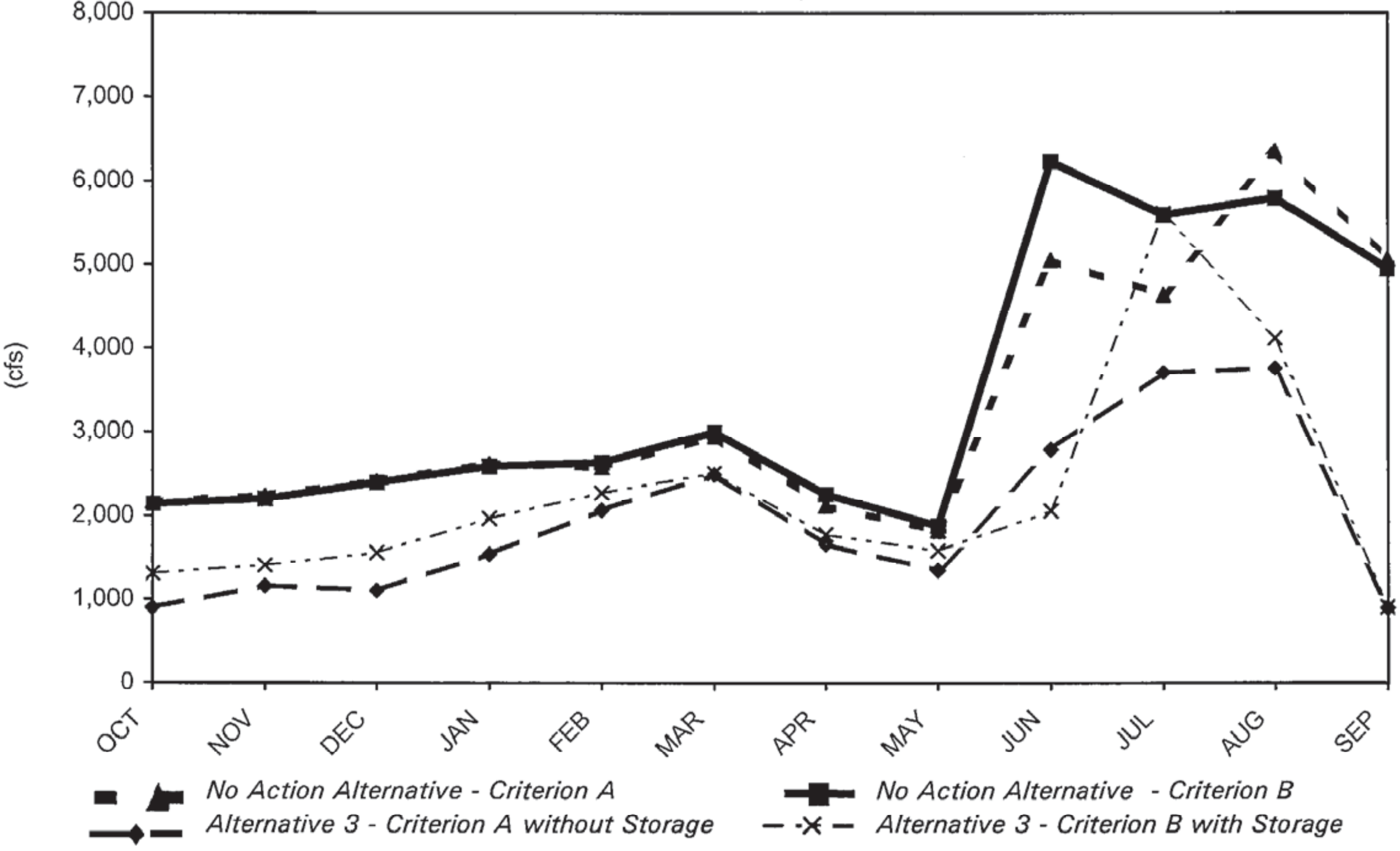


Figure 5.2-49. Average Monthly Cross-Delta Flow under Alternative 3 for Dry and Critical Years



River at Antioch typically occurs in October and ranges from (-1,200) to (-1,000) cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from (-2,400) to (-2,100) cfs.

Average monthly San Joaquin River flow at Antioch ranges from 2,100 to 4,100 cfs in August over the long-term period under Alternative 3. In dry and critical years under Alternative 3, reverse flow decreases in August range from 3,000 to 3,700 cfs, resulting in flow ranging from 2,700 to 3,500 cfs. Decreases in reverse flow in December range from 1,900 to 5,000 cfs under Alternative 3 in dry and critical years, resulting in flow ranging from (-150) to 2,900 cfs.

Mass Fate. The DSM2 model was used to perform several mass tracking simulations for Alternative 3. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 3 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 3 may increase average monthly X2 position by about 1.1 km or may decrease X2 position by 2.3 km in September. Alternative 3 may increase X2 position by about 0.8 km or decrease X2 position by 0.3 km in March. During dry and critical years under the No Action alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. Alternative 3 decreases average monthly X2 position by about 3.9 km in September and by about 0.4 km in March. Alternative 3 also may increase monthly X2 position in March during dry and critical years by about 1.2 km. Figures 5.2-50 and 5.2-51 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 3 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 3. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an instream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B under the modeling analysis.

River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 3 and the No Action Alternative. Figures 5.2-52 and 5.2-53 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, Alternative 3 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in

Figure 5.2-50. Average Monthly X2 Position under Alternative 3 for the Long-Term Period

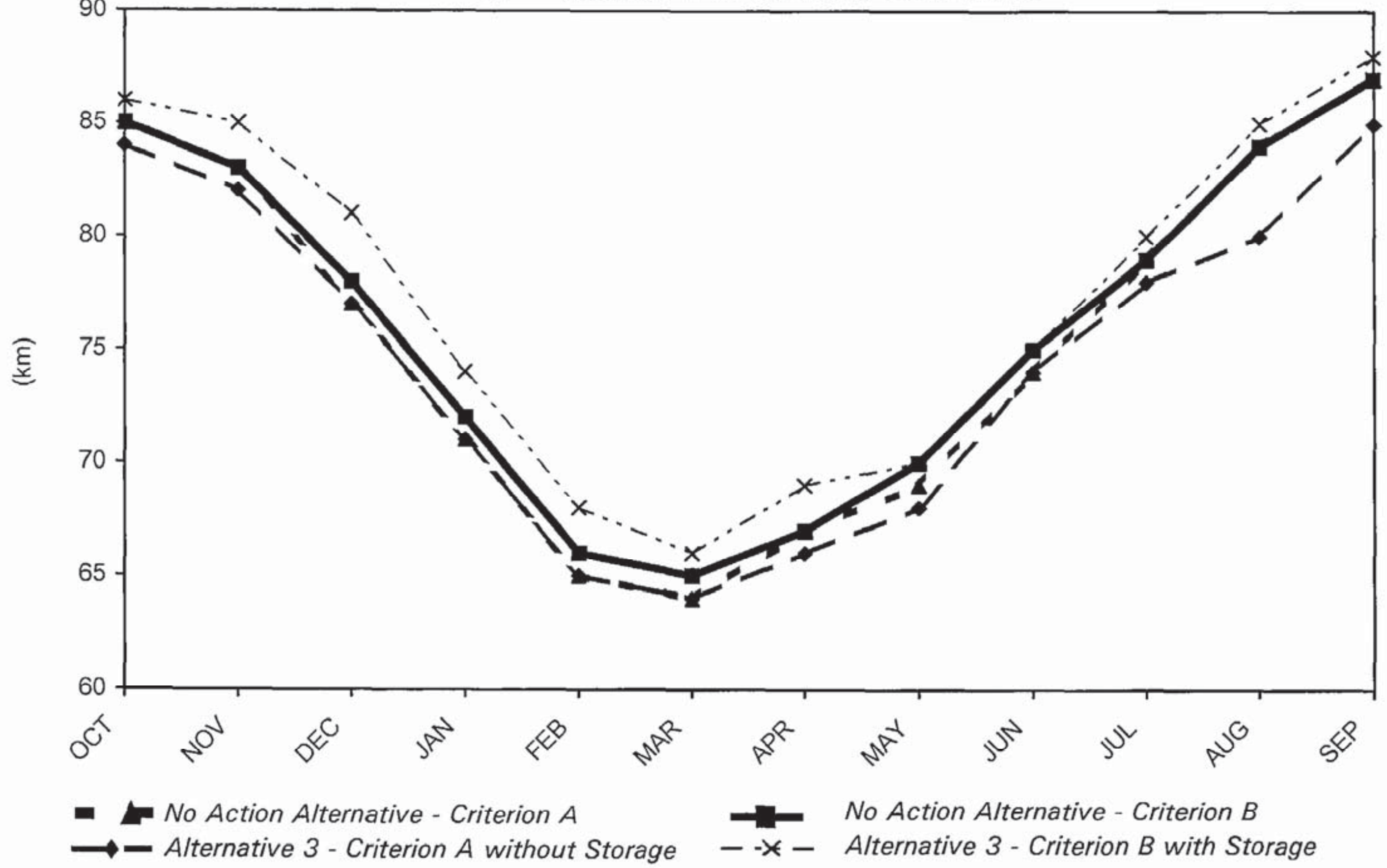


Figure 5.2-51. Average Monthly X2 Position under Alternative 3 for Dry and Critical Years

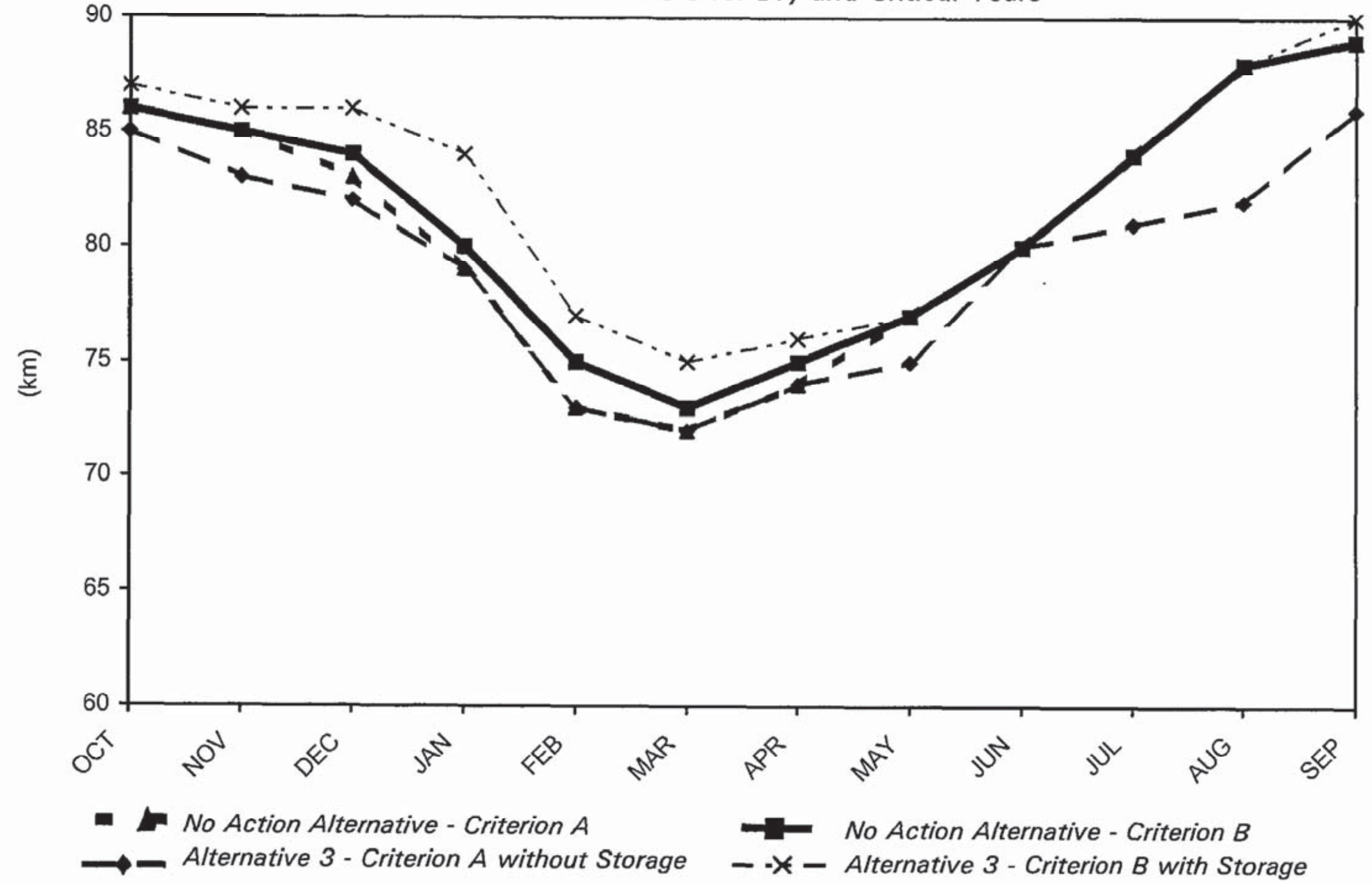


Figure 5.2-52. Average Monthly Sacramento River Flow at Freeport under Alternative 3 for the Long-Term Period

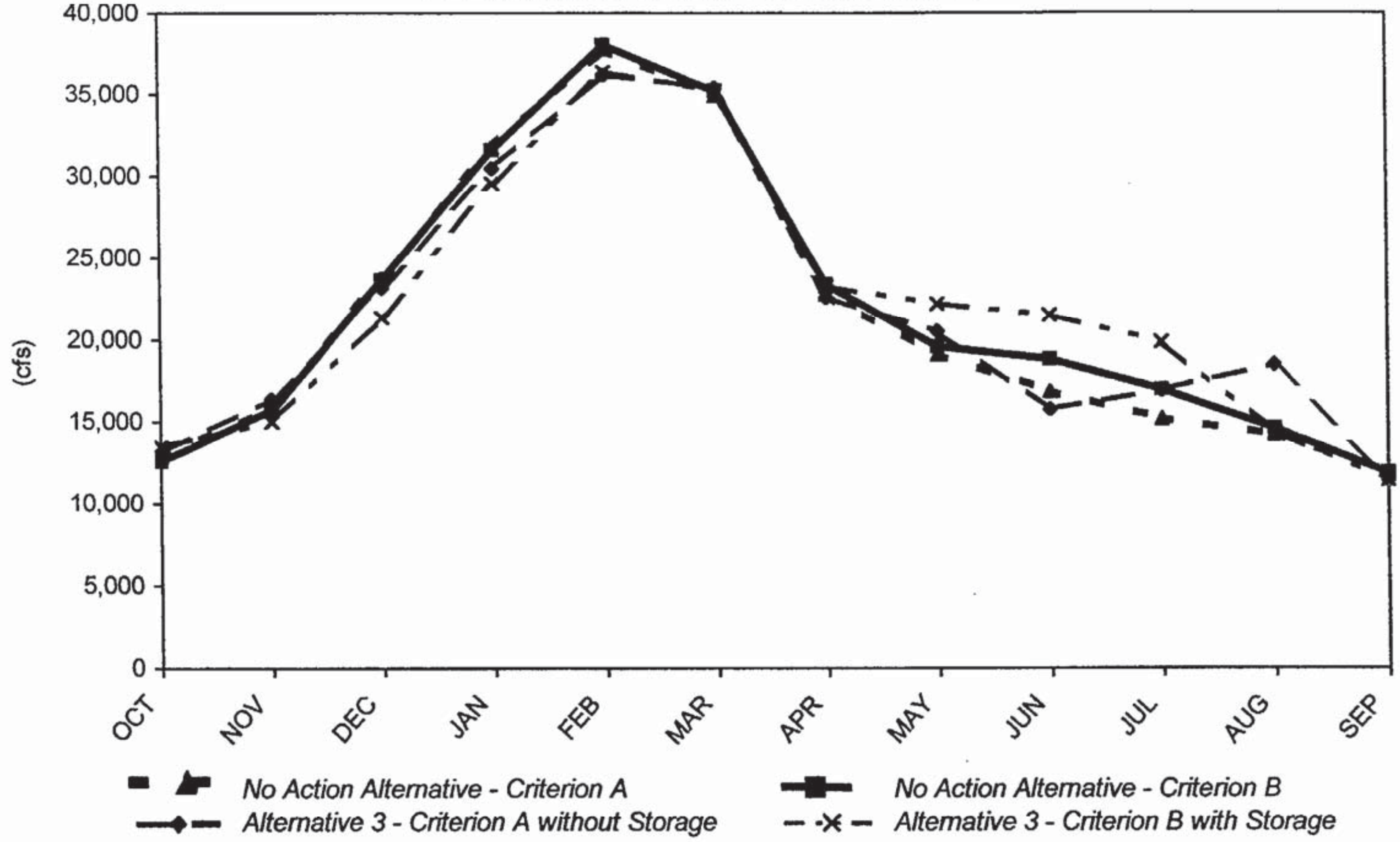
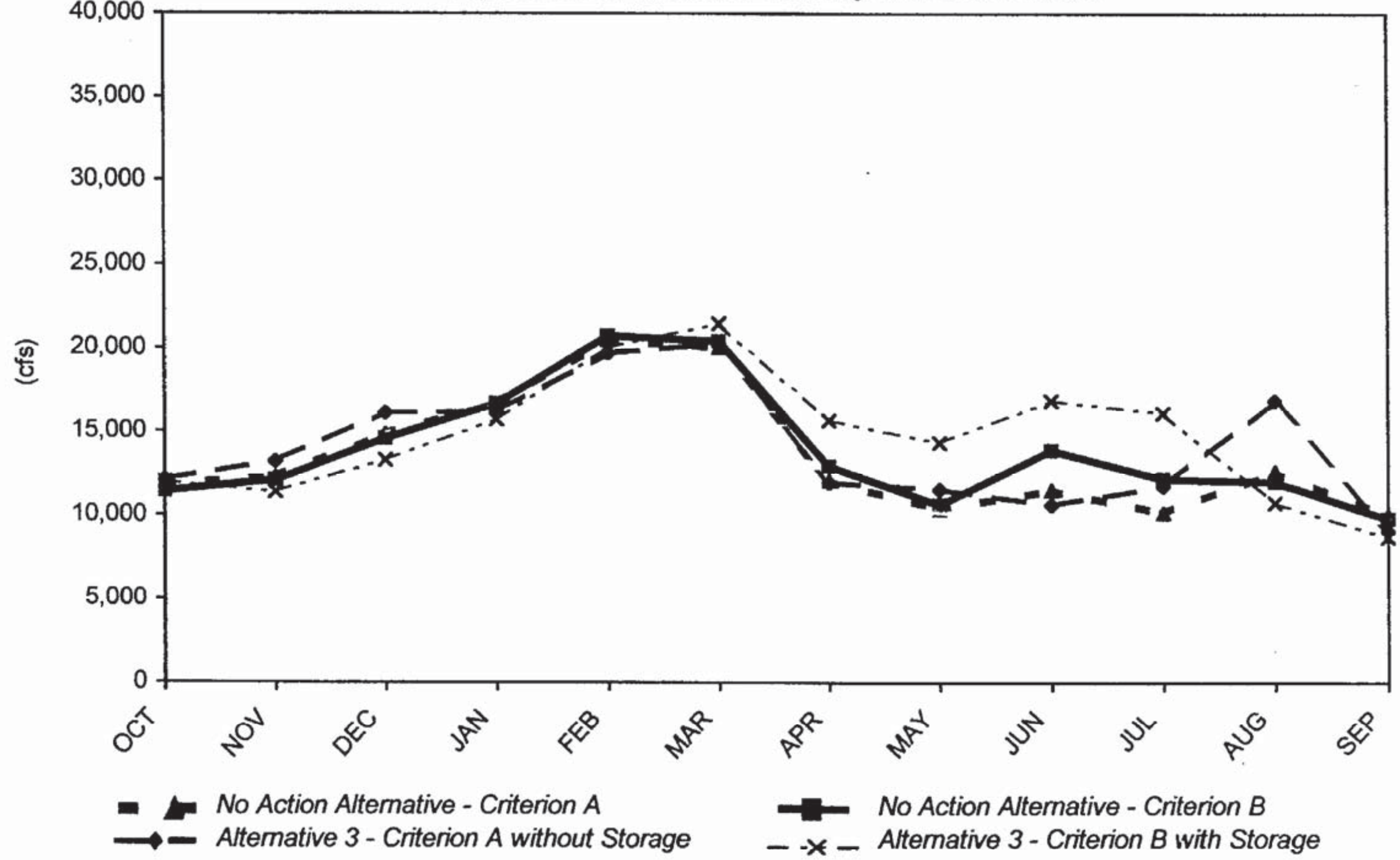


Figure 5.2-53. Average Monthly Sacramento River Flow at Freeport under Alternative 3 for Dry and Critical Years



summer months under both hydrologic periods. Alternative 3 may increase average monthly flow by as much as 2,900 cfs during the summer. Even with new storage facilities, Alternative 3 has little impact on average monthly flow in most months. Flow increases are most pronounced during summers of dry and critical years—up to 4,000 cfs.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alternative 3 and the No Action Alternative. Figures 5.2-54 and 5.2-55 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 3, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. Alternative 3 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 3 increases average monthly flow in spring by as much as 1,500 cfs.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer months under the No Action Alternative as well as under Alternative 3. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 3, the lowest long-term period summer releases are generally associated with the Criterion A water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under Alternative 3, summer releases from existing facilities may increase up to 1,600 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 3, releases may increase as much as 1,300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 3, necessitates increased flood control releases in winter months.

Under Alternative 3, average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

New Reservoir Diversions and Releases. Figures 5.2-56 and 5.2-57 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 3. Under Alternative 3, new surface storage diversions typically occur during winter and spring months, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is from 1,300 to 2,600 cfs. For dry and critical years, the range of peak average monthly diversions is from 200 to 1,900 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer months when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. For the long-term period, environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Under Alternative 3, maximum average monthly releases in dry and

Figure 5.2-54. Average Monthly San Joaquin River Flow at Vernalis under Alternative 3 for the Long-Term Period

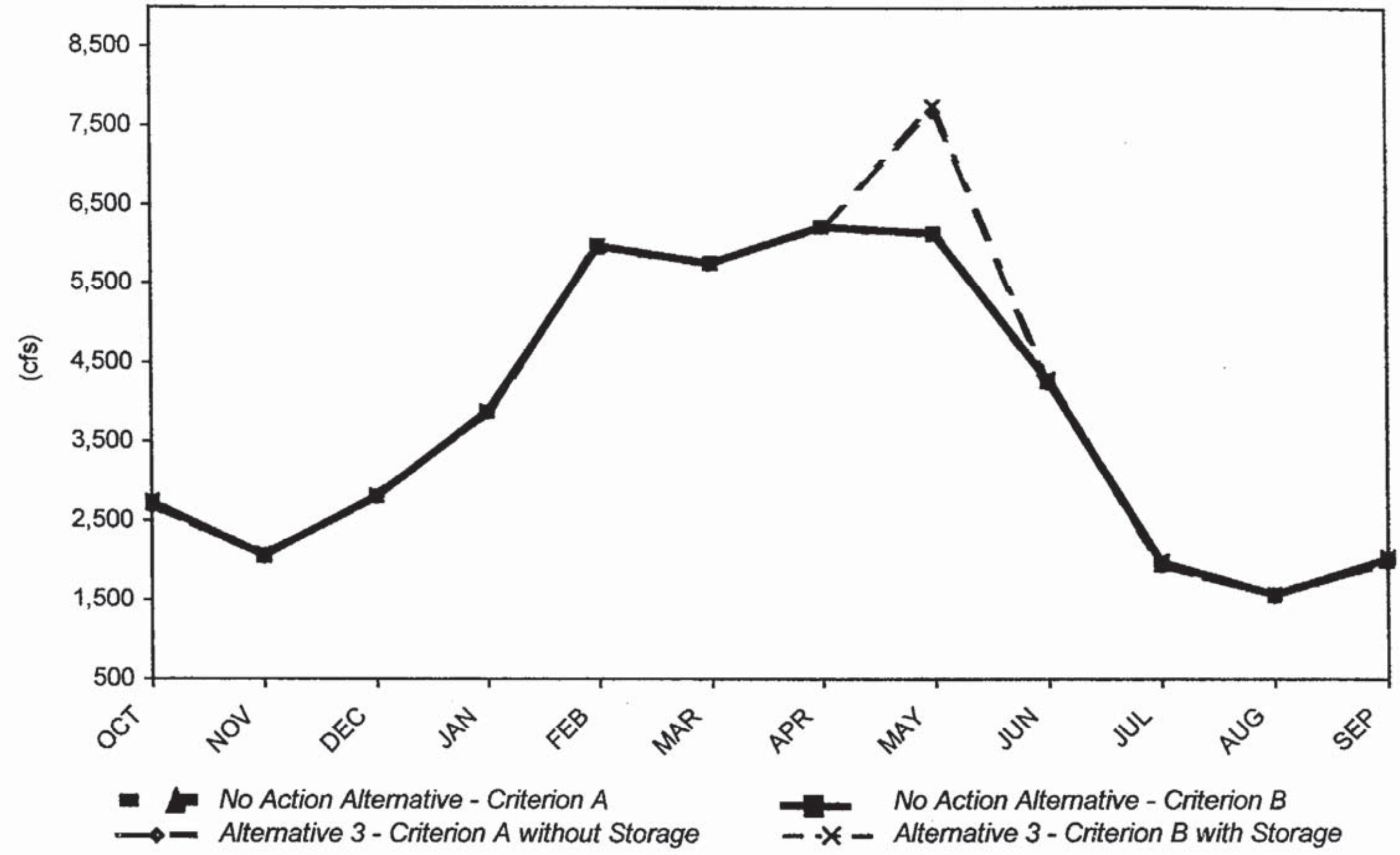


Figure 5.2-55. Average Monthly San Joaquin River Flow at Vernalis under Alternative 3 for Dry and Critical Years

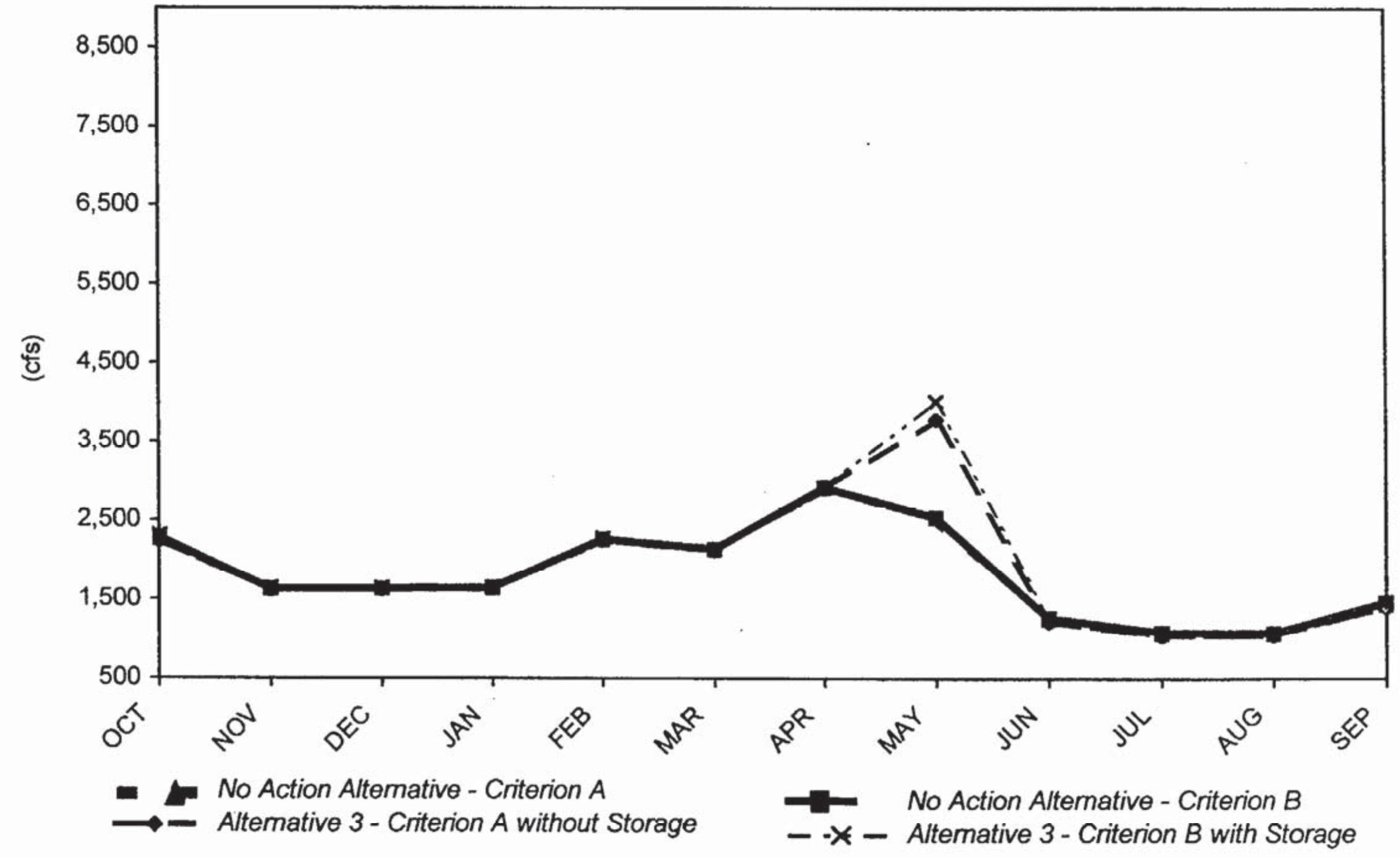


Figure 5.2-56. New Surface Storage Diversions in the Sacramento River Region under Alternative 3 for the Long-Term Period

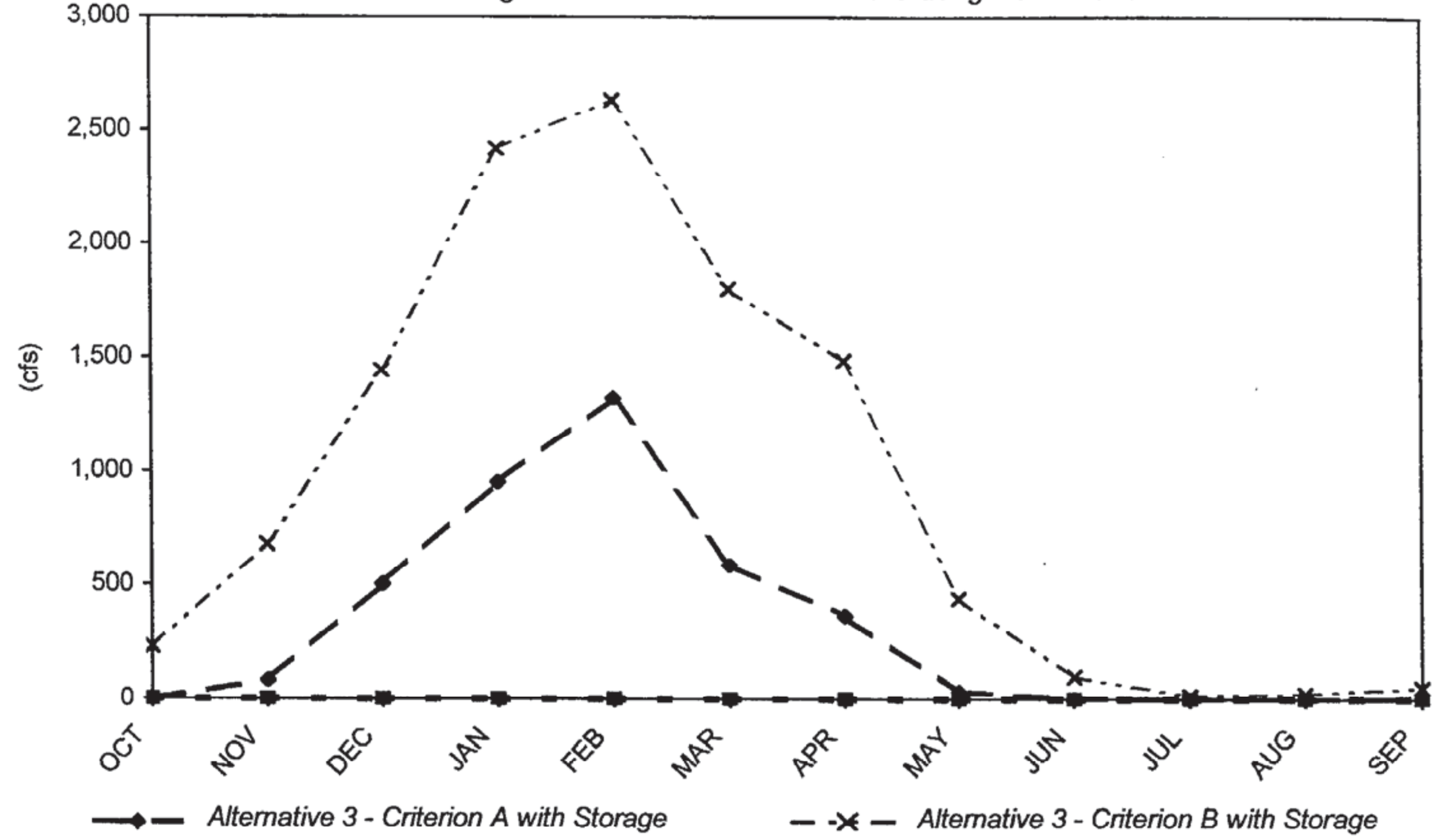
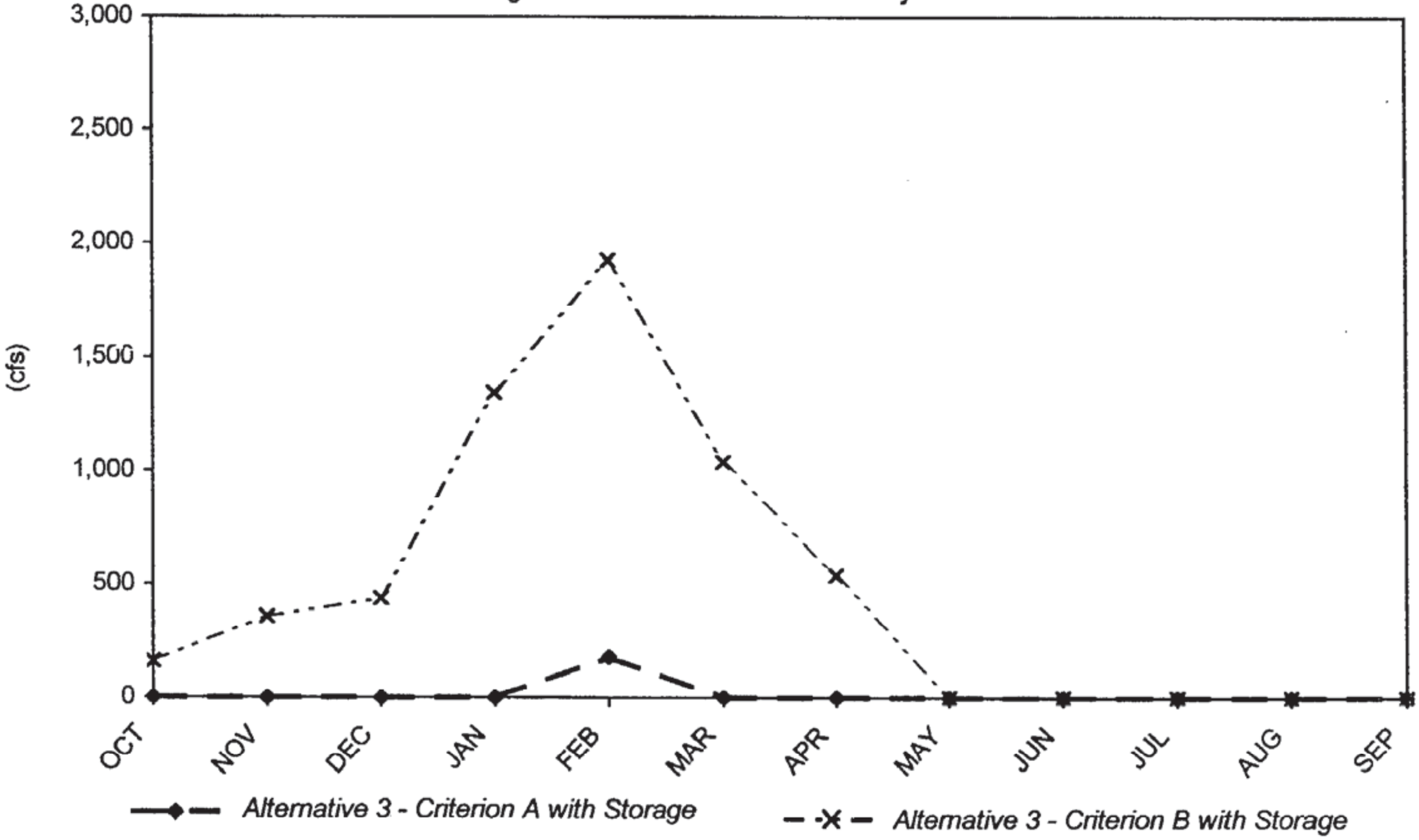


Figure 5.2-57. New Surface Storage Diversions in the Sacramento River Region under Alternative 3 for Dry and Critical Years



critical years are on the order of 1,000 cfs, while maximum average monthly releases are approximately 800 cfs over the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Under Alternative 3, peak average monthly releases range from 400 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200 to over 2,700 cfs.

San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (160 cfs), while average monthly diversions over the long-term period are greatest in late winter (230 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 3. Maximum average monthly releases are approximately 570 cfs for the long-term period and 360 cfs for dry and critical years.

5.2.8.4 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

For evaluation purposes, the Preferred Program Alternative was simulated with and without a new screened diversion (2,000-4,000 cfs) from the Sacramento River to the Mokelumne River system. Without the new diversion, consequences of the Preferred Program Alternative relative to Bay-Delta hydrodynamics and riverine hydraulics are similar to consequences under Alternative 1, as described in Section 5.2.8.1. Consequences of the Preferred Program Alternative with a diversion facility are described below.

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch) and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, channel flows are described at five locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about

5,900 cfs. The Preferred Program Alternative decreases flow by as much as 4,100 cfs in February. The Preferred Program Alternative modifies flow by (-300) to 1,600 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occur in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, the Preferred Program Alternative decreases flow in February by as much as 3,400 cfs. In September, the Preferred Program Alternative modifies flow by (-300) to 1,600 cfs. Figures 5.2-58 and 5.2-59 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

Rio Vista flow under the Preferred Program Alternative also was compared with Rio Vista flow under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-3. The dry and critical year comparison is summarized in Table 5.2-4. Additionally, Figures 5.2-60 and 5.2-61 present Rio Vista flow comparisons for the long-term period and dry and critical years, respectively.

Table 5.2-3. Sacramento River Flow at Rio Vista under All Program Alternatives for the Long-Term Period (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak monthly flow (February)	42,600-42,900	41,600-42,500	34,100-39,300	35,200-37,900	38,400-40,800
Low monthly flow (September)	5,800-5,900	5,700-6,100	3,200-5,200	3,000-4,800	5,500-7,400

Note:
PPA = Preferred Program Alternative.

Table 5.2-4. Sacramento River Flow at Rio Vista under All Program Alternatives for Dry and Critical Years (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak monthly flow (February)	17,900-18,100	17,800-18,000	11,000-15,700	13,600-14,400	14,500-16,400
Low monthly flow (September)	4,300-4,500	4,300-5,300	3,000-4,600	3,000-3,200	4,000-6,100

Note:
PPA = Preferred Program Alternative.

QWEST Flow. QWEST flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about (-4,300) to (-4,000) cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and

Figure 5.2-58. Average Monthly Sacramento River Flow at Rio Vista under the Preferred Program Alternative for the Long-Term Period

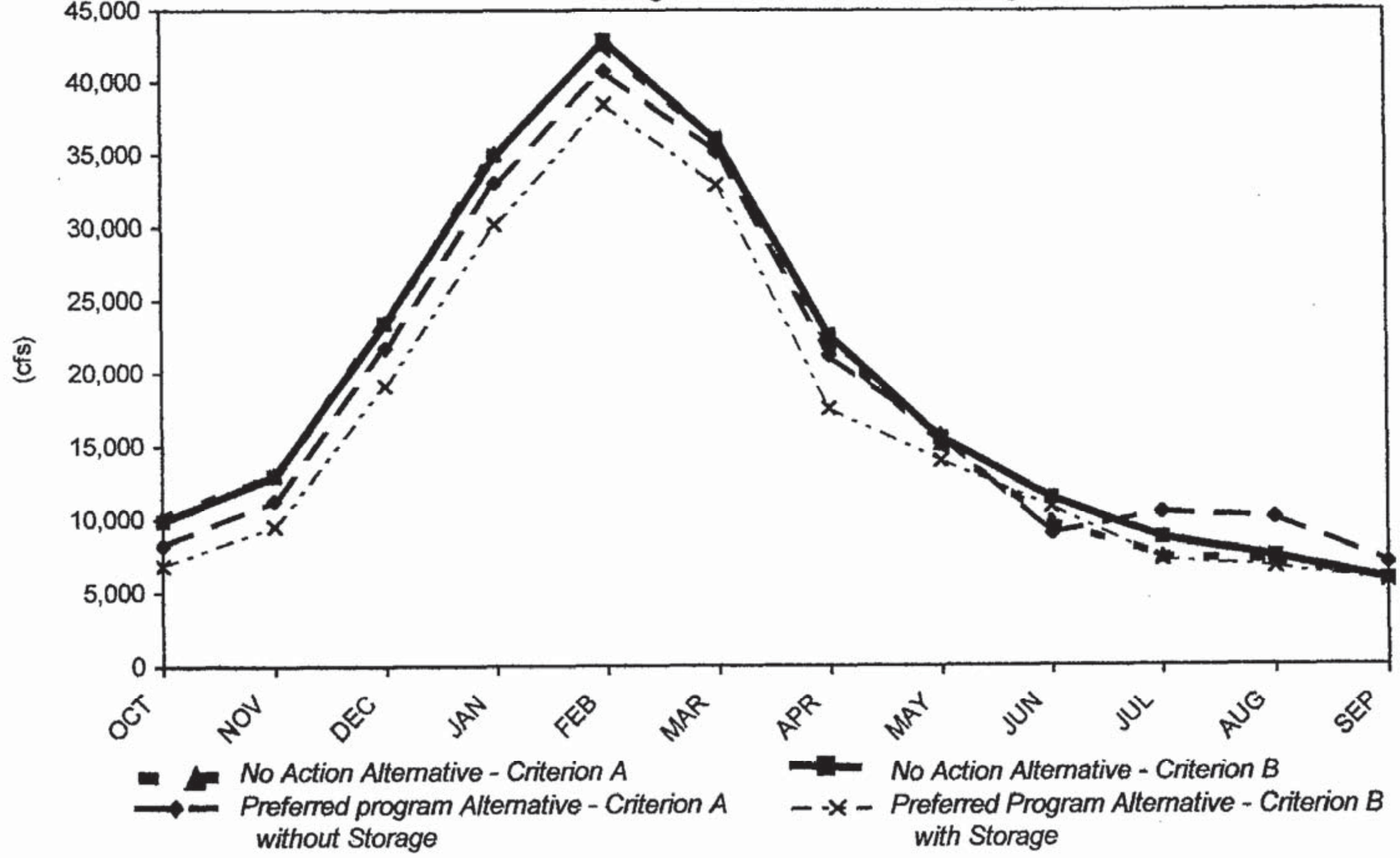


Figure 5.2-59. Average Monthly Sacramento River Flow at Rio Vista under the Preferred Program Alternative for Dry and Critical Years

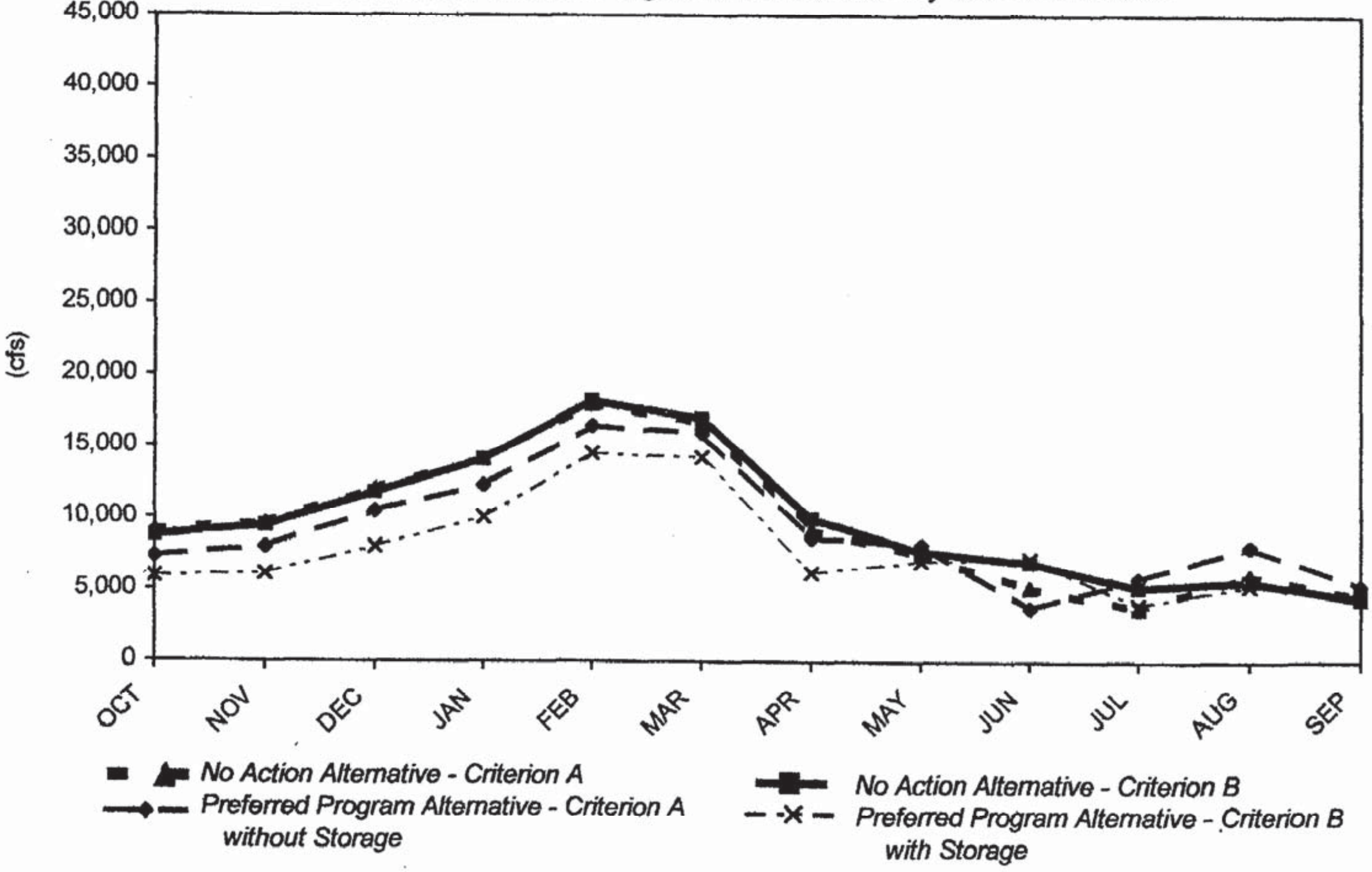


Figure 5.2-60. September Sacramento River Flows at Rio Vista under All Program Alternatives for the Long-Term Period

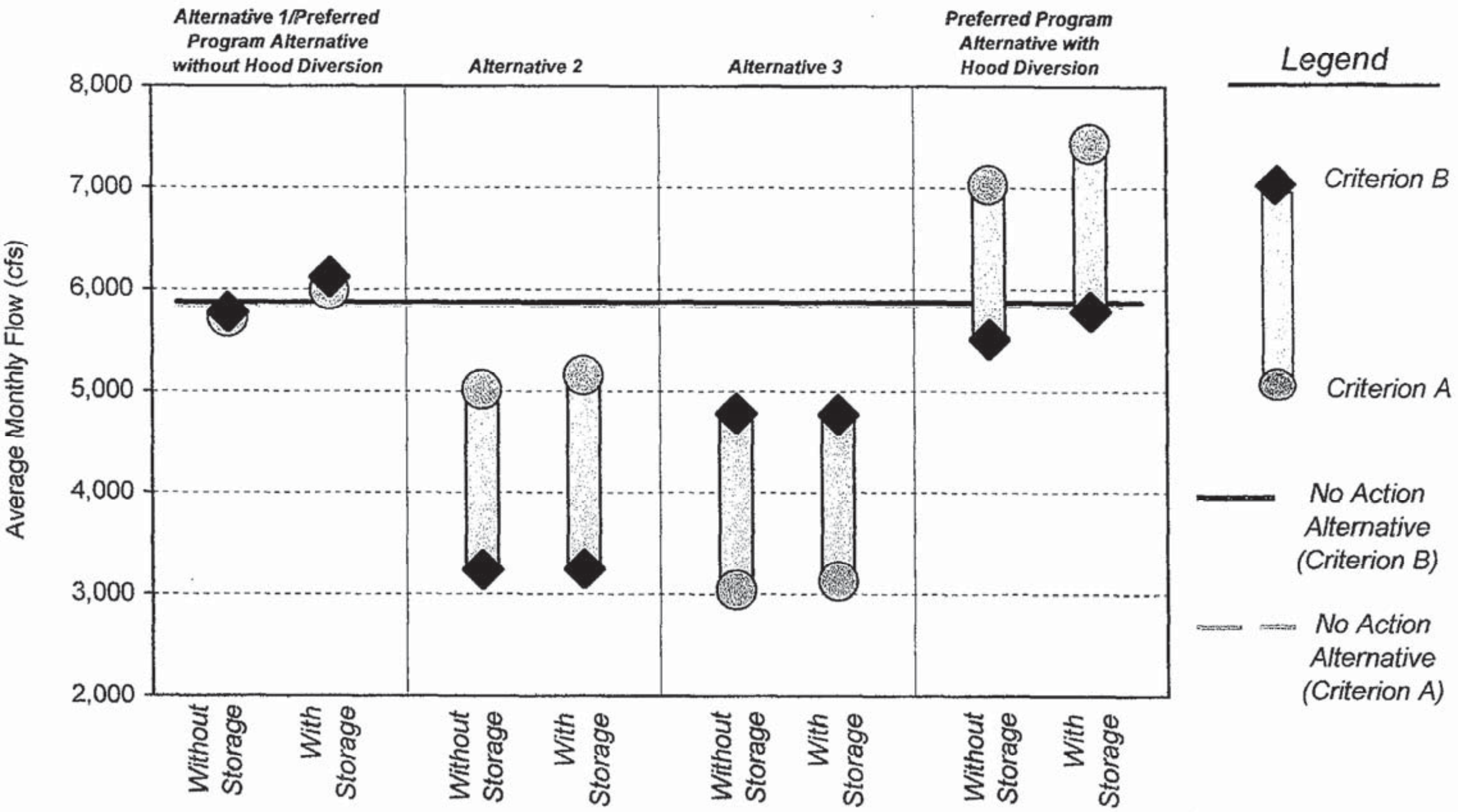


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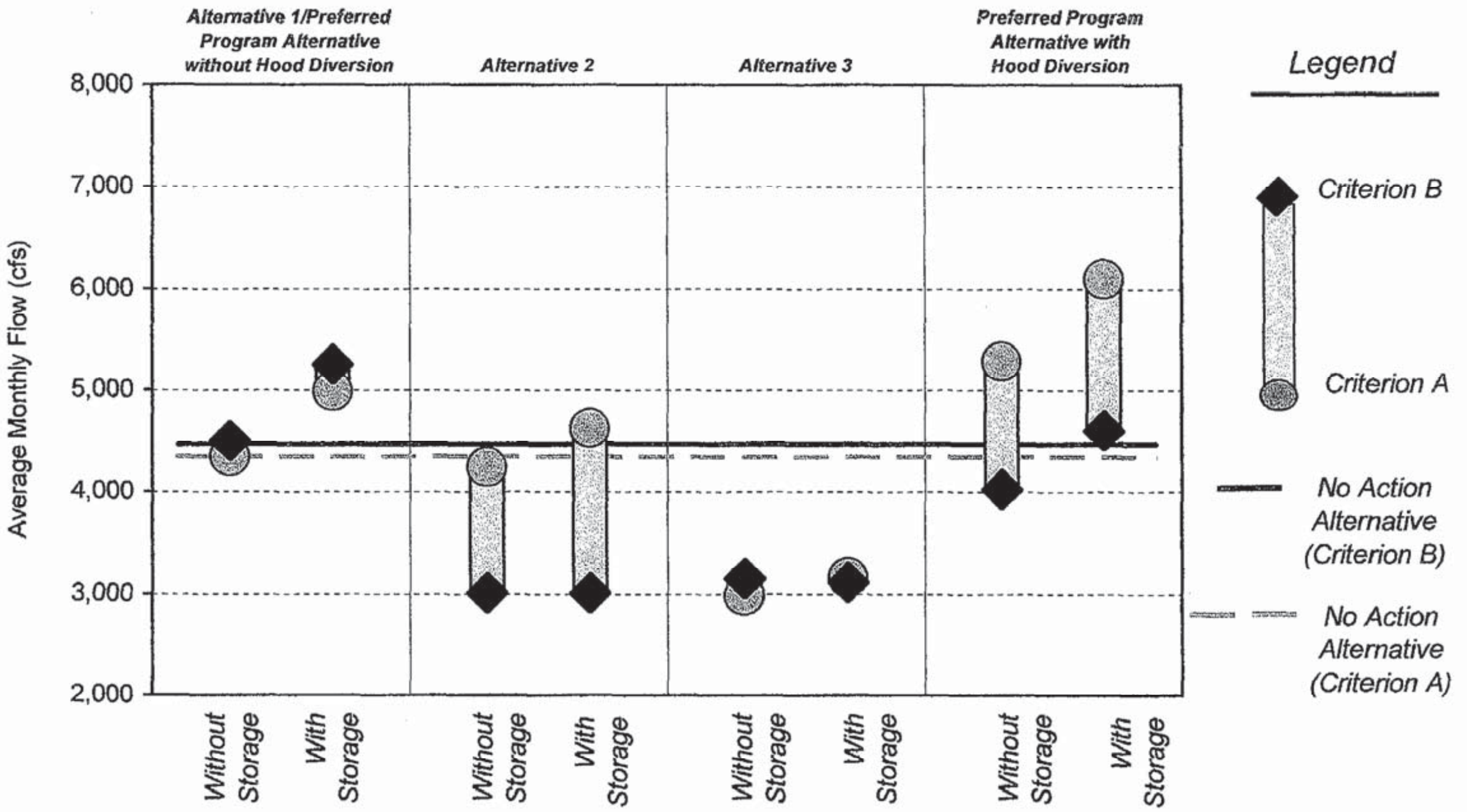
Figure 5.2-61. September Sacramento River Flows at Rio Vista under All Program Alternatives for Dry and Critical Years



ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from (-5,200) to (-4,900) cfs.

The Preferred Program Alternative increases average monthly positive QWEST flow over the long-term period in April by as much as 900 cfs and decreases average monthly reverse QWEST flow in October by as much as 2,500 cfs. During dry and critical years, the Preferred Program Alternative increases average monthly positive QWEST flow in April by as much as 1,200 cfs and decreases average monthly reverse QWEST flow in December by as much as 2,400 cfs. Figures 5.2-62 and 5.2-63 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

QWEST flow under the Preferred Program Alternative also was compared with QWEST flow under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-5. The dry and critical year comparison is summarized in Table 5.2-6. Additionally, Figures 5.2-64 and 5.2-65 present Delta export comparisons for the long-term period and dry and critical years, respectively.

Table 5.2-5. QWEST Flow under All Program Alternatives for the Long-Term Period (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak positive monthly flow (April)	6,400-9,100	5,800-9,100	8,900-10,300	6,100-11,200	8,300-10,000
Peak negative monthly flow (October)	(-4,300)-(-4,000)	(-4,500)-(-4,800)	(-600)-700	(-1,800)-1,800	(-1,500)-(-3,000)

Note:
PPA = Preferred Program Alternative.

Table 5.2-6. QWEST Flow under All Program Alternatives for Dry and Critical Years (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak positive monthly flow (April)	1,400-3,100	1,400-3,100	3,100-4,400	1,500-5,000	3,100-4,300
Peak negative monthly flow (December)	(-5,200)-(-4,900)	(-5,500)-(-6,200)	(-1,200)-700	(-2,400)-1,800	(-2,500)-(-3,800)

Note:
PPA = Preferred Program Alternative.

Cross-Delta Flow. Cross-Delta flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average

Figure 5.2-62. Average Monthly QWEST Flow under the Preferred Program Alternative for the Long-Term Period

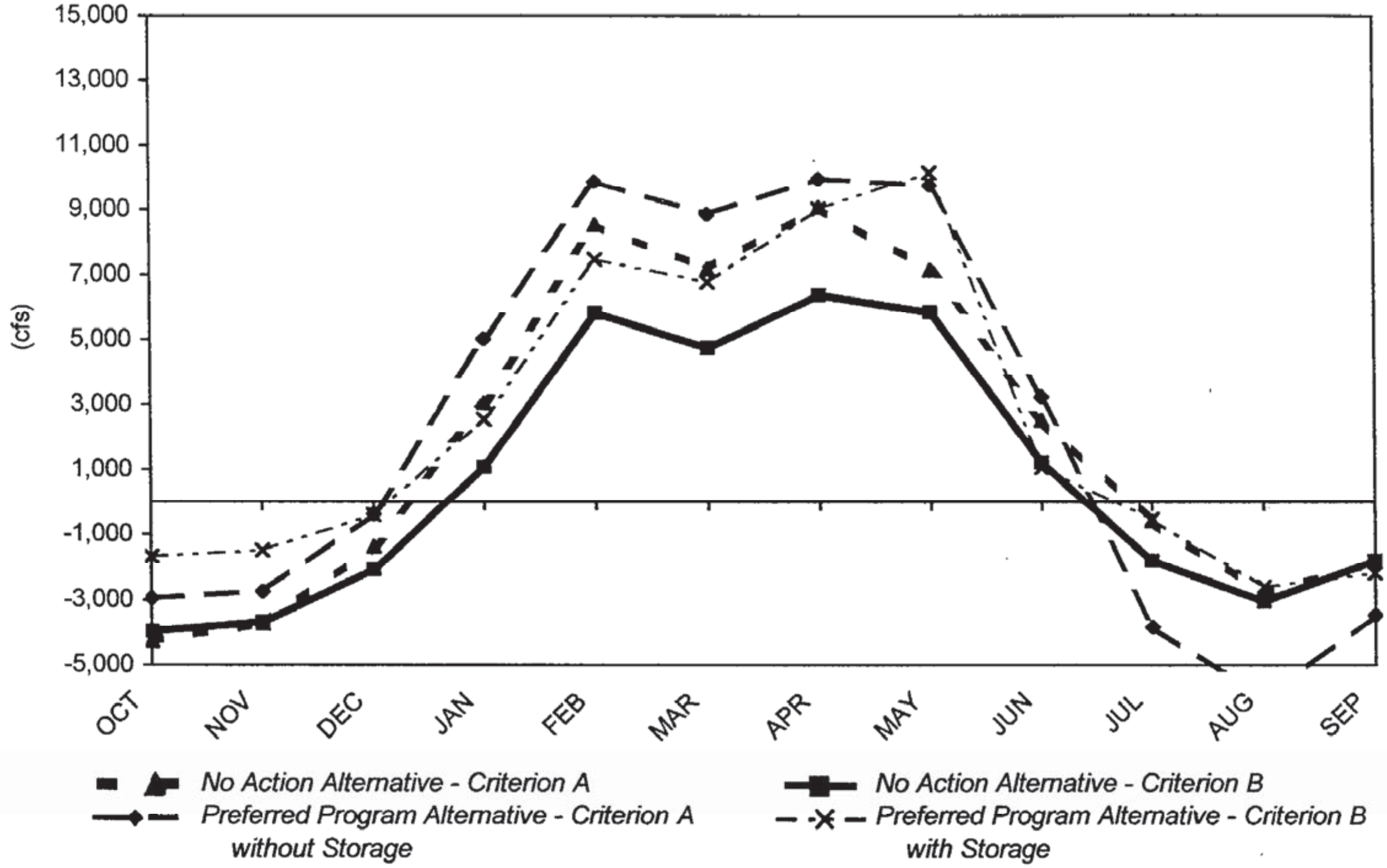


Figure 5.2-63. Average Monthly QWEST Flow under the Preferred Program Alternative for Dry and Critical Years

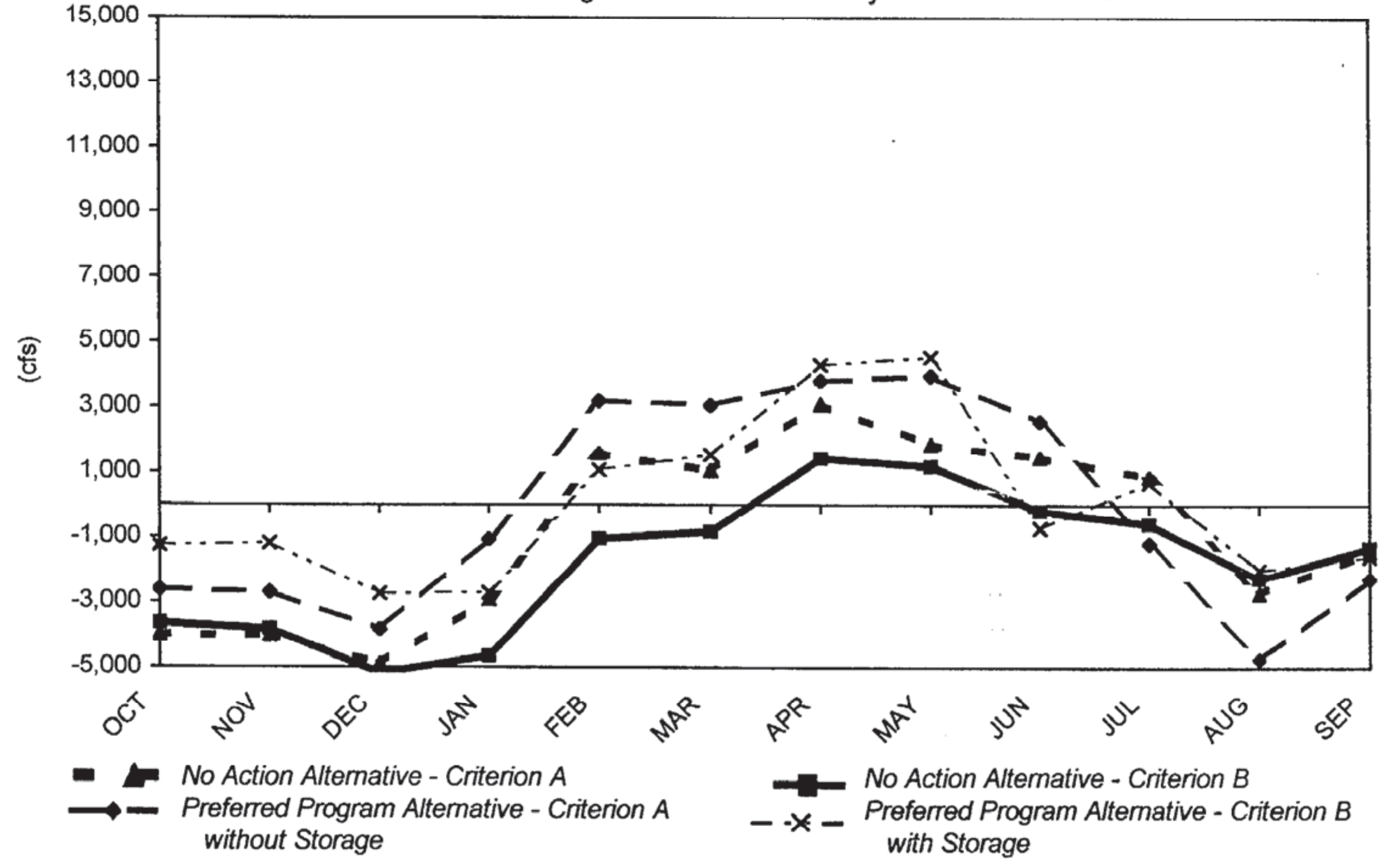


Figure 5.2-64. October QWEST Flows under All Program Alternatives for the Long-Term Period

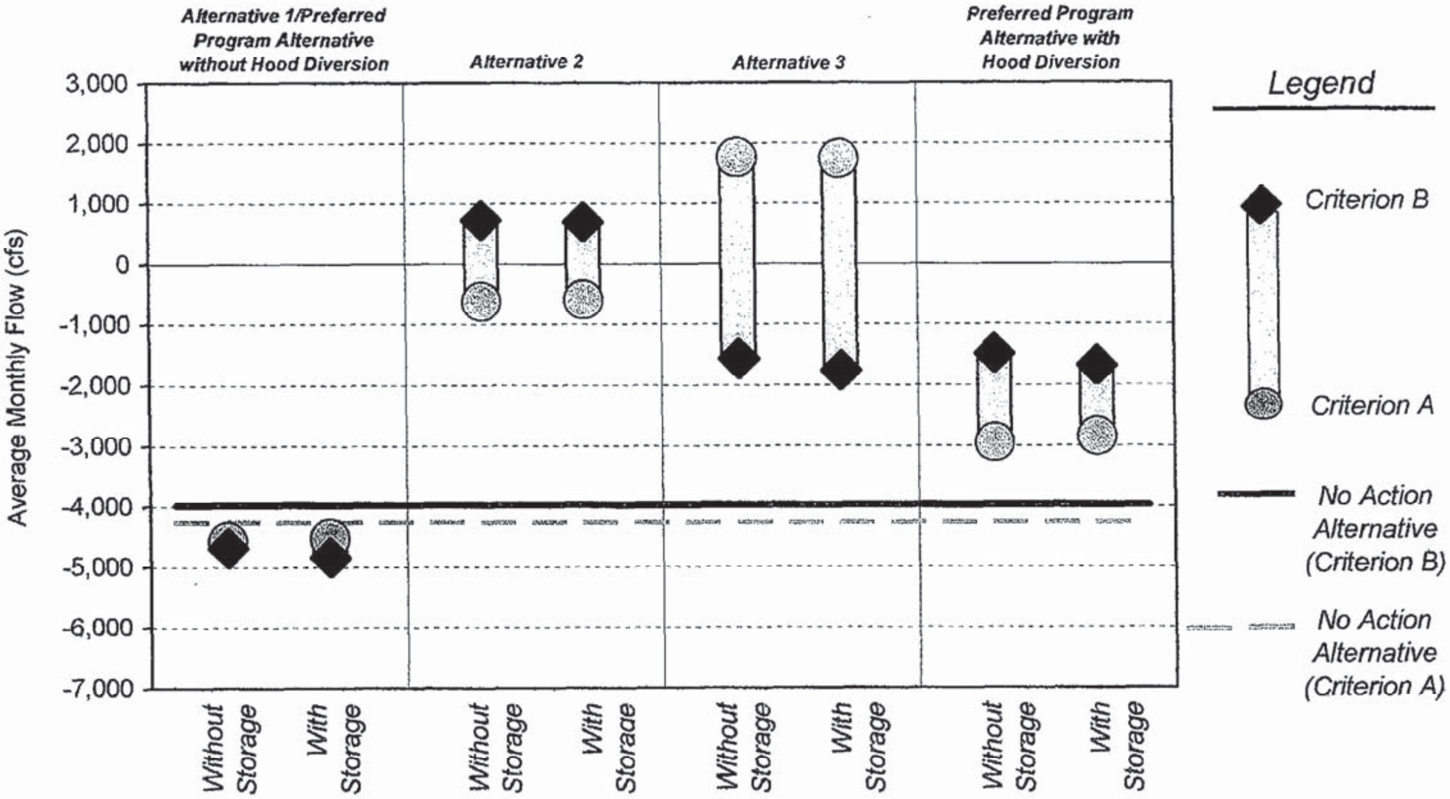


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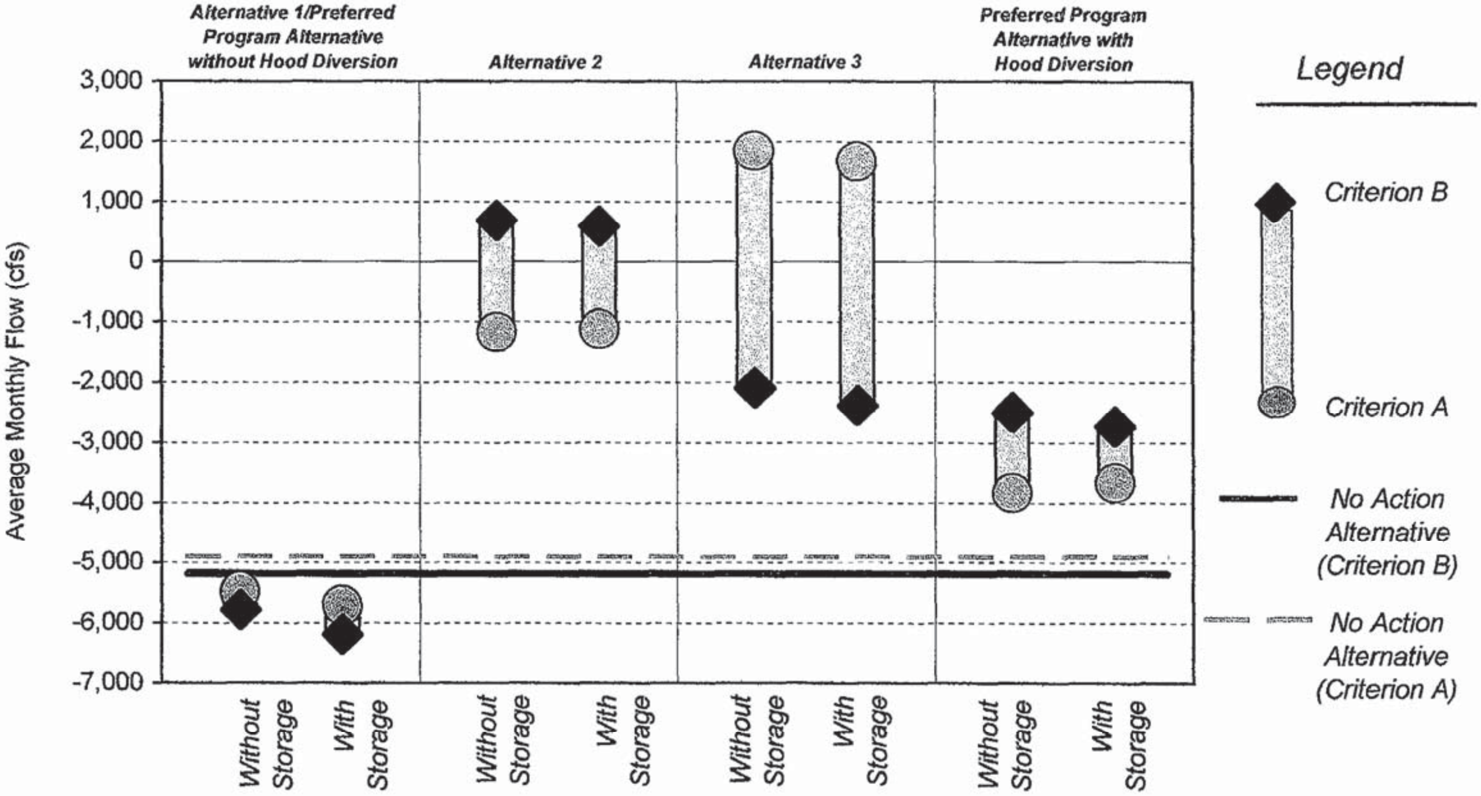
Figure 5.2-65. December QWEST Flows under All Program Alternatives for Dry and Critical Years



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monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May. Under the Preferred Program Alternative, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas cross-Delta flow in December and May typically increases. Over the long-term period under the Preferred Program Alternative, cross-Delta flow in August may vary by (-2,500) cfs to 2,000 cfs relative to the No Action Alternative. Increases in cross-Delta flow over the long-term period ranges from 1,700 to 3,300 cfs in December and from 700 to 1,700 cfs in May. During dry and critical years under the Preferred Program Alternative, cross-Delta flow in August may vary by (-2,000) to 1,600 cfs relative to the No Action Alternative. Increases in cross-Delta flow during dry and critical years range from 1,700 to 3,300 cfs in December and from 600 to 1,200 cfs in May. Figures 5.2-66 and 5.2-67 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about (-3,400) cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from (-3,600) to (-3,000) cfs.

Over the long-term period under the Preferred Program Alternative, increases in reverse flow in Old River at Bacon Island in August range from 800 to 1,600 cfs, resulting in flow ranging from (-5,100) to (-4,200) cfs. In dry and critical years under the Preferred Program Alternative, increases in reverse flow in August range from 100 to 900 cfs, resulting in flow ranging from (-4,500) to (-3,700) cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from (-1,200) to (-1,000) cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from (-2,400) to (-2,100) cfs.

Average monthly San Joaquin River flow at Antioch ranges from (-2,900) to (-900) cfs in August over the long-term period under the Preferred Program Alternative. In dry and critical years under Alternative 3, reverse flow in August may vary by (-100) cfs to 1,700 cfs relative to the No Action Alternative, resulting in flow ranging from (-2,500) to (-700) cfs. Decreases in reverse flow in December range from 800 to 1,200 cfs under the Preferred Program Alternative in dry and critical years, resulting in flow ranging from (-1,300) to (-900) cfs.

Mass Fate. The DSM2 model was used to perform several mass tracking simulations for the Preferred Program Alternative. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Table 5.2-7 for high inflow and high export conditions. Similar results are presented in Table 5.2-8 for low inflow and high export conditions.

Bay Region

The Preferred Program Alternative may increase the average monthly X2 position. Bay-Delta X2 position was evaluated for the No Action Alternative and the Preferred Program Alternative for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Table 5.2-7. Mass Tracking Results for High Inflow and High Export Conditions under All Program Alternatives (%)

ALTERNATIVE	CHIPPS ISLAND	EXPORTS	DELTA ISLANDS	IN-CHANNEL
Mass Injection at Freeport				
Existing conditions	96.5	1.7	0.6	1.2
No Action Alternative	95.0	3.0	0.6	1.4
Alternative 1	88.8	8.4	0.6	2.2
Alternative 2	85.0	13.3	0.8	0.9
Alternative 3	72.3	27.0	0.4	0.3
Preferred Program Alternative	86.5	11.0	0.8	1.7
Mass Injection at Prisoner's Point				
Existing conditions	77.8	15.8	1.3	5.1
No Action Alternative	65.8	26.8	1.1	6.3
Alternative 1	33.2	59.5	1.0	6.3
Alternative 2	55.7	42.3	0.8	1.2
Alternative 3	97.8	0.0	0.5	1.7
Preferred Program Alternative	45.3	50.7	1.0	3.0
Mass Injection at Vernalis				
Existing conditions	8.8	82.6	2.4	6.2
No Action Alternative	4.4	89.5	2.1	4.0
Alternative 1	0.7	96.2	1.9	1.2
Alternative 2	1.5	95.8	1.9	0.8
Alternative 3	38.3	39.8	3.0	18.9
Preferred Program Alternative	0.9	96.3	1.9	0.9

Table 5.2-8. Mass Tracking Results for Low Inflow and High Export Conditions under All Program Alternatives (%)

ALTERNATIVE	CHIPPS ISLAND	EXPORTS	DELTA ISLANDS	IN-CHANNEL
Mass Injection at Freeport				
Existing conditions	19.8	39.0	6.5	34.7
No Action Alternative	19.7	41.6	7.5	31.2
Alternative 1	19.1	40.3	7.6	33.0
Alternative 2	11.6	44.7	7.9	35.8
Alternative 3	16.5	47.6	4.2	31.7
Preferred Program Alternative	21.0	45.0	7.0	27.0
Mass Injection at Prisoner's Point				
Existing conditions	7.7	69.1	3.5	19.7
No Action Alternative	6.4	73.2	4.3	16.1
Alternative 1	7.2	70.3	4.3	18.2
Alternative 2	9.9	65.9	4.2	20.0
Alternative 3	16.5	6.9	5.4	71.2
Preferred Program Alternative	4.5	80.9	4.2	10.4
Mass Injection at Vernalis				
Existing conditions	0.0	92.4	6.0	1.6
No Action Alternative	0.0	91.4	7.6	1.0
Alternative 1	0.0	76.0	13.2	10.8
Alternative 2	0.0	76.3	13.2	10.5
Alternative 3	0.2	5.7	16.3	77.8
Preferred Program Alternative	0.0	81.6	12.9	5.5

Figure 5.2-66. Monthly Average Cross-Delta Flow under the Preferred Program Alternative for the Long-Term Period

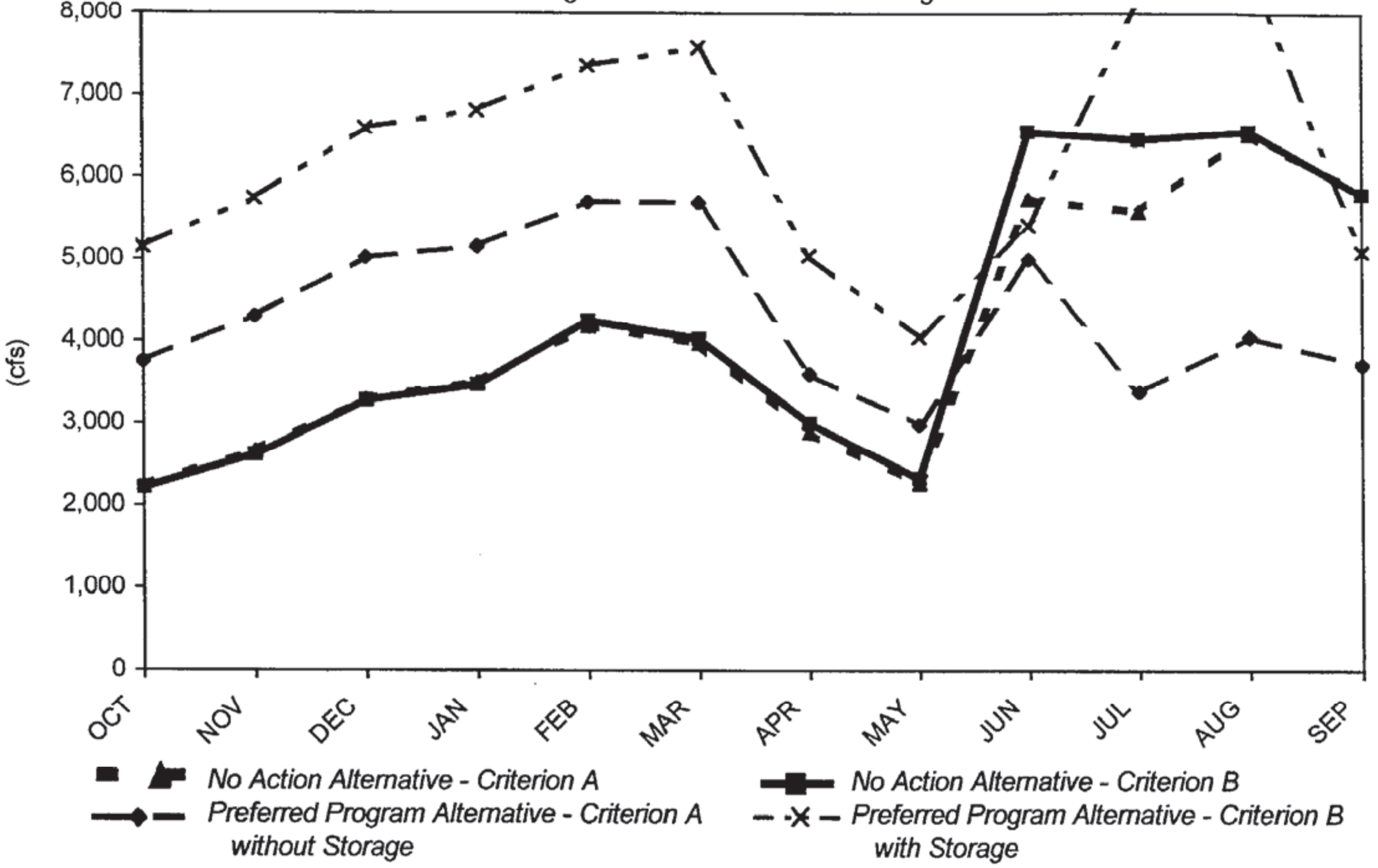
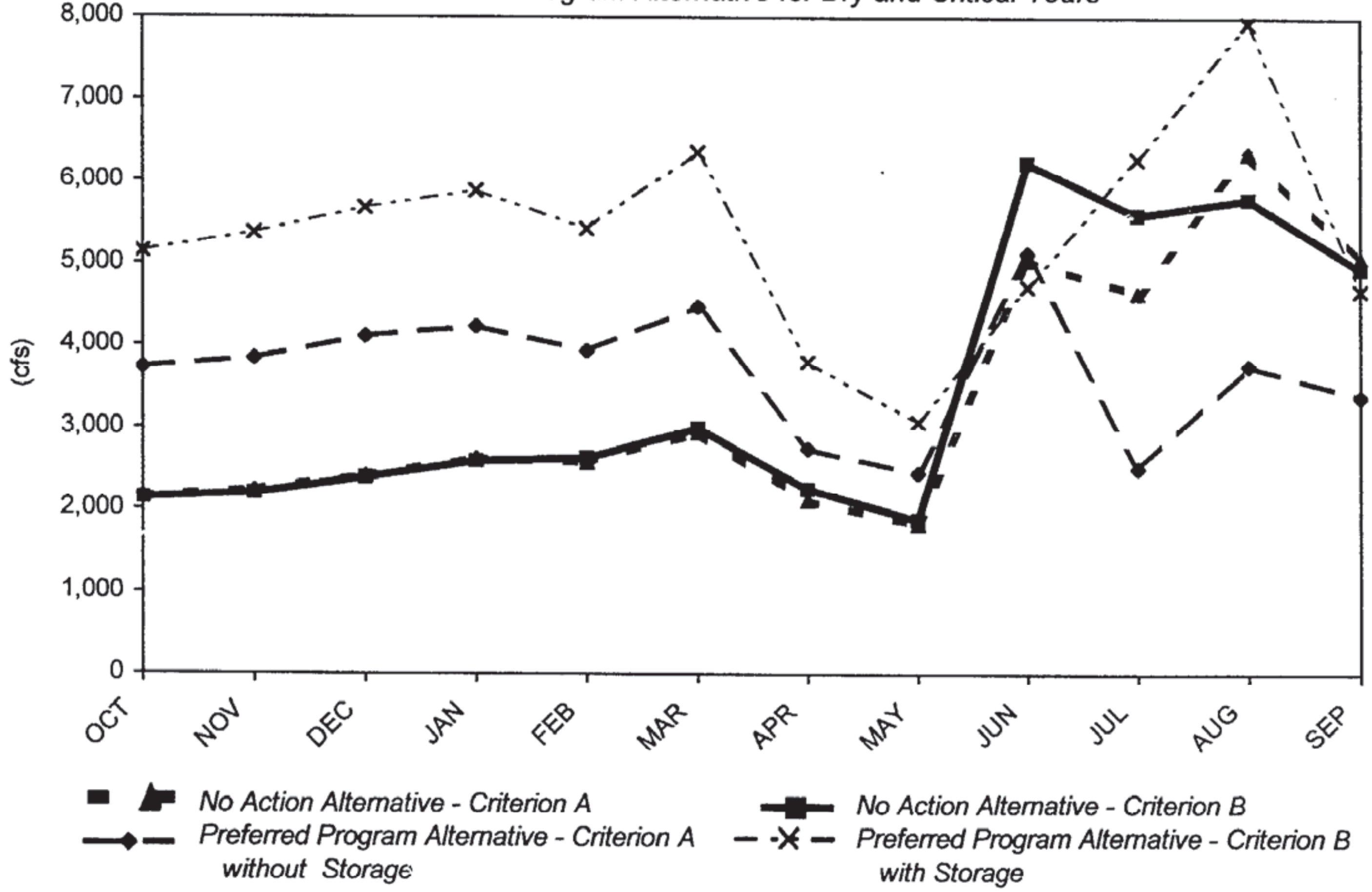


Figure 5.2-67. Monthly Average Cross-Delta Flow under the Preferred Program Alternative for Dry and Critical Years



The Preferred Program Alternative increases average monthly X2 position by about 0.6 km in September. The Preferred Program Alternative may increase or decrease average monthly X2 position by about 0.3 km in March. During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. The Preferred Program Alternative decreases average monthly X2 position by about 0.1 km in September. The Preferred Program Alternative may decrease X2 position by about 0.5 km or increase X2 position by 0.3 km in March.

Figures 5.2-68 and 5.2-69 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

X2 position under the Preferred Program Alternative also was compared with X2 position under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-9. The dry and critical year comparison is summarized in Table 5.2-10. Additionally, Figures 5.2-70 and 5.2-71 present X2 position comparisons for the long-term period and dry and critical years, respectively.

Table 5.2-9. X2 Position under All Program Alternatives for the Long-Term Period (km)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Upstream X2 position (September)	86.9-87.0	87.4-87.6	87.4-87.6	84.6-88.1	87.4-87.6
Downstream X2 position (March)	64.3-65.3	64.0-65.5	63.9-65.5	64.0-66.1	64.0-65.6

Note:
PPA = Preferred Program Alternative.

Table 5.2-10. X2 Position under All Program Alternatives for Dry and Critical Years (km)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Upstream X2 position (September)	89.4-89.5	89.4-89.5	89.3-89.5	85.5-89.5	89.3-89.5
Downstream X2 position (March)	72.0-73.3	71.6-73.6	71.4-73.7	71.6-74.5	71.5-73.6

Note: PPA = Preferred Program Alternative.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between the Preferred Program Alternative and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under the Preferred Program Alternative. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an instream daily flow of 20,000 cfs exists below the

Figure 5.2-68. Monthly Average X2 Position under the Preferred Program Alternative for the Long-Term Period

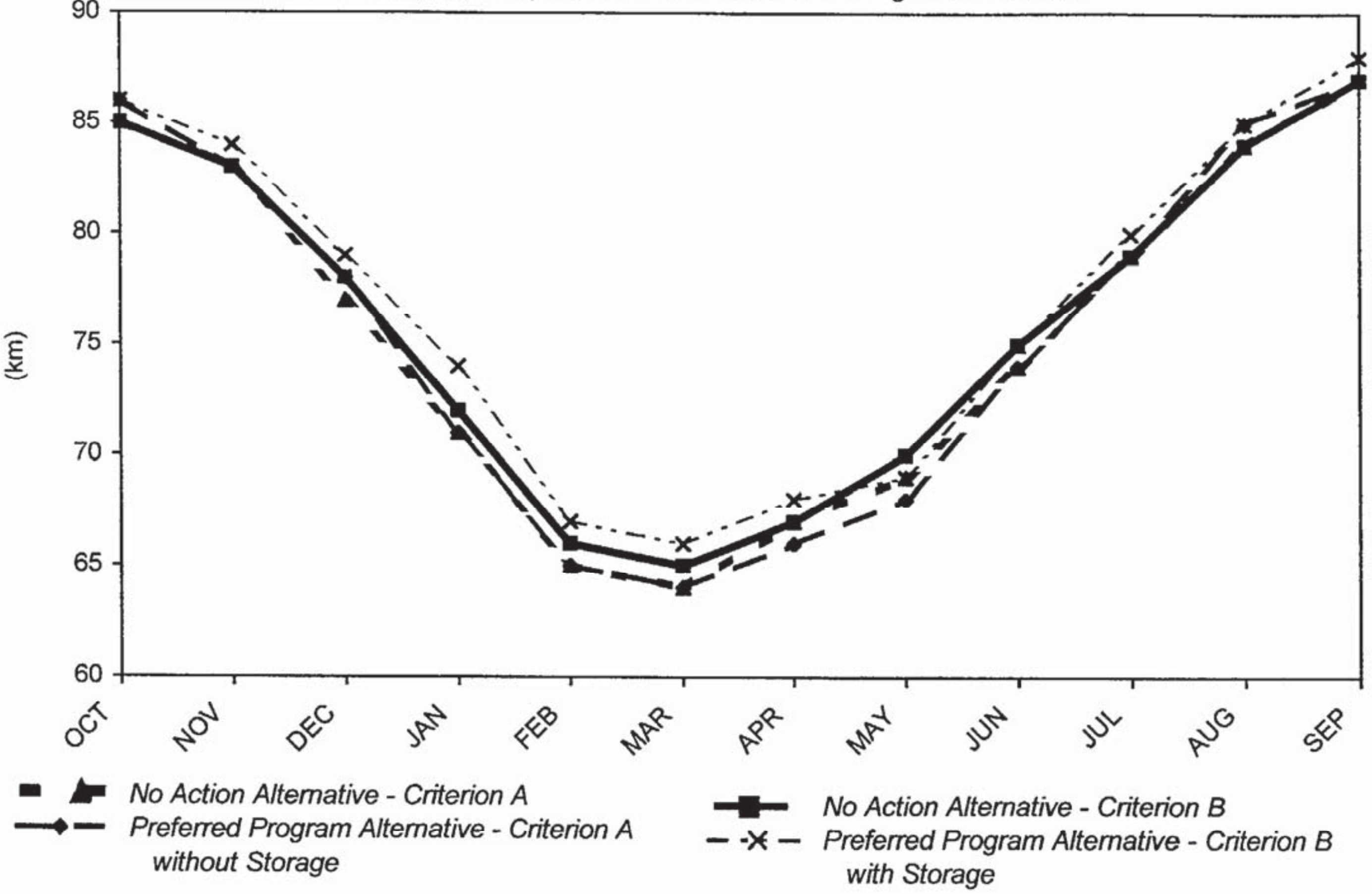


Figure 5.2-69. Monthly Average X2 Position under the Preferred Program Alternative for Dry and Critical Years

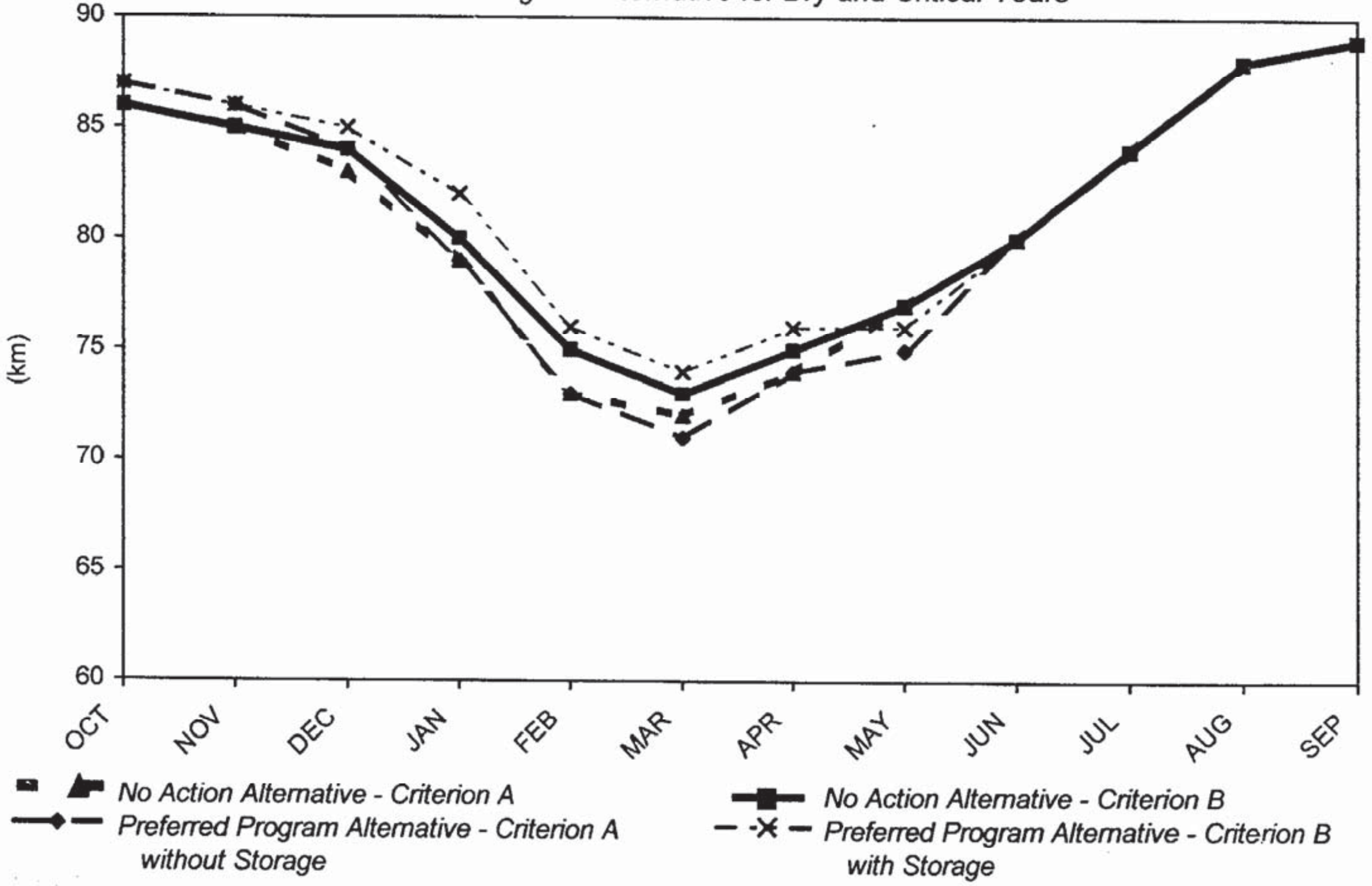


Figure 5.2-70. March X2 Position under All Program Alternatives for the Long-Term Period

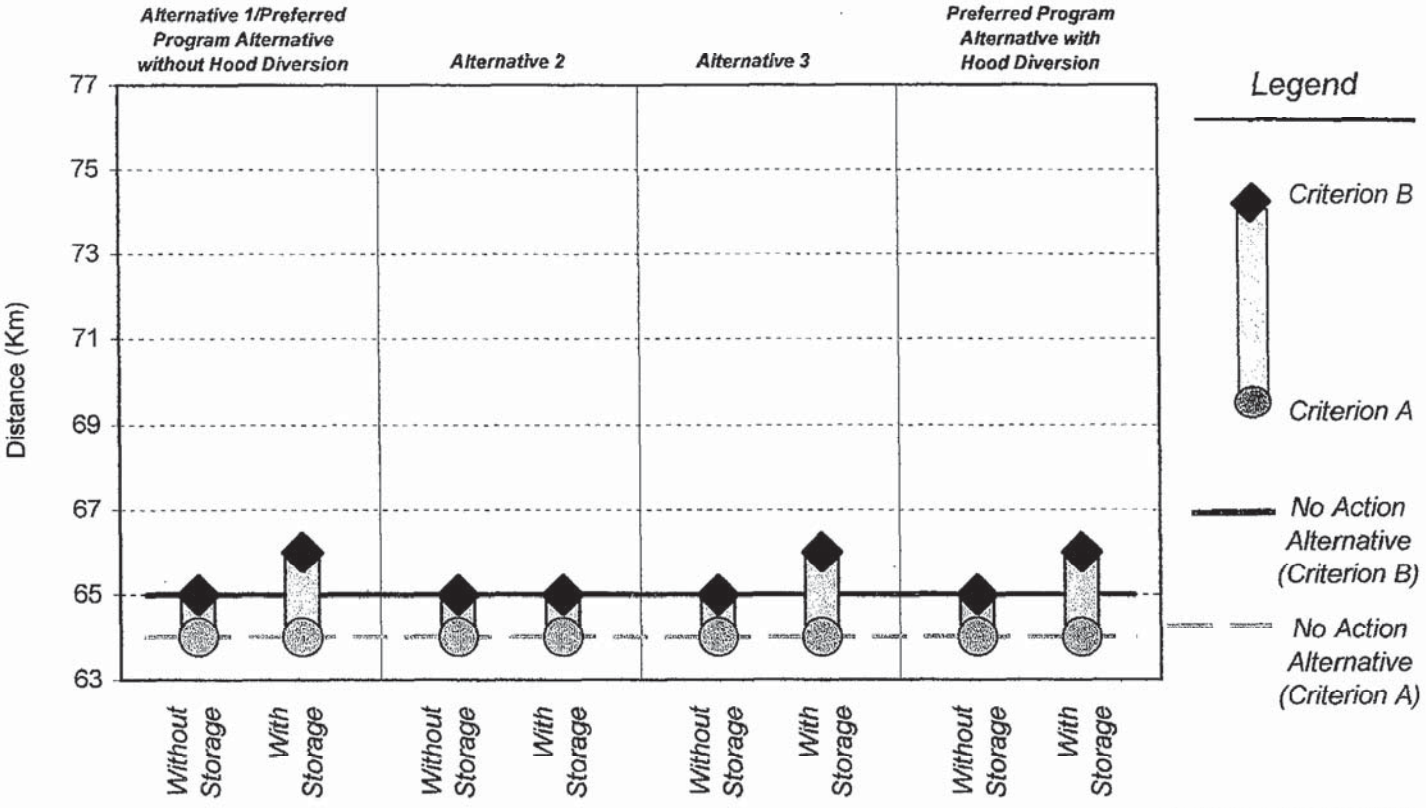


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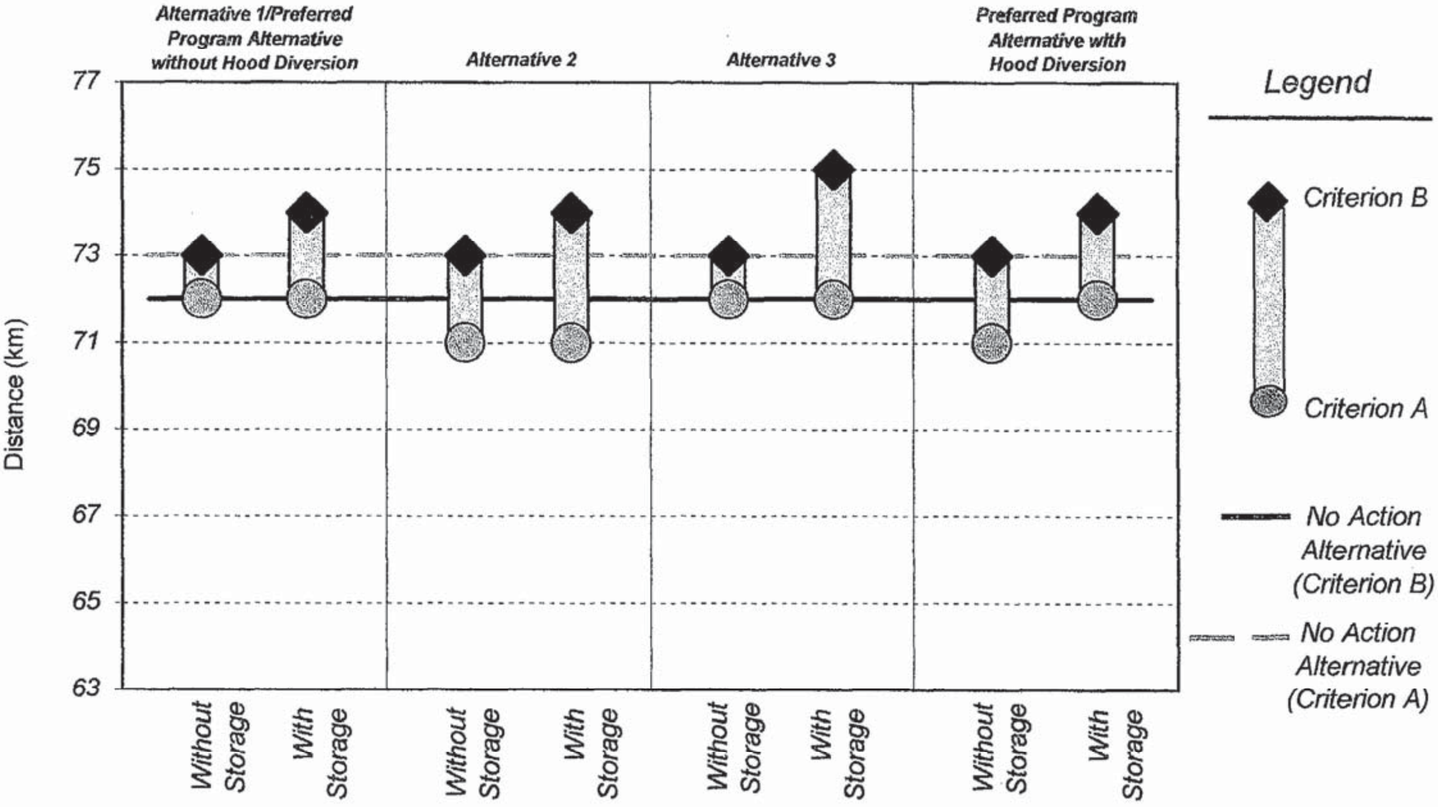
Figure 5.2-71. March X2 Position under All Program Alternatives for Dry and Critical Years



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diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B in the modeling analysis.

Average monthly flow in the Sacramento River at Freeport was evaluated for the Preferred Program Alternative and the No Action Alternative. Figures 5.2-72 and 5.2-73 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, the Preferred Program Alternative has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer months under all hydrologic conditions. The Preferred Program Alternative increases average monthly flow by as much as 1,700 cfs during summer. Even with new storage facilities, the Preferred Program Alternative has little impact on average monthly flow in most months. Anticipated flow increases are most pronounced during summer months of dry and critical years—up to 1,400 cfs.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for the Preferred Program Alternative and the No Action Alternative. Figures 5.2-74 and 5.2-75 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under the Preferred Program Alternative, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. The Preferred Program Alternative increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. The same trends occur during the long-term period and dry and critical years, with an increase of 1,300 cfs in monthly average flow for dry and critical years.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer months under the No Action Alternative as well as under the Preferred Program Alternative. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs.

Under the Preferred Program Alternative, the lowest long-term period summer releases are generally associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under the Preferred Program Alternative, summer releases from existing facilities may increase up to 1,300 cfs relative to the No Action Alternative. If new storage is implemented under the Preferred Program Alternative, releases may decrease as much as 1,000 cfs or increase up to 300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in the Preferred Program Alternative, necessitates increased flood control releases in winter months.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of the Preferred Program Alternative. Release patterns are not influenced by varying water management strategies or by implementa-tion of new surface storage.

Figure 5.2-72. Average Monthly Sacramento River Flow at Freeport under the Preferred Program Alternative for the Long-Term Period

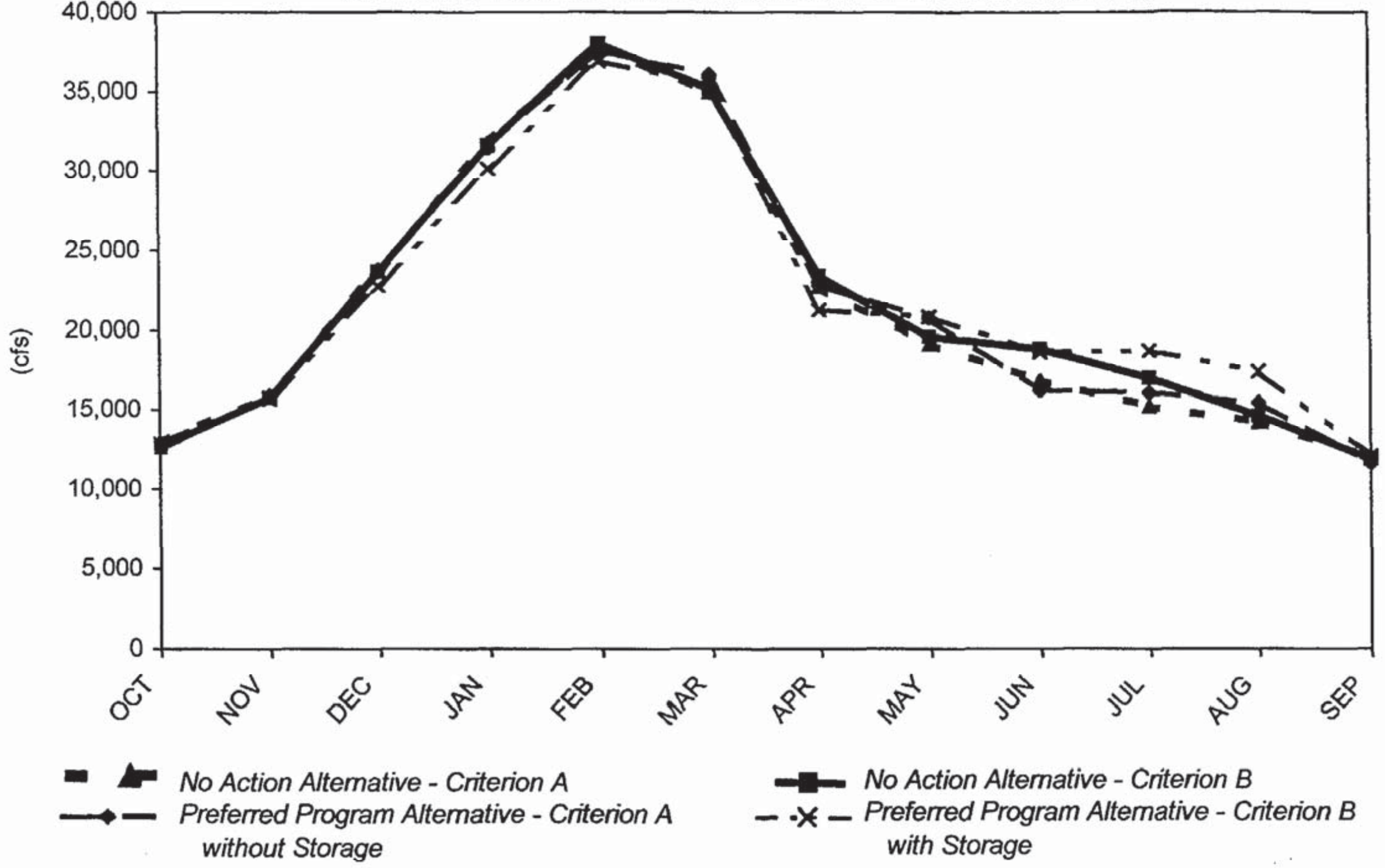


Figure 5.2-73. Average Monthly Sacramento River Flow at Freeport under the Preferred Program Alternative for Dry and Critical Years

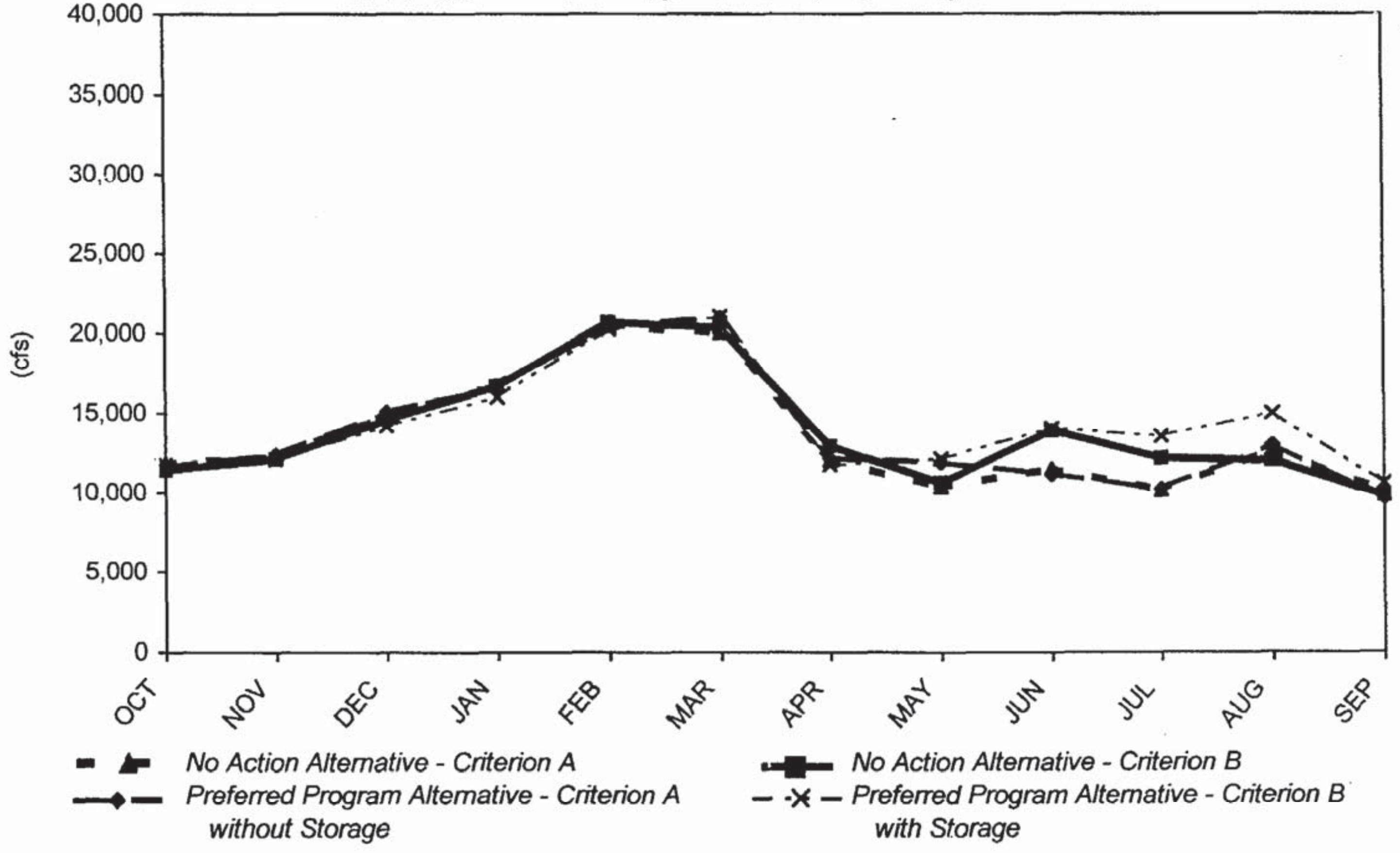


Figure 5.2-74. Average Monthly San Joaquin River Flow at Vernalis under the Preferred Program Alternative for the Long-Term Period

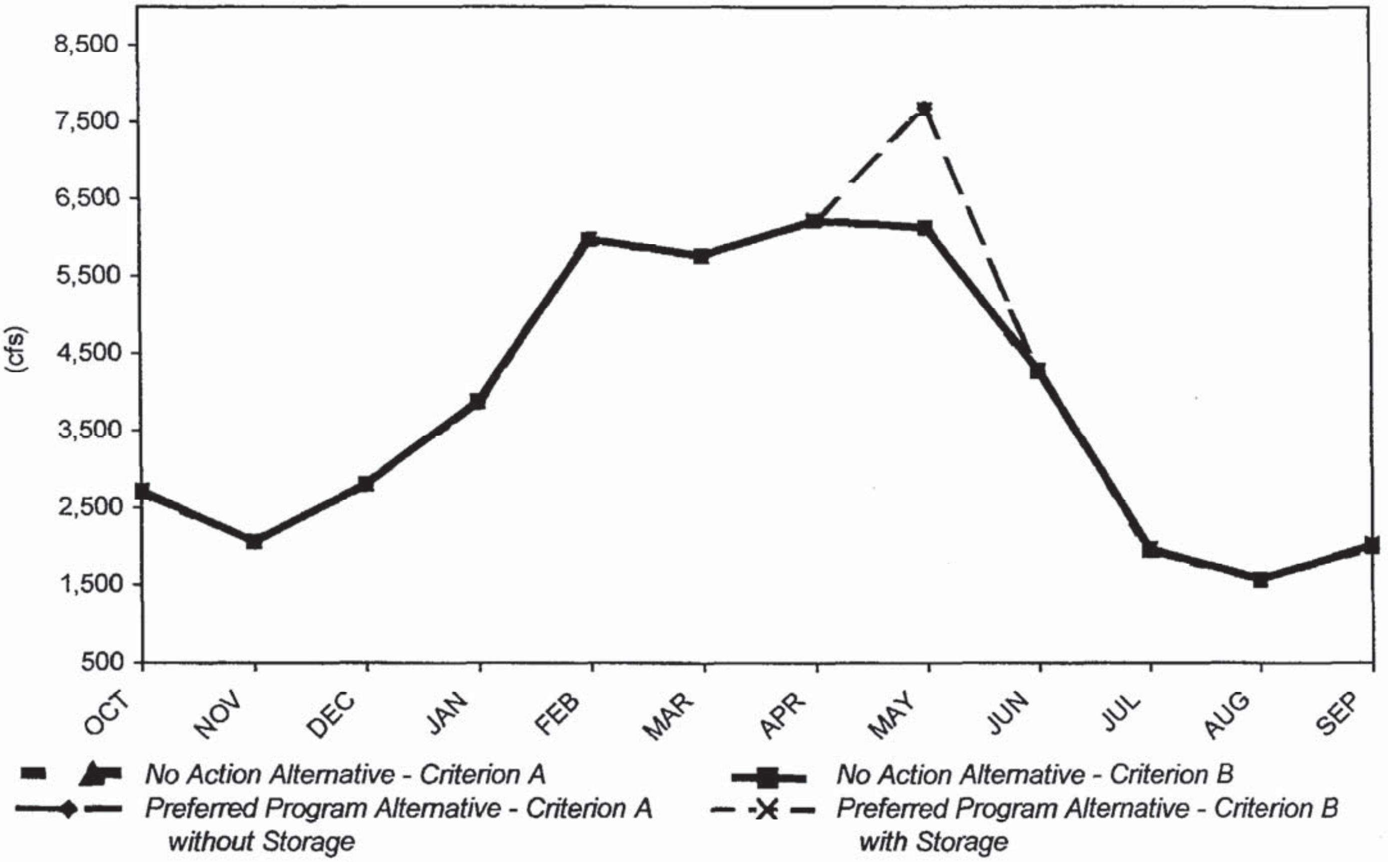
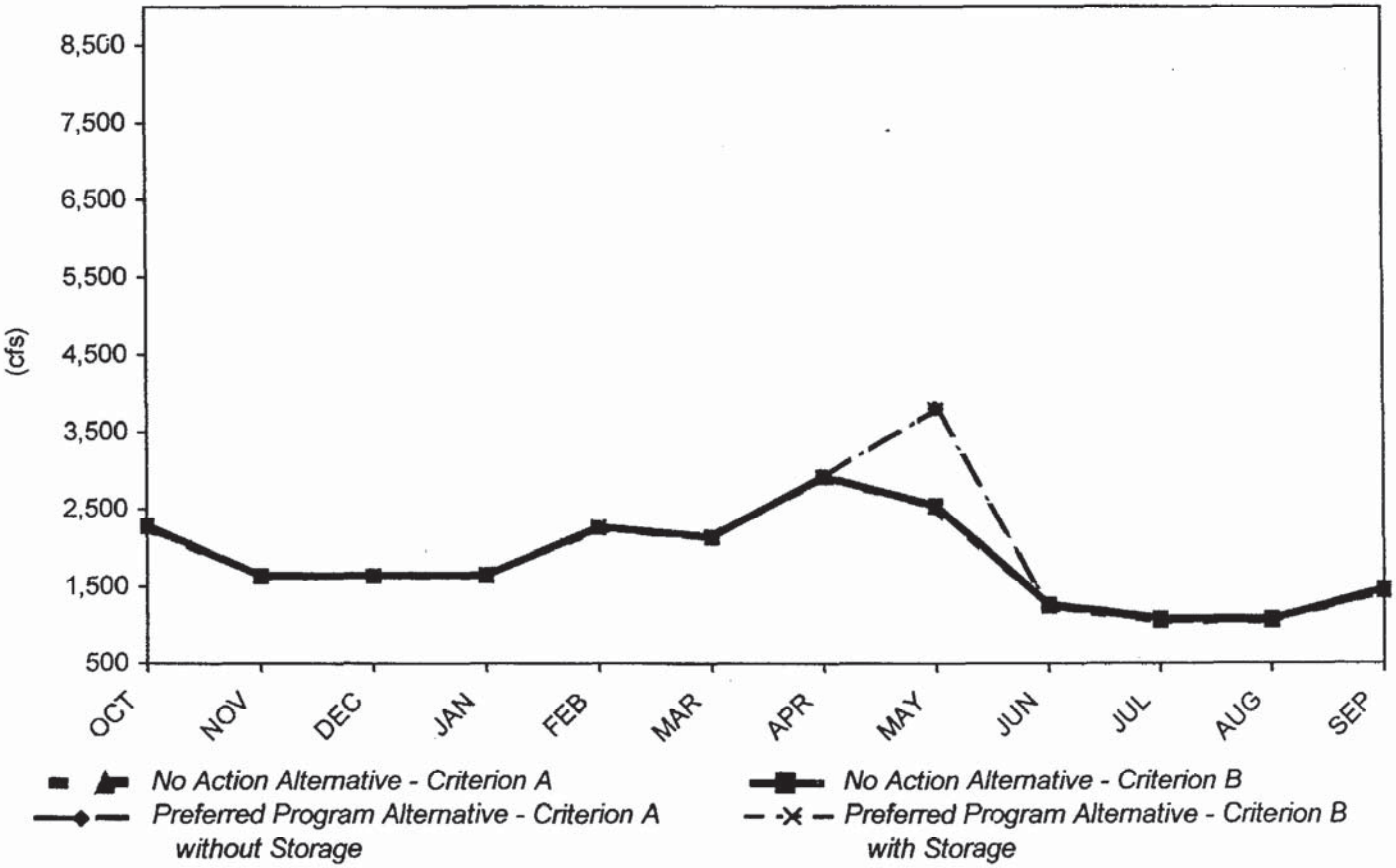


Figure 5.2-75. Average Monthly San Joaquin River Flow at Vernalis under the Preferred Program Alternative for Dry and Critical Years



New Reservoir Diversions and Releases. Figures 5.2-76 and 5.2-77 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under the Preferred Program Alternative. New surface storage diversions typically occur during winter and spring months, with peak diversions in late winter. For the Preferred Program Alternative, over the long-term period, the range of peak average monthly diversions is from 1,400 to 2,200 cfs. For dry and critical years, the range of peak average monthly diversions is from 200 to 1,100 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer months when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Peak average monthly releases in the Sacramento River Region range from 1,600 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200 to over 2,200 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (140 cfs), while average monthly diversions over the long-term period are greatest in late winter (160 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under the Preferred Program Alternative. Maximum average monthly releases range from 550 to 560 cfs for the long-term period and 340 to 350 cfs for dry and critical years.

5.2.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents a comparison of existing conditions to the Program alternatives for determining environmental consequences. As discussed earlier, potential changes to Bay-Delta hydrodynamics and riverine hydraulics due to Program actions are discussed in this section; the environmental implications of these changes are addressed in other sections of this report in the context of the resources affected by the changes. The programmatic analysis found that the effects on Bay-Delta hydrodynamics and riverine hydraulics from implementing any of the Program alternatives when compared to existing conditions are within the same range of effects as those identified in Sections 5.2.7 and 5.2.8.

As discussed in Section 5.1.4, in order to make programmatic comparisons between the No Action Alternative and Program alternatives, existing conditions were simulated based on an extensive set of modeling assumptions. The No Action Alternative was defined to represent a reasonable range of uncertainty in the preimplementation condition. This range of uncertainty was quantified for purposes

Figure 5.2-76. New Surface Storage Diversions in the Sacramento River Region under the Preferred Program Alternative for the Long-Term Period

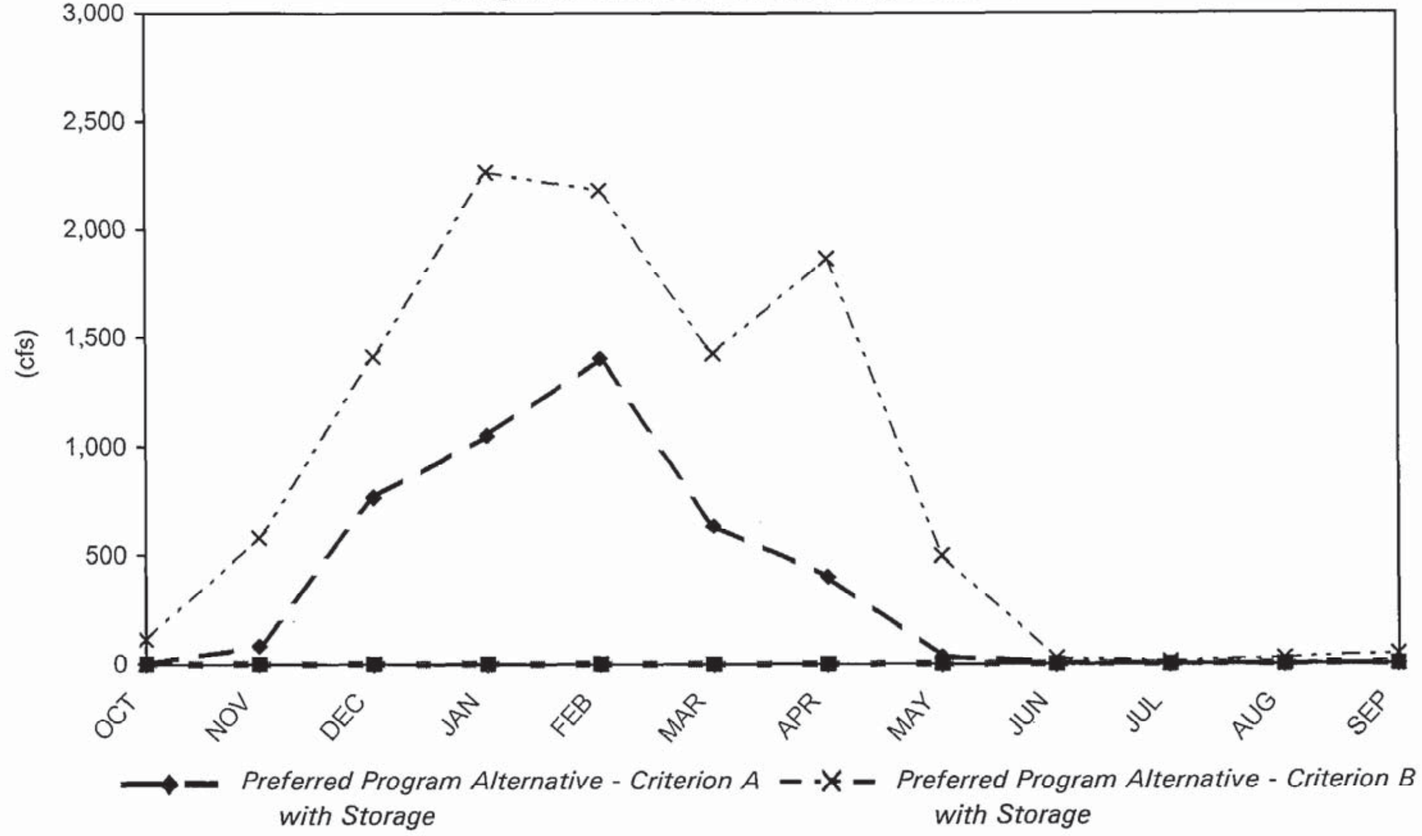
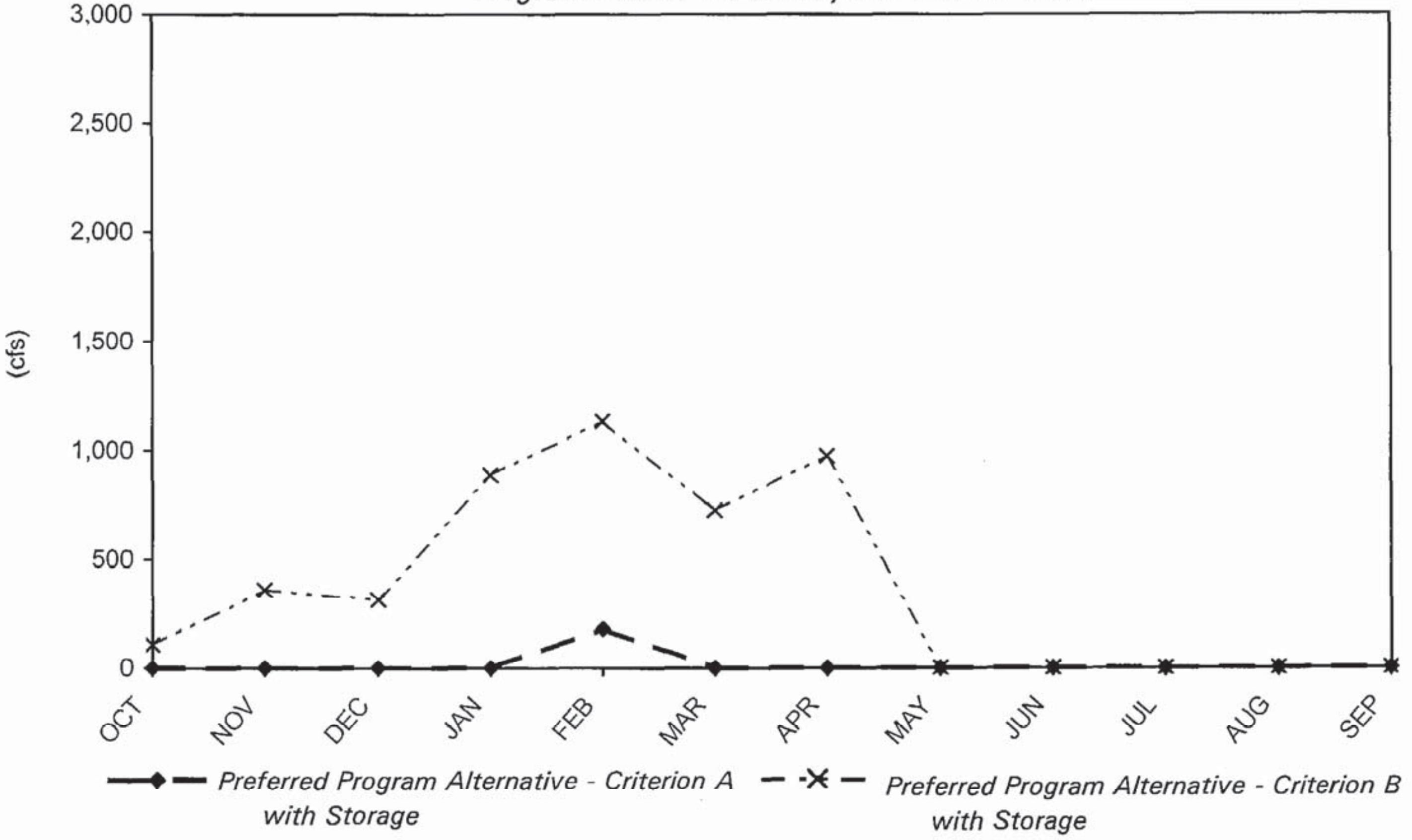


Figure 5.2-77. New Surface Storage Diversions in the Sacramento River Region under the Preferred Program Alternative for Dry and Critical Years



of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta management criteria that regulate system operations.

Under Criterion A, the Program assumes that 1995-level Bay-Delta system water demands (the same demands used to define existing conditions) apply throughout the Program planning horizon. Under this assumption, any future increase in demands in the Program study area would be met by alternative supply or demand management options. This bookend of the No Action Alternative also includes more protective Delta management criteria regulating flows and exports. While specific assumptions regarding Delta management criteria were made to complete the water simulation modeling, the Program's intention is to depict a general level of protection. These assumptions should not be interpreted as specific predictions of future Delta management requirements. Criterion A results in generally lower Delta exports than existing conditions.

Under Criterion B, the Program assumes Bay-Delta system water demands increase by about 10%. This bookend of the No Action Alternative includes no change in Delta management criteria from existing conditions. Criterion B results in generally higher Delta exports than existing conditions.

A comparison of effects on Bay-Delta hydrodynamics and riverine hydraulics of the Program alternatives relative to existing conditions indicates that:

- The impacts identified when compared to the No Action Alternative are the same when compared to existing conditions.

- No additional impacts are identified when Program alternatives are compared to existing conditions as opposed to the No Action Alternative.

5.2.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to significant adverse cumulative impacts on Bay-Delta hydrodynamics and riverine hydraulics. As described in Section 5.2.5, while Program-induced changes in Bay-Delta hydro-dynamics and riverine hydraulics are described in this section, the significance and environmental impacts of these changes are addressed in other sections of this report in the context of how the resources are affected by the changes. Section 5.3, "Water Quality," Section 6.1, "Fisheries and Aquatic Resources," Section 7.7, "Recreation Resources," and Section 7.9, "Power Production and Energy," present the environmental consequences related to changes in Bay-Delta hydrodynamics and riverine hydraulics. These sections also present mitigation strategies to avoid, reduce, or mitigate the potentially significant adverse environmental consequences identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For Bay-Delta hydrodynamics and riverine hydraulics, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This similarity is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. The potentially significant adverse long-term impacts and mitigation strategies that can be used to avoid, reduce, or mitigate impacts caused by changes in Bay-Delta hydrodynamics and riverine hydraulics are listed in summary form in the "Environmental Consequences" sections of resources affected—namely Sections 5.3.1, 6.1.1, 7.7.1, and 7.9.1. At the programmatic level, the analysis identified an impact related to Bay-Delta hydrodynamics and riverine hydraulics that cannot be avoided, reduced, or mitigated to a less-than-significant level. This impact is localized increases in EC (a measure of salinity) in water in the central Delta (see Section 5.3). The long-term impacts on Bay-Delta hydrodynamics and riverine hydraulics are elaborated on in Sections 5.2.7 and 5.2.8; related environmental consequences are described in Sections 5.3, 6.1, 7.7, and 7.9.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on Bay-Delta hydrodynamics and riverine hydraulics in the Delta, Bay, Sacramento River, and San Joaquin River Regions: American River Watershed Project, American River Water Resource Investigation, CVPIA Anadromous Fish Restoration Program and other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Red Bluff Diversion Dam Fish Passage Program, Sacramento Water Forum process, Supplemental Water Supply Project, and Sacramento County municipal and industrial water supply contracts. Together, these projects could affect river flows or Delta water circulation and cause cumulative effects on Bay-Delta hydrodynamics and riverine hydraulics. The effects on Bay-Delta hydrodynamics and riverine hydraulics of the Trinity River Restoration Project, ISDP, and urbanization were evaluated in Sections 5.2.7 and 5.2.8 and, consequently, would not contribute to additional cumulative effects on Bay-Delta hydrodynamics and riverine hydraulics. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts on fisheries and aquatic resources, recreation, and power and energy that are caused by changes to Bay-Delta hydrodynamics and riverine hydraulics are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level. Water quality impacts in the Delta Region related to changes in Bay-Delta hydrodynamics and riverine hydraulics, however, may be unavoidable (see Section 5.3.12). It is not anticipated that the CALFED Program's contribution to this cumulative impact, at the programmatic level, can be avoided, reduced, or mitigated to a less than cumulatively considerable level. Therefore, this analysis concludes that this impact is cumulatively significant and unavoidable. This conclusion is based on currently available information and the high level of uncertainty as to whether this impact can be avoided, mitigated, or reduced to a level that is less than cumulatively considerable.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. Short-term, construction-related effects on Bay-Delta hydrodynamics and riverine hydraulics would be localized and cease after construction is completed. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on affected resources.

Irreversible and Irretrievable Commitments. The Water Use Efficiency, Water Transfer, Water Quality, Storage, Conveyance, and other elements of the Preferred Program Alternative can be considered to cause significant irreversible changes to Bay-Delta hydrodynamics and riverine hydraulics. The environmental consequences of these irreversible changes, along with possible avoidance and mitigation measures, are addressed in other sections of this report in the context of the affected resources.

5.2.11 MITIGATION STRATEGIES

As described in Section 5.2.5, while Program-induced changes in Bay-Delta hydro-dynamics and riverine hydraulics are described in this section, the significance and environmental impacts of these changes are addressed in other sections of this report in the context of each of the resources affected by the changes. Mitigation strategies to deal with potential effects also are discussed in the sections of this report in the context of the affected resources.

5.2.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Any potentially significant unavoidable impacts on resources affected by Program-induced changes in Bay-Delta hydrodynamics and riverine hydraulics are described in other sections of this report in the context of each of the resources affected by the changes.

5.3 Water Quality

The CALFED Bay-Delta Program is expected to produce continuous overall improvements over the term of the Program to ensure that good-quality water is provided to serve all beneficial uses dependent on the water resources of the Bay-Delta system and its tributary watersheds.

5.3 Water Quality

5.3.1 SUMMARY

The Delta and its tributaries are key surface water sources of drinking water for the majority of Californians. These water resources also replenish reservoirs and groundwater basins that are relied on to maintain the continuity of water supplies throughout most of the state. The continued availability of good-quality water supplies from these sources is crucial to the maintenance of agriculture and other important water-dependent industries. The Sacramento-San Joaquin Delta and Bay (Bay-Delta) is the ecological hub of the Central Valley, and provides critical habitat for diverse fish and wildlife populations. Although individual criteria for beneficial uses vary, these beneficial uses require sustainable high-quality water for their maintenance and improvement. To be utilized effectively, source water supplies for municipal and industrial uses should be free of potentially harmful concentrations of contaminants that are infeasible, or unreasonably expensive, to remove. Population growth and future industrial development may increase waste loads to the Bay-Delta, which in turn would increase the burden on water resources, infrastructure, and drinking water treatment capabilities. Improved and increased measures will be needed to prevent or to reverse the potentially adverse effects of increased waste loads. Left unchecked, these pressures would lead to serious water quality degradation—potentially resulting in losses of agricultural, industrial, and biological productivity; increases in water treatment costs and associated secondary impacts; and increased risks to public health and welfare.

Preferred Program Alternative. The Water Quality and Watershed Programs would improve overall water quality by reducing the loadings of many constituents of concern that enter Delta tributaries from point and nonpoint sources. Actions under these program elements would reduce adverse concentrations of key contaminants contained in receiving waters, especially the Bay-Delta system. Principal targeted constituents include heavy metals, pesticide residues, salts, selenium, pathogens, suspended sediments, adverse temperatures, and disinfection byproduct precursors (DBPs) such as bromide and total organic carbon (TOC). Conversion of Delta islands from agriculture to wetlands could increase TOC loadings to the Delta channels, potentially contributing to the formation of DBPs in water treatment processes.

The Water Use Efficiency Program could result in beneficial and adverse effects, depending on conditions. For example, program actions such as conservation would reduce diversions from channels and reduce loads of contaminants returned to the channels, resulting in general water quality benefits. However, some actions could result in increased releases of contaminants and produce localized increases in concentrations that in most cases would be limited to the mixing zone around the discharge. The Water Use Efficiency Program is focusing on achieving multiple benefits related to water quantity, quality, and timing; therefore, the adverse impacts from this program are expected to be less than significant.

Improvements to the Delta levee system under the Levee System Integrity Program would greatly reduce the risk of rapid sea-water intrusion contaminating the Delta and disrupting water supplies following major levee failures, particularly seismically induced failures. All program actions (particularly channel dredging and construction of new levees and setback levees) could produce short-term adverse impacts during construction activities. Dredging may expose mercury-laden sediments, which could contribute to increased mercury availability to aquatic organisms and increased mercury concentrations in sediment; dredging also may mobilize other toxic elements. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. Potentially significant impacts can be mitigated to a less-than-significant level through these mitigation strategies.

Based on ranges of results obtained from model runs, the Preferred Program Alternative generally would improve in-Delta and export water quality, and dependent beneficial uses because of increased inflows of higher quality water from Sacramento River and the north Delta, and improved circulation in Delta channels. Electrical conductivity (EC, an index of salinity) would be reduced in the northeast Delta, south Delta, and southwest Delta, and on the San Joaquin River in the west Delta. These improvements generally would occur from November through March of average, dry, and critical years, and in September of dry and critical years. Similar improvements in EC would occur at the CVP and SWP intakes, and at both of the Contra Costa Water District (CCWD) diversions from Old River. EC would increase at some times in the Lower Sacramento River. Although the Preferred Program Alternative would improve water quality at many locations in the Delta, it could cause water quality to deteriorate in localized areas of the central Delta. If the diversion facility on the Sacramento River is not constructed, the Preferred Program Alternative's impacts on water quality in the Delta would be similar to those of Alternative 1. Increased EC of water in a few localized areas of the central Delta would result in a potentially significant unavoidable impact on the local suitability of the water as a source for agricultural irrigation. Although this impact may be reduced by mitigation strategies, it is unknown at this time whether the impact can be reduced to a less-than-significant level.

The Preferred Program Alternative should result in increased cross-Delta flows, improved circulation, and resultant increases in dispersion and dilution of ocean salt. Given that sea-water intrusion is the major source of bromide in the Delta, bromide concentrations should decrease along Old and Middle Rivers, which would benefit the primary diversion and export facilities. This would depend on Delta Cross Channel (DCC) gate operation in coordination with the Sacramento River to Mokelumne River channel operations.

Although the effects of additional upstream storage may differ depending on its location and operations, additional upstream storage generally would increase the flexibility to provide for additional fresh-water releases and Delta inflows that will improve Delta water quality. These benefits would be most apparent in dry months and seasons when additional water would be needed to meet consumptive and environmental demands. Upstream storage releases also could benefit export water quality during dry years.

In-Delta storage could provide many of the same benefits to export water quality as upstream storage. There is uncertainty concerning to what extent the peat soils on Delta islands would affect the TOC concentrations in export water. Further, it is uncertain whether TOC from peat soils contributes to a greater or lesser degree to the health concerns surrounding DBPs. Studies to address these uncertainties are underway, and more studies are likely to be proposed. Results from these studies would be included in any project-specific environmental review for in-Delta storage.

Additional off-aqueduct south-of-Delta storage could relieve export pressures in the south Delta, thereby avoiding some of the potential for pumping-induced water quality degradation. Storage- and nonstorage-dependent operational changes being considered by the Program could significantly extend or magnify the ranges of water quality effects of the Preferred Program Alternative, depending on existing and antecedent hydrologic conditions. Releases from storage also could augment Delta outflows when needed to control sea-water intrusion and optimize estuarine conditions for the ecosystem and dependent fish species (as indicated by the position of the X2 [isohaline] index compared to standards). X2 refers to the mean tidal distance of the 2,000 milligrams per liter (mg/L) isohaline (a line of equal salinity) upstream from the Golden Gate Bridge. (Note that although this standard is based on temporal variations in salinity, it is used to regulate flow; therefore the topic is covered in Section 5.2, "Bay-Delta Hydrodynamics and Riverine Hydraulics."

Construction of Delta facilities could result in potentially significant impacts on water quality that are associated with earth moving and dredging. Impacts would consist primarily of increased sediment loads caused by erosion and sediment disturbance. Releases of nutrients, natural organic matter, and toxicants into the water column could increase to various degrees, depending on the types of construction methods, materials, and mitigation strategies used. Disturbances to previously farmed soils could release residual agricultural pesticides, including organochlorinated pesticides, mercury, nutrients, and other chemicals that may adversely affect water quality. Most of these impacts would be relatively short term in duration. In general, potentially significant impacts that are associated with construction of Delta facilities can be mitigated to a less-than-significant level.

Alternatives 1, 2, and 3. Under Alternatives 1, 2, and 3, the water quality impacts of Program elements other than Conveyance would be similar to those described for the Preferred Program Alternative. In terms of the impacts of Conveyance on in-Delta and export water quality, Alternative 1 would cause water quality conditions in the Delta and export service areas to worsen. Alternative 2 generally would improve water quality compared to the No Action Alternative in the central Delta and at the export facilities. Alternative 3, compared to the No Action Alternative, would result in significant decreases in average salinities and bromides in the south Delta, along Old River, and at the two CCWD intakes, during all or most months of most years. Alternative 3 also would result in greatly improved export water quality at Clifton Court Forebay (CCFB) (and at the Delta-Mendota Canal [DMC] intake if an intertie is constructed), and in the SWP and CVP service areas to the south and west—particularly for the following parameters: EC, total dissolved solids (TDS), bromide, chloride, and dissolved organic carbon (DOC). Salinities are projected to increase compared to the No Action Alternative in the northeast Delta, the central Delta, and in the south Delta along Middle River.

The following table presents a summary of the potentially significant adverse impacts associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Releases of inorganic and organic suspended solids into the water column and turbidity resulting from increased erosion during construction, dredging, or drainage of flooded lands (7,8,9,19).

Releases of toxic substances, such as pesticides, selenium, and heavy metal residues, into the water column during construction and dredging and other program actions (7,8,9,14,15,19).

Net increases in salinity, if evaporation increases from in-Delta storage or converting irrigated cropland to wetlands (2,3,13).

Increased EC (a measure of salinity) of water in a few localized areas of the central Delta would result in a potentially significant unavoidable impact on the local suitability of the water as a source for agricultural irrigation. (2,3,12).

Increases of TOC in river water caused by the increased contact between flowing or ponded water and vegetation or peat soils that would result from conversion of agricultural lands to wetlands and from actions in other Program elements (4,5,10,11,12).

Increased water temperatures and resultant decreased dissolved oxygen concentrations due to the increased residence time of water in the Delta (2,3,13).

Decreases in in-stream water quality if water use efficiency measures or water transfers reduce diluting flows (1,2,3).

Increases in concentrations of constituents of concern if water transfers reduce in-stream flows and deplete river assimilative capacities (1,2,3,6).

Increases in methylation of mercury in constructed shallow-water habitat (16).

Degradation of surface water by the transfer of poorer quality groundwater (2,3).

Changes in natural flow regimes in areas where new surface storage is built (17).

Surface storage inundation of toxic material (18).

Mitigation Strategies

1. Improving treatment levels provided at municipal wastewater treatment plants to upgrade the quality of the constituents of concern discharged to receiving waters in order to compensate for the reduction in dilution caused by improved water use efficiency or water transfers. Salt concentrations in discharges could be reduced by improved salt management of wastewater inputs to treatment plants.

2. Releasing additional water from enlarged or additional off-stream surface storage, or from additional groundwater storage.

3. Releasing additional water from storage in existing reservoirs or groundwater basins.

4. Treating water at the source (such as Delta drains), upgrading water treatment processes at drinking water treatment plants, and/or providing treatment at the point of use (consumer's tap).

5. Using innovative, cost-effective disinfection processes (for example, UV irradiation and ozonation—in combination with other agents) that form fewer or less harmful DBPs.

6. Using existing river channels for water transfers and timing the transfers to avoid adverse water quality impacts.

7. Using best construction and drainage management practices to avoid transport of soils and sediments into waterways.

8. Using cofferdams to construct levees and channel modifications in isolation from existing waterways.

9. Using sediment curtains to contain turbidity plumes during dredging.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative (continued)

10. Separating water supply intakes from discharges of agricultural and urban runoff.
11. Applying agricultural and urban BMPs, and treating drainage from lands with concentrations of potentially harmful constituents to reduce contaminants. Treating drainage from agricultural lands underlain by peat soils to remove TOC.
12. Relocating diversion intakes to locations with better source water quality.
13. Restoring additional riparian vegetation to increase shading of channels.
14. Conducting core sampling and analysis of proposed dredge areas and implementing engineering solutions to avoid or prevent environmental exposure of toxic substances after dredging.
15. Capping exposed toxic sediments with clean clay/silt and protective gravel.
16. Testing for mercury in soils and locating constructed shallow-water habitat away from sources of mercury until methods for reducing mercury in water and sediment are implemented.
17. Operating surface storage release times and magnitude to mimic natural regimes.
18. Avoiding inundation or designing solutions to inundation of toxic materials, such as covering with an engineered cap.
19. Scheduling ground-disturbing construction during the dry season.

Bold indicates a potentially significant unavoidable impact.

5.3.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the areas of controversy for this resource category. Given the programmatic nature of this document, many of these areas of controversy cannot be fully addressed; however, subsequent project-specific environmental analysis will evaluate these topics in more detail.

Total Organic Carbon Drinking Water Concerns. Water Quality Program actions are aimed at controlling organic carbon, a precursor to DBPs. Treatment of Delta island drainage is being studied as a potential means of reducing organic carbon loading. Source control may offer more cost-effective means than downstream treatment to meet regulatory requirements. There is limited knowledge of baseline conditions of TOC at key Delta locations and tributaries, including the intake to the NBA. There is also limited understanding of TOC loads in the system and of the extent to which CALFED actions will reduce or increase TOC at drinking water diversion points. Controversy exists concerning the contribution of natural or developed wetlands to TOC concentrations found in Delta waters at drinking water intakes. The proposed restoration of wetlands through the Ecosystem Restoration Program may increase the total amount of TOC and DOC at drinking water intakes, increasing the potential to form DBPs. This controversy is likely to exist until further studies determine the extent that restored wetlands may influence Delta drinking water quality and what levels of DBPs are considered safe. The Preferred Program Alternative is expected to result in a net beneficial effect on DOC concentrations at the export pumps in the south Delta, but the Preferred Program Alternative may not improve water quality sufficiently to avoid treatment needed to remove DOC.

Pathogens. The drinking water objective of the Water Quality Program is to sufficiently improve source water quality to allow production of drinking water that is safe, meets anticipated regulatory standards, and is acceptable to the consumers. Of primary importance is the reduction and maintenance of pathogen loadings in source waters to required levels. Pathogen levels in Delta waters are largely unknown at this time. Utilities using Delta water sources primarily disinfect with chlorine, which is effective for total coliform, viruses, and *Giardia lamblia*, at reasonably feasible concentrations and contact times. However, chlorine is not able to inactivate some microorganisms, such as *Cryptosporidium parvum*, which may be present in source waters and may be regulated in the near future. An increasing number of utilities are using ozone or a combination of disinfectants that more effectively inactivates most pathogenic microorganisms, including *Cryptosporidium parvum*. Utilities are anticipating stricter requirements from the EPA for the control of pathogenic microorganisms. Since the Delta is a relatively unprotected and unknown source of pathogens, and treatment technology continues to be advanced, controversy exists on whether taking water from the Delta constitutes adequate source water protection.

Bromide. The Phase II Report identifies bromide as a critical constituent concerning selection of the Preferred Program Alternative. Bromide is critical because the selection of storage and conveyance options can profoundly affect bromide concentrations in municipal water supplies diverted from the Delta. It is believed that the primary source of bromide in Delta waters is sea-water intrusion. Other possible sources of bromide have been hypothesized, as follows:

- Bromide loading in the San Joaquin River from agricultural application of the fumigant, methyl bromide.
- Bromide leached from the geological strata in the watershed of the San Luis Reservoir.
- Connate groundwater sources (sources of ancient sea-water origin) of bromide in or around Empire Tract in the Delta.

The limited available data suggest that none of these sources is a highly significant source of bromide when compared to sea water.

Although the following issue does not meet the CEQA criteria as an area of controversy, the subject is one of concern to CALFED agencies.

Good Samaritan Protection. Water Quality Program actions include remedial activities to clean up abandoned mine sites in order to reduce metals that enter water bodies. A step-wide approach would be conducted, leading to implementation of what are expected to be the cost effective remediation strategies. An agency or entity performing a clean-up of an abandoned mine, however, may be subject to liability for its efforts. A major concern, for example, is liability under the Clean Water Act. Some CALFED implementing agencies are unlikely to undertake abandoned mine remediation due to the risk of liability under the present law. Some people recommend that federal law provides additional "Good Samaritan" protections to reduce the liability risk and thus encourage mine remediation. Others object to such provisions, arguing that current law better balances the goals of encouraging clean-ups and avoiding unwarranted litigation with other goals, such as providing incentives to ensure that clean-ups are completed with proper care and providing citizens with appropriate relief if they are harmed.

Drinking Water Regulations. The future of drinking water regulations and the ability of water purveyors to meet them by increasing treatment is a matter of controversy. It is difficult to predict what substances will be regulated in the future and their likely acceptable maximum contaminant levels (MCLs) in drinking water. Some believe that whatever the regulations are, treatment systems can be designed and built to meet regulatory standards. Others believe that treatment may be technically infeasible, too costly, and not justified by the resulting benefits to public health.

5.3.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

5.3.3.1 DELTA REGION

Activities and Sources That Affect Water Quality in the Delta

Hydraulic and hard-rock mining for gold in the late 1800s produced the first significant impacts on water quality in the Delta. Mercury, mined in the Coast Ranges, was used to separate gold in the Sierra Foothills. Hydraulic mining created large amounts of sediment that contained high levels of heavy metals (cadmium, copper, zinc, and mercury). This sediment was washed from the hillsides, carried downstream, and deposited in river beds, Delta tidal marshes, and mudflats. These metals still are considered contaminants of concern because of their continuing potential to adversely affect beneficial uses in the Delta. Sampling in the Sacramento River from 1987 to 1992 indicates that about 75% of the mass of these metals found in sediments can be traced to past mining activities. Disturbing these sediments could release toxics into the water column.

The growth of agriculture, enabled by the diversion of irrigation water from the rivers and Delta during this century, also has led to water quality concerns. The application of fertilizers and pesticides on 500,000 acres of farmland in the Delta and another 4.5 million acres in the San Joaquin and Sacramento Valleys has adversely affected the beneficial uses of water for drinking, fishery resources, recreation, and agricultural uses.

Water quality in the San Joaquin River and the south Delta has been affected by salts and natural deposits of selenium-rich soils. Salts and selenium that are concentrated in shallow groundwater on the west side of the San Joaquin Valley are mobilized when subsurface water must be pumped to drain agricultural lands. The San Joaquin Valley Drainage Program (1990) includes plans to curtail discharges of drain water to the river, reduce the amount of applied irrigation, and retire some irrigated lands.

Compared to historical conditions, Delta salinity during low-flow periods is much lower since the construction of dams, which allow storage and fresh-water releases during dry and critical periods. Sea-water intrusion into the Delta can be intensified by diversion of fresh water and the corresponding decrease of fresh-water outflow from the Delta. As a result, the west Delta often experiences increased salinity during summer and fall, although to a substantially lessened extent since construction of the upstream dams. High salinity adversely affects the quality of drinking and irrigation water.

More recently, urban development and population growth in and around the Delta have contributed to adverse impacts on water quality and simultaneously have increased demand for better water quality. When Delta water is disinfected for household consumption, unwanted byproducts are formed, some of which are suspected to be carcinogenic in humans.

Water quality in the Delta also is affected by various point and nonpoint pollutant sources—some of which are located in the Delta, most of which occur in the Sacramento and San Joaquin Valleys.

Industrial and municipal wastewater treatment plant discharges are strictly regulated to minimize adverse impacts on water quality; however, these discharges are not regulated for organic carbon and pathogenic protozoa, two important constituents of drinking water. Much of the runoff from urban and agricultural areas is unregulated and more difficult to control. Runoff, containing oil, grease, metals, pesticides, fertilizers, and many other pollutants, contributes to the pollution of Delta and Bay waters.

Recreational uses also have contributed to deterioration of the water quality in the Bay-Delta. Key contaminants associated with recreational uses are pathogens caused by human and animal detritus; and oil, grease, fuel, and fuel additive discharges from recreational vehicles.

The principal sources of pollutants to the Delta include:

- Drainage from inactive and abandoned mines that contribute metals, such as cadmium, copper, zinc, and mercury.

- Stormwater inflows and urban runoff that contribute metals, sediment, pathogens, organic carbon, nutrients, pesticides, dissolved solids (salts), petroleum products, and other chemical residues.

- Municipal and industrial wastewater discharges that can contribute salts, metals, trace elements, nutrients, pathogens, pesticides, organic carbon, oil and grease, and turbidity.

- Surface agricultural irrigation return flows and nonpoint discharges that can contribute salts (including bromide), organic carbon, nutrients, pesticides, pathogens, and sediment.

- Subsurface agricultural drainage that can contribute salts (including bromide), selenium, nutrients, and some agricultural chemical residues.

- Large dairies and feedlots that can contribute nutrients, organic carbon, and pathogenic organisms.

- Water-based recreational activities (such as boating) that can contribute hydrocarbon compounds, nutrients, turbidity, and pathogens.

- Atmospheric deposition that can contribute metals, pesticides, and other synthetic organic chemicals, and may lower pH.

- Sea-water intrusion that can contribute salts, including bromide.

In addition to these sources, natural processes, such as high flows, and anthropogenic activities, such as dredging, can mobilize constituents that originate from these sources.

Beneficial Uses, Water Quality Objectives, and Pollutants of Concern

Specific beneficial uses and water quality objectives for the Bay-Delta waters have been identified by the San Francisco Bay and Central Valley Regional Water Quality Control Boards. Similar lists of beneficial uses have been developed for surface water in other regions.

Drinking water standards are designed to protect human health and to maintain the aesthetic qualities of appearance, taste and odor, and color. Water quality objectives to protect environmental beneficial uses are often more stringent than drinking water standards. However, for TOC and pathogens that are of concern for drinking water, no environmental objectives are established. One of the most important distinctions between drinking water standards and environmental water quality objectives may be the point at which they apply. Environmental water quality objectives typically are applied to discharges and to receiving waters. For drinking water, some standards are designed to apply at the drinking water source, some at the treatment plants, and some at the customer's tap. There are no corresponding ecological protection standards for some substances that are regulated in drinking water.

Water treatment requires disinfection to kill pathogens and to guard against contamination in the supply system. However, disinfection of water containing TOC and bromide can result in the formation of DBPs, which are believed to cause cancer. As a result, TOC and bromide are undesirable in drinking water supplies. Some of the water quality parameters that are very important for agriculture or industry (for example, temperature, boron, and sodium adsorption ratio) are less important for drinking water.

Recreational beneficial uses include in-stream uses. Water quality standards may be designed to reduce the hazards that are associated with contacting contaminated water, to prevent bioconcentration of contaminants in fish and wildlife, or to prevent degradation of such qualities as water clarity.

Under Section 303(d), the Clean Water Act requires regulatory agencies to periodically evaluate the extent to which water bodies are supporting these beneficial uses, based on an evaluation of exceedances of water quality objectives. The result is a list of impaired water bodies and the constituents and sources that may be causing that impairment. A Section 303(d) list was compiled for the Program in the Water Quality Program Plan. Based on this and other sources of information, the stakeholders and CALFED staff developed the list of parameters of concern shown in Table 5.3-1.

Factors That Affect Variability of Water Quality in the Delta

Water quality in the Delta is continually changing over time and space in response to natural hydrologic conditions, operation of upstream reservoirs, agricultural and water supply diversions, and discharges into the system. Seasonal trends reflect the effects of higher winter/spring runoff and summer/fall low-flow periods. Yearly changes in water quality are associated with different water-year types, as defined in the SWRCB's D-1485.

Table 5.3-1. Water Quality Parameters of Concern to Beneficial Uses

METALS AND TOXIC ELEMENTS	ORGANICS/ PESTICIDES	DISINFECTION BY-PRODUCT PRECURSORS	OTHER
Cadmium	Carbofuran	Bromide	DO
Copper	Chlordane[a]	TOC	Salinity (TDS, EC)
Mercury	Chlorpyrifos		Temperature
Selenium	DDT[a]		Turbidity
Zinc	Diazinon		Toxicity of unknown origin[b]
	PCBs[a]		Pathogens
	Toxaphene[a]		Nutrients[c]
	Dioxins[d]		pH (Alkalinity)
	Dioxin-like compounds[d]		Boron
			Sodium adsorption ratio

Notes:

DO = Dissolved oxygen.
EC = Electrical conductivity.
TDS = Total dissolved solids.
TOC = Total organic carbon.

[a] These compounds are no longer used in California. Toxicity from these compounds is remnant from past use.
[b] Toxicity of unknown origin refers to observed aquatic toxicity, the source of which is unknown.
[c] Nutrients includes nitrate, nitrite, ammonia, organic nitrogen, total phosphorus, and soluble reactive phosphorus.
[d] These compounds may be added after review.

Spatial trends of water quality in the Delta reflect the effects of inflows, exchange with the Bay, diversions, and pollutant releases within the Delta. The north Delta tends to have better water quality, in large part because of the inflow from the Sacramento River, which is fed by reservoirs containing high-quality water. The quality of water in the west Delta is strongly influenced by exchange with the Bay; during low-flow periods, sea-water intrusion causes poorer water quality. In the south Delta, water quality tends to be poorer because of the combination of inflows of poorer water quality from the San Joaquin River, discharges from Delta islands, and the effects of diversions that can sometimes increase sea-water intrusion from the Bay.

Water Quality Issues in the Delta

Based on the above discussion, the significant water quality issues in the Delta Region are as follows:

- Discharges from Delta islands have elevated concentrations of TOC (a DBP precursor) and salts that affect industrial, municipal, and agricultural uses.

- High-salinity water from Suisun and San Francisco Bays intrudes into the Delta during periods of low Delta outflow. Salinity adversely affects most beneficial uses. Bromides associated with sea water leads to the formation of brominated DBPs in treated water.

- Synthetic chemicals (such as pesticides and herbicides) and natural contaminants (heavy metals) have accumulated in sediments in the Delta, and can accumulate in aquatic organisms. For example, mercury and DDT, which bioaccumulate through the food web in fish and shellfish, can exceed acceptable limits for human consumption. Disturbance of contaminated sediments can release these constituents into the water column.

- Agricultural drainage to the Delta can contain elevated levels of nutrients, suspended solids, organic carbon, salinity, selenium, and boron, in addition to chemical residues. All of these constituents may adversely affect the beneficial uses of Delta water.

- Heavy metals, including cadmium, copper, mercury, and zinc, continue to enter the Delta. Sources of these metals include runoff from abandoned mine sites, tailings deposits, downstream sediments where the metals have been deposited over the past 150 years, urban runoff, and industrial and municipal wastewater discharges.

- The estuarine salinity gradient and its associated entrapment zone (where biological productivity is relatively high because of the mixing dynamics and accumulation of suspended materials) affect the quality and extent of habitat for some estuarine species. The entrapment zone and adjacent habitats support fish food production in the Delta. The location of the entrapment zone and its extent are controlled by Delta outflow, and directly affect environmental and dependent recreational beneficial uses.

- Oxygen depletion adversely affects aquatic organisms. It is caused by discharges of inadequately treated wastes, and discharges of nutrients that promote the growth and decay of natural vegetation. Sources of oxygen-demanding materials and nutrients include discharges from industrial and municipal treatment plants, and from agricultural and urban sources. Such problems are of particular concern in the lower San Joaquin River and in the south Delta.

- The population of the Central Valley is expected to increase substantially by 2020. Increased discharge of municipal wastewater and urban runoff in the valley could degrade water quality.

Summary of Data for Key Water Quality Constituents

The following section describes the results of water quality sampling in the Delta for some key constituents. Except for salinity predictions, which are made possible by available mathematical modeling tools, there is currently little consensus regarding the ability to predict levels of other water quality constituents that would be present in the Delta estuary, with or without CALFED actions. Even accurate qualitative assessments are generally not possible, due to the many changes that will be made in the system. CALFED is, however, investing in the development of modeling tools that may have the capability of assessing water quality constituents other than salinity. When these tools become available, they will be used to prepare project-specific environmental documentation in conjunction with planning CALFED projects.

Bromide. The primary source of bromide in Delta waters is sea-water intrusion. Other sources include drainage returns in the San Joaquin River and within the Delta, connate water (saline water trapped in sediment when the sediment was deposited) beneath some Delta islands, and possibly agricultural applications of methyl bromide. The river and agricultural irrigations sources are primarily a "recirculation" of bromide that originated from sea-water intrusion. Dissolved bromide concentrations at sampling stations for the Municipal Water Quality Investigation (MWQI) shown in Table 5.3-2 indicate a gradient in bromide such that mean concentrations range from about 0.46 mg/L at Rock Slough to 0.27 mg/L at CCFB. The effect of recirculating bromide in the lower San Joaquin River is indicated by a mean concentration of about 0.27 mg/L at the DMC and 0.31 mg/L at Vernalis. In contrast, the mean bromide concentration on the Sacramento River at Greene's Landing is about 0.018 mg/L.

Table 5.3-2. Mean Concentration of Constituents

DELTA AREA	LOCATION	BROMIDE, DISSOLVED (mg/L)	CHLORIDE, DISSOLVED (mg/L)	DOC (mg/L)	SELENIUM, DISSOLVED (mg/L)	SPECIFIC CONDUCTANCE (μmhos/cm)	TDS (mg/L)
North	Sacramento River at Greene's Landing	0.018	6.8	2.5	0.000	160	100
	North Bay Aqueduct at Barker Slough	0.015	26	5.3	0.000	332	192
South	SWP Clifton Court Forebay	0.269	77	4.0	0.000	476	286
	CVP Banks Pumping Plant	0.269	81	3.7	0.000	482	258
	San Joaquin River at Vernalis	0.313	102	3.9	0.002	749	459
	Contra Costa Intake at Rock Slough	0.455	109	3.4	0.000	553	305

Notes:
mg/L = Milligram per liter.
μmhos/cm = Micromhos per centimeter.

Source: DWR Municipal Water Quality Investigation (MWQI) data. Sampling period varies, depending on location and constituent, but generally is between 1990 and 1998.

Total and Dissolved Organic Carbon. The sources of organic carbon are primarily decayed vegetation. Important sources to the Delta include the Sacramento River, the San Joaquin River, and in-Delta island drainage return flows. Based on diversion estimates from DWR's Delta Island Consumptive Use Model (1995a), and DWR data on concentrations in the Delta and in return flows (1995b), in-Delta sources are estimated to contribute about 40-50% of the TOC to the Delta.

Monitoring data show that most of the TOC in the Delta is in the dissolved form, called DOC. DOC concentrations in the Delta channels vary seasonally, showing a peak during the wet season (from January through March) when runoff occurs. Mean annual concentrations of DOC in the Delta channels range from 6 to 13 mg/L. At the Barker Slough intake to the NBA, where local drainage predominates, the range is from 6 to 20 mg/L (Table 5.3-2).

The contribution of DOC from agricultural drains varies, depending on conditions on the island and especially the peat (organic) content of the soils. Sampling data obtained through DWR's MWQI Program show that mean annual concentrations of DOC may range from 17 mg/L at Brannan Island to 44 mg/L at Empire Tract. A strong seasonal variation, with concentrations increasing by about a factor of 2 during the wet season, also is indicated in the data.

More monitoring data and research are needed to determine the quality and quantity of sources of TOC and DOC from various land use practices in the Delta. CALFED has funded research on amounts and types of organic carbon emanated from restored wetlands. Research on reactivity of different DOC chemicals to form harmful DBPs also has begun. CALFED has formed a Drinking Water Constituents

Work Group to evaluate efforts to protect public health through the reduction of DBPs. DWR's MWQI Program has convened a scientific advisory panel to address DBP reduction and will coordinate with CALFED activities. These groups and studies will help to refine the CALFED actions in order to reduce TOC to applicable levels. The types of CALFED actions would not significantly differ from what is discussed in the Water Quality Program Plan.

Salinity, Total Dissolved Solids, and Electrical Conductivity. These parameters are measures of dissolved salts in water. Salinity is a measure of the mass fraction of salts (measured in parts per thousand [ppt]), whereas TDS is a measure of the concentration of salts (measured in mg/L). Since EC of water generally changes proportionately to changes in dissolved salt concentrations, EC is a convenient surrogate measure for TDS. Based on DWR's MWQI data for Delta channels, TDS is approximately equal to EC times 0.58.

While a precise conversion between TDS and EC is not possible (the equation is approximate), EC can be used as a modeling parameter that remains constant for each of the surface water supplies to the Bay-Delta. When the model shows a decrease in EC, we deduce that lower saline water from a cleaner source (perhaps the Sacramento River) is producing a lower EC, because the EC remains the same in the model for the Bay and the contributing rivers. The changes shown in the model are relative changes and do not reflect the actual EC. The EC reported in the model results should not be used to calculate TDS because a precise conversion is not possible.

Excess salinity in Delta waters affects agricultural, industrial, and municipal water supply beneficial uses, as well as habitat quality for aquatic biota in the Delta. For example, the monthly average TDS objective in the SWP water service contract is 440 mg/L. Sources of salinity include sea-water intrusion, agricultural drainage, municipal wastewater, urban runoff, connate groundwater, and evapotranspiration of plants. Sea-water intrusion is the major source of salinity in the Delta. Agricultural drainage, particularly from the San Joaquin Valley also is an important source—especially in the south Delta. Much of the San Joaquin River salt load, however, reflects recirculation of salts from the agricultural irrigation water that is obtained from the DMC.

TDS concentrations, as indicated in Table 5.3-2, are highest in the west Delta and the south Delta channels affected by the San Joaquin River. The mean concentration at CCFB is about 286 mg/L; at the Contra Costa intake at Rock Slough, the mean concentration is about 305 mg/L. The high concentrations in the San Joaquin River at Vernalis (459 mg/L) reflect the accumulation of salts in agricultural soils and the effects of recirculation of salts via the DMC. At Barker Slough in the north Delta, which is not substantially affected by sea-water intrusion, the mean TDS concentration is about 192 mg/L. Mean TDS in the Sacramento River at Greene's Landing is relatively low, around 100 mg/L.

Pathogens. The term "pathogens" refers to viruses, bacteria, and protozoa that are a potential threat to human health. Of particular concern, from the point of view of water supply, are protozoa such as *Giardia lamblia* and *Cryptosporidium parvum*, which are resistant to traditional disinfection methods. The frequency of detection of *Giardia lamblia* and *Cryptosporidium parvum* in samples obtained by DWR's Coordinated Pathogen Monitoring Program (1998) at 14 stations located in the SWP or SWP service area indicated positive detection of *Giardia lamblia* cysts in about 26% of all the samples (wet and dry weather) and positive detection of *Cryptosporidium parvum* cysts in about 8% of all the samples. The frequency of detection increased in those samples obtained during runoff events (wet-weather events), which suggests sources such as urban and agricultural runoff, and wet-weather bypass flows from wastewater treatment plants. However, the limited data and significant technical limitations in analysis techniques do not enable reliable conclusions to be drawn at this time.

Mercury. Mining-related activities are known to be a significant source of mercury in the Delta. The Coast Ranges, on the west side of the Sacramento Valley, contain a large deposit of cinnabar (mercury ore). At one time, mines in the area supplied the majority of mined mercury in the United States. The majority of the mercury mines in the Coast Ranges are abandoned and remain unclaimed. During the late 1800s and early 1900s, mercury was intensively mined and refined in the Coast Ranges, and transported across the Central Valley to the Sierra Nevada for use in placer gold mining operations. The Central Valley Regional Water Quality Control Board (CVRWQCB) (1998) has estimated that approximately 7,600 tons of refined mercury (commonly called quicksilver) were deposited in the Mother Lode region during the Gold Rush mining era. Studies by UC Davis and, more recently, by Bouse et al. (1996) and Harnberger et al. (1999) at the U.S. Geological Survey (USGS) show that the sediments mobilized by hydraulic mining ultimately were transported to the Bay-Delta, where they formed marshes and islands or were deposited in shallow water. USGS studies show that mercury concentrations in Bay sediments containing hydraulic mining debris range from 0.3 to 1 microgram per gram (μg/g). More importantly, certain conditions in these sediments can cause the formation of methyl mercury, the most bioavailable form of mercury.

Pesticides (Diazinon and Chlorpyrifos). Organophosphate pesticides, such as diazinon and chlorpyrifos, are used in the Central Valley on orchard crops (about half a million acres), including almonds, peaches, and prunes. The pesticides are applied during the dormant spray season from December through February. In 1993, Domagalski (1996) at the USGS estimated that over 45,000 kilograms (kg) of diazinon and 300 kg of chlorpyrifos were used predominantly in the Central Valley during the dormant spray season. Diazinon and chlorpyrifos also are used by commercial applicators and home owners to control common pests.

Diazinon and chlorpyrifos have been detected in surface water during winter and early spring from applications to orchards, in irrigation return water during summer, and in urban runoff samples during both winter and summer. Concentrations of diazinon measured in the Sacramento River in Sacramento during a January 1994 runoff event peaked at around 350 nanograms per liter (ng/L). In the Sacramento Slough north of the Delta, concentrations exceeded 1,000 ng/L. Toxicity identification evaluations (TIEs) were conducted by Foe (1995) from the CVRWQCB on samples to determine the presence of toxics in *Ceriodaphnia* bioassays from the Sacramento and San Joaquin Rivers. The results confirmed that diazinon was a primary toxicant.

Organochlorine Pesticides. Organochlorine pesticides (DDT, toxaphene, dieldrin, and chlordane) were widely used in the Central Valley until the 1970s and remain very persistent. Residues of these agents are still widespread in the Central Valley and are mobilized during winter storms, by irrigation and dredging and by construction activities. Fish tissue analyses indicate that levels of these pesticides can exceed recommended safe levels for human consumption. According to Fox and Archibald (1996), concentrations of organochlorine pesticides are generally much lower in bed sediment and biota in the Sacramento River basin compared to the San Joaquin River basin. Dioxin and dioxin-like compounds have been identified by the EPA as substances that impair beneficial uses in the San Francisco Bay and portions of the Delta. The impacts of these compounds will be reviewed by an appropriate stakeholder group to determine whether these compounds should be added to the list of parameters of concern. If listed, a CALFED stakeholder team will be assembled to develop a list of actions CALFED might take to address these compounds. Appropriate environmental documentation will be prepared, as necessary.

Selenium. Selenium is naturally abundant in the marine sedimentary rocks and soils weathered from the rocks of the Coast Ranges west of the San Joaquin Valley. Mobilization and transport of selenium occurs during large runoff events or by land uses, such as road building, over-grazing, mining, and irrigated agriculture. Between 1986 and 1995, annual selenium loads in the San Joaquin River near Vernalis averaged 4,040 kg (8,906 pounds [lbs]), with a range of from 1,615 to 7,819 kg (from 3,558 to 17,238 lbs). Wastewater discharges from the refineries in the San Francisco Bay Area are another important source of selenium. Alpers and others from the USGS indicate that in 1991, the average riverine selenium loads that reached the San Francisco Bay Estuary was around 2 kg per day (730 kg per year), while refinery loads averaged 7.1 kg per day (2,592 kg per year) and municipal loads averaged 2.2 kg per day (803 kg per year). (Alpers et al. 1999a, 1999b.)

Trace Metals. Heavy metal loading in the watershed has been suspected as a possible source of aquatic toxicity throughout the Bay-Delta and its tributaries. The major sources of metals are abandoned mines, agriculture, and urban runoff. For example, data collected by Alpers et al. (1999a, 1999b) from USGS indicate copper loads from the Colusa Basin Drain were 39.7 lbs per day, based on sampling conducted in June 1997; whereas the loads from Iron Mountain in Spring Creek were about 26 lbs per day, based on measurements conducted in May 28, 1997. In May and September, DWR measured concentrations of 9 trace metals at 11 stations in the Bay-Delta and Suisun Bay from 1975 to 1993. Trace metals frequently exceeded the guidelines for marine and fresh-water toxicity. Trace metals (most frequently copper) exceeded the guidelines for fresh-water acute and chronic toxicity on 34 occasions. Marine acute and chronic toxicity guidelines were exceeded 181 times; copper accounted for 160 of these exceedances. In a USGS study conducted by Alpers et al., (1999a) to determine the role of Iron Mountain as a source of toxicity in the Sacramento River, lead-isotope data in suspended colloidal material and sediments were analyzed, indicating that the effects of Iron Mountain were relatively minor downstream of Red Bluff.

5.3.3.2 BAY REGION

Water quality in San Francisco Bay is affected by flows from the Delta, runoff from the surrounding urban areas, municipal and industrial wastewater discharges, and drainage from abandoned mines. Water quality monitoring has been conducted in the Bay by the San Francisco Estuary Institute as part of its Regional Monitoring Program (RMP), as well as by industrial and sanitary dischargers. The contaminants of concern identified by the RMP include diazinon and chlorpyrifos in water; DDT, chlordanes, polycyclic aromatic hydrocarbons (PAHs) in sediment; and PCBs, cadmium, mercury, selenium, PAHs, chlordanes, dieldrin, and DDTs in bivalve and fish tissue. Copper and nickel in the South Bay are currently the subject of a total maximum daily load (TMDL) evaluation. TMDLs identify the maximum amount of contaminant allowed in a water body that would not harm any beneficial uses of the water body. Selenium discharges from refineries and other sources in the Bay Area also are of concern. Dioxin discharges, especially from combustion sources, typify chemicals whose origin in part is atmospheric but may adversely affect water quality. Methyl tert-butyl ether (MTBE) has been found in a number of drinking water reservoirs in the Bay Area, which has prompted restrictions on certain types of water recreation.

5.3.3.3 SACRAMENTO RIVER REGION

Past mining practices, particularly hydraulic mining, have resulted in the discharge of huge quantities of sediment into major tributaries in gold-producing areas. Areas where mining operations were conducted continue to be a major source of toxic chemical loading to streams in some areas, including the Clear Creek watershed and local watersheds of the Sierra Nevada. Logging operations increased erosion and discharge of sediments into streams and rivers over widespread areas in upper watersheds of the Sierra Nevada and Cascade Ranges. Other water quality issues in the Sacramento River Region are similar to those described for the Delta Region.

In general, water quality in the Sacramento River is good, although the possible adverse effects associated with metals contamination from abandoned mercury and other hard-rock mining activities are of concern. Mercury is likely to be found in sediments and aquatic tissue rather than in the water column. In 1986, the CVRWQCB surveyed mercury contamination in fish and sediment in the Sacramento River watershed. The CVRWQCB detected elevated mercury levels in sediment in the Yuba and Bear Rivers and in Cache, Putah, and Stony Creeks. Recent sampling by the USGS National Water Quality Assessment (NAWQA) Program and reported by Domalgalski (1999) has confirmed the continued presence of elevated concentrations of mercury in the sediments of the Yuba River, Bear River, and Cache Creek, as well as in the sediments of other streams and rivers in the Sacramento River basin.

Data collected by researchers at UC Davis (Slotten et al. 1997) and as part of the Sacramento River Watershed Program Mercury Control Planning Project (Larry Walker and Associates 1997) also indicates that mercury in a bioavailable form is affecting the aquatic food chain. Survey results of bioavailable mercury throughout the northwestern Sierra Nevada (from the Feather River south to the Cosumnes River) found the most highly elevated mercury in the aquatic food webs of the South and Middle Forks of the Yuba River, the North Fork of the Cosumnes River, tributaries throughout the Bear River drainage, the mid-section of the Middle Fork of the Feather River, and Deer Creek.

Other metals, such as copper, cadmium, lead, and zinc, are of concern in the Sacramento River Region. The influence of metal-laden acidic drainage from the Iron Mountain Mine site (via Spring Creek and the Spring Creek arm of Keswick Reservoir) is apparent in water samples from the site below Keswick Dam, where occasional exceedances of water quality standards for copper have been noted. Sample analysis using very small filtrates (0.005-micrometer-equivalent pore size) indicated that much of the copper and, to a lesser extent, zinc were in the colloidal form. Available data from agricultural drain samples indicate that trace-metal loading from agricultural drainage may be significant during certain flow conditions.

5.3.3.4 SAN JOAQUIN RIVER REGION

Water quality conditions in the San Joaquin River Region are influenced by agricultural activities that are associated with irrigation and agricultural chemical applications. Selenium in the lower San Joaquin River comes primarily from subsurface agricultural drainage discharged from the Grasslands area on the west side of the San Joaquin Valley through Mud Slough. Selenium also is conveyed to the San Joaquin River in natural storm runoff during wet years, primarily from Panoche and Silver Creeks. Annual selenium loads in the San Joaquin River near Vernalis between 1986 and 1995 averaged 4,040 kg (8,906 lbs) per year. The riverine load seldom reaches the estuary, as flows are generally insufficient and south Delta diversions draw most of the San Joaquin River water from the Delta. A report by Alpers et al. (1999a, 1999b) indicated that in 1991, for example, the average San Joaquin River selenium load that reached the estuary was around 2 kg per day (730 kg), compared to an average load from Bay Area refineries of 7.1 kg per day (2,592 kg) and municipal loads that averaged 2.2 kg per day (803 kg).

Salt loading can lead to impairment of water quality in the lower San Joaquin River, in the south Delta, and at diversion facilities. Surface and subsurface agricultural drainage waters are the major source of salts in the San Joaquin River. The mean annual salt load exported out of the basin was approximately 770,000 tons per year from 1985 to 1994. Recirculation of salt from the Delta, via the DMC to the west side of the San Joaquin Valley and through accumulation of salts in the soils and shallow groundwater in the west side of the Valley, are the major sources of salts in the San Joaquin River. Data reported by Grober (1999) at the CVRWQCB indicate that concentrations in the San Joaquin River at Vernalis, expressed in terms of specific conductance (μmhos/centimeter [cm]) exceeded the 700-μmhos/cm 30-day running average objective for April through August in about 54% of the time from 1986 to 1997. These concentrations exceed desirable levels for agricultural irrigation and cause problems for south Delta farmers and for export water.

Low dissolved oxygen conditions occur in the Stockton reach of the San Joaquin River and in urban waterways around the City of Stockton. After storms, dissolved oxygen concentrations as low as 0.34 mg/L have been recorded in Smith Canal, Mosher Slough, 5-Mile Slough, and the Calaveras River. These conditions also occur during late summer and fall because of a combination of high water temperature, nutrients, algal blooms, and discharge. Effluent from the Stockton Regional Wastewater Control Facility is considered to be a relatively large source of oxygen-depleting substances, as is water from the Stockton Turning Basin. Although the data are not conclusive, other sources such as urban runoff, runoff from confined animal facilities, and sediment demand also may contribute significantly to lowering dissolved oxygen.

5.3.3.5 OTHER SWP AND CVP SERVICE AREAS

Two distinct, noncontiguous areas are included in the Other SWP and CVP Service Areas: in the north are the CVP's San Felipe Division and the SWP's South Bay service areas, and to the south are the other SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

The quality of water from the Delta delivered to the Other SWP and CVP Service Areas is of major concern, particularly with respect to salinity and drinking water quality. Salinity is an issue because excessive salinity may adversely affect crop yields and require more water for salt leaching, may require additional municipal and industrial treatment, may increase salinity levels in agricultural soils and groundwater, and is the primary water quality constraint to recycling wastewater. Also, according to a Salinity Management Study, conducted by The Metropolitan Water District of Southern California (MWD) (1997), alternative sources for MWD's service area generally have quite high levels of salinity. The TDS of Colorado River water averages about 700 mg/L, whereas the TDS average at the SWP terminal reservoirs is about 300 mg/L. The lack of alternate sources of low-salinity water reduces opportunities to stretch water supplies by blending.

Constituents that affect drinking water quality include bromide, natural organic matter, microbial pathogens, nutrients, TDS, hardness, alkalinity, pH, and turbidity. Of particular concern to water purveyors are anticipated drinking water regulations that may require reductions in the levels of DBPs that are formed during water treatment disinfection and oxidation while also implementing more stringent disinfection regulations. The problem of formation of brominated DBPs is specific to the Delta as a drinking water source. Brominated DBPs are formed by the reaction of bromide and TOC with the disinfectant chemicals used in water treatment. Brominated DBPs are of concern because of their link to miscarriages and cancer. Elevated levels of bromide (primarily from sea-water intrusion) and elevated levels of TOC that are associated in large part with Delta island drainage contribute to the formation of brominated DBPs. The Delta has higher average levels of bromide than 95% of the source waters in the rest of the country, making the water more difficult to treat.

5.3.4 ASSESSMENT METHODS

Qualitative and quantitative methods were used to assess the impacts of the Preferred Program Alternative and the Program alternatives on water quality. Primarily qualitative methods were used to determine water quality impacts from implementation of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs. Quantitative analysis is not possible because there is insufficient research to support reliable mathematical models of the effectiveness of individual Program actions on water quality parameters. Impacts on water quality associated with construction of facilities for surface and groundwater storage were assessed qualitatively. Impacts on water quality unrelated to facility construction that are associated with storage and conveyance were quantitatively assessed for each option under the alternatives based on monitoring results.

Quantitative methods were used to predict changes in the concentrations of constituents of concern from implementing the Storage and Conveyance elements. Specifically, the impacts of the Program alternatives on water quality were analyzed with DWR's Delta Simulation Models (DSM1 and DSM2).

The generation of modeling results, which help to predict impacts, evolved in response to decisions on the Preferred Program Alternative and Alternatives 1, 2, and 3. Since spring 1997, there have been several DSM2 model runs; and assumptions for these runs have not been uniform. The most recent DSM2 modeling, completed in July 1999, includes a set of modeling runs that predicts the ranges of impacts of each Program Alternative under a reasonable range of water management scenarios, referred to as "bookends." The set of assumptions for the bookends include a range of water demands and regulatory requirements. The assumed ranges also were included in the No Action Alternative. A more detailed description of the bookends is included in Sections 5.1.4.1 and 5.1.4.2. Modeling results in the impact analysis reflect the same modeling assumptions used in modeling for the Preferred Program Alternative. Refer to Attachment A for a description of modeling assumptions.

The initial study (dated March 1997) uses DWRDSM1 and simulates five alternatives, including Existing Delta Geometry, the Interim South Delta Program (ISDP), the North Delta Program, the North Delta Program with Hood Diversion, and California Urban Water Agency (CUWA) Alternative C Geometry. Similarly, the next study (dated August 1997) uses DWRDSM1 to simulate Program Alternatives 1A, 1C, 2B, 2D, and 3E. The January 1998 study uses DWRDSM2 to simulate Program Alternatives 1A, 1C, 2B, 3E, and 3X. Finally, the June 1998 study also uses DWRDSM2 to simulate Program Alternatives 1C, 2B, and 3X (DWR 1998). The difference between the January and June studies, however, is a variation in the DWRSIM studies that was incorporated into the simulations. Further descriptions of the Delta hydrology and operating assumptions for each alternative for each run are presented in each of the above-referenced documents.

In February 1998, Delta modeling studies were performed for the Diversion Effects on Fisheries Team (DEFT) and were completed using DWRDSM2. These modeling results were used to predict the performance of the Preferred Program Alternative for a range of assumptions that would affect water operations.

Delta modeling of flow, EC, and water levels in the south Delta were used to predict water quality impacts of the Program alternatives. Additionally, the simulations were used to describe Delta inflows and exports under various alternatives over an extended period of time.

During the past year, the Delta Modeling Section of DWR has been conducting EC-based water quality model runs for the Program. EC is a convenient water quality indicator because it is a good index for salinity. EC is easily measured in the field, and therefore provides good records for model calibration and verification. In evaluating the overall environmental consequences of alternatives, model predictions of mean annual EC values for a 16-year hydrologic sequence were used to compare the predicted long-term performance of each alternative against the No Action Alternative or existing conditions. In evaluating the performance of each alternative for "worst-case" conditions, model predictions of mean monthly EC during dry and critical years were used. However, the results of these runs may not predict the concentrations of other water quality constituents that are not directly related to salinity.

A different approach was introduced, called "fingerprinting," to help facilitate predictions of constituents other than salinity. The idea behind fingerprinting is to track the water coming from each source separately. It was assumed that six major sources of water enter the Delta: the Sacramento River, San Joaquin River, east side streams, Yolo Bypass, water from Martinez, and in-Delta agricultural drainage returns. Tracking these inflows to the Delta is called "source tracking." In addition, the water entering the Delta at different times is tracked separately, called "time tracking." For most model runs, the hydrology is assumed to change monthly; therefore, time tracking was performed in a monthly mode. For example, the water that enters the Delta in February is monitored separately from the water that enters the Delta in January. In the fingerprinting mode, DSM2 is simulating a total of 72 constituents (from 6 sources and for 12 months in the year). The results can be applied to any conservative constituent. A conservative water quality constituent is a relatively stable constituent that does not change chemical composition in an aquatic environment. The analysis was verified by comparing the results of the fingerprinting analyses with the EC modeling, using DWRDSM2.

The output from a fingerprinting run consists of 72 numbers at any given location and time. In essence, these numbers represent the "source blending ratios" that depend on location and time. Once these blending ratios are known, they can be applied to any conservative water quality constituent, provided the concentration for that constituent is known for all the sources of water in the Delta at all times.

While the output from the fingerprinting run can be used on various conservative constituents, only bromide has been analyzed using this data. All bromide values presented in this chapter are approximations based on EC modeling and fingerprinting models.

To verify this approach, the Delta Modeling Section applied the fingerprinting approach to predict EC concentrations and compared their results to actual EC predictions by DSM2 in standard water quality runs. The results are quite consistent. While the output from the fingerprinting can be used on various conservative constituents, only bromide has been analyzed using fingerprint data. All bromide values presented in this chapter are approximations based on EC modeling and fingerprinting models.

The modeling effort is a valuable tool developed to predict the effects of the proposed storage and conveyance facilities. Models are subject to continued refinement and improvement, and cannot provide all of the information needed to analyze the impacts of the Program alternatives. A more complete description of modeling assessment methods is given in Attachment A. Where the modeling results are incomplete or not applicable, impacts were estimated based on other available information and professional judgement.

Impacts on water quality from in-Delta storage were assessed qualitatively in the absence of specific information on project formulation. The impacts will be evaluated in greater detail in future project-specific analyses, if in-Delta storage is pursued as a component of the CALFED Program.

5.3.5 SIGNIFICANCE CRITERIA

The significance of both adverse and beneficial effects on water quality was assessed based on modeling studies described above and in Attachment A and on programmatic analyses. Impacts on water quality are considered potentially significant if implementing the Preferred Program Alternative has the potential to result in any of the following conditions:

- Beneficial uses of the water are adversely affected.
- Existing regulatory standards are exceeded.
- An undesirable effect on public health or environmental receptors is produced.

Program effects are considered beneficial if implementing the Preferred Program Alternative would result in the reverse of one or more conditions listed above. Given that model predictions are subject to error, potentially significant water quality changes are defined as those that exceed the probable uncertainty in the modeling results. Predicted effects that fell within the probable uncertainty in the modeling results could not be interpreted and were considered less than significant. The uncertainty in the modeling results is estimated at approximately ±10%.

5.3.6 NO ACTION ALTERNATIVE

By 2020, statewide water use is projected to increase from 79.49 MAF (based on 1995 demands) to 80.50 MAF during near-normal years, and from 64.79 to 65.96 MAF during drought years. Although water use is projected to decrease slightly in agricultural regions, reductions in alternative supplies and proportionately larger increases in urban area demands would result in increased overall demands for Delta exports. As a result, total annual demands for Delta exports could increase from the current range of 5.9-6.9 MAF, to a range of 7.1-7.6 MAF in 2020, depending on the annual hydrology.

The No Action Alternative supplements the existing conditions with some reoperation of system facilities to accommodate changes in flow timing resulting from 2020 demands.

Under the No Action Alternative, future SWP and CVP operations, and resultant controlled flow conditions in the Bay-Delta system and its tributaries are assumed to be managed essentially as they are today, with one exception. Increased Delta export demands are projected to be satisfied largely by increased south Delta pumping during August through March in near-normal and wet years, and December through February in dry and critical years.

The following elements of the No Action Alternative are particularly pertinent to water quality:

- Water storage and conveyance facilities currently under construction would be completed. These facilities include the Diamond Valley Reservoir and Inland Feeder; interim reoperation of Folsom Reservoir; levee restoration along selected reaches of the Sacramento River, its tributaries, and flood bypasses; and Stone Lakes NWR.

- Wastewater and water treatment facilities would be expanded by local agencies to meet the needs of growing populations.

- Treatment levels would remain at current levels, increase if source water becomes more degraded, or improve in response to new regulations.

Other operations and factors that would affect Bay-Delta channel and export water quality conditions include hydrologic and environmental conditions in the watersheds, population and land use, the quality of point and nonpoint source discharges, upstream reservoir releases and diversions, Delta outflows and sea-water intrusion, the provisions of the CVPIA and Bay-Delta Accord, and compliance with the State and Regional Water Quality Control Boards' Basin Plans and the State Board and Delta Water Quality Control Plan standards. Future changes in the Bay-Delta Accord, flow requirements, water quality standards, and water rights decisions could impose additional regulatory controls over SWP and CVP operations and Delta inflows controlled by upstream users. Changes in such regulatory controls could result in proportionately larger effects on water quality during dry and critically dry water-year types.

Tables 5.3.3a and 5.3.3b show predicted changes in salinity that would occur in the Delta under the No Action Alternative compared to existing conditions. Table 5.3.3a shows average changes over a long period that includes a full range of hydrologic conditions (wet, normal, dry, and critically dry years). Table 5.3.3b shows changes only for dry and critically dry years. Positive values in the tables indicate an increase in salinity relative to the existing condition; negative values indicate a decrease.

Separate predictions are shown for Water Management Criteria A and B. For each criterion, changes are shown for average monthly values and for the month during which the highest salinity concentrations are predicted to occur.

Tables 5.3-3a and 5.3-3b indicate that the No Action Alternative is projected to result in less-than-significant changes throughout the Delta Region when compared to modeled existing conditions. For example, during the long-term hydrologic sequence at CCFB, the annual average salinity is projected to increase by 10-40 μmhos/cm (2-8%), and the mean monthly salinity for December is projected to increase by about 40-70 μmhos/cm (4-8%). (A change between ±10% is considered within the margin of error of

Table 5.3-3a. Predicted Salinity Changes Between the No Action Alternative and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT[†] ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	Jan	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	-10	0	0	0	-4%	0%	0%	0%	Mar	LTS
Mokelumne River at Terminous	8	0	0	0	0	0%	0%	0%	0%	Jan	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	30	40	0	20	7%	6%	0%	3%	Nov	LTS
Turner Cut	29	40	40	0	0	9%	6%	0%	0%	Jan	LTS
San Joaquin River at Prisoner's Point	12	20	70	10	60	4%	8%	2%	7%	Dec	LTS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	0	-10	-10	-2%	0%	-2%	-1%	Dec	LTS
San Joaquin River at Brandt Bridge	10	-10	-30	0	-10	-2%	-4%	0%	-1%	Dec	LTS
Middle River at Tracy Road	21	40	40	10	20	8%	5%	2%	3%	Jan	LTS
Grant Line Canal at Tracy Road	24	-10	0	-10	0	-2%	0%	-2%	0%	Dec	LTS
Old River at Tracy Road	17	-10	-10	-10	0	-2%	-1%	-2%	0%	Dec	LTS
Old River at Rock Slough	19	30	90	20	60	5%	8%	4%	5%	Dec	LTS
Contra Costa Canal Intake at Rock Slough	28*	40	90	20	60	6%	8%	3%	5%	Dec	LTS
Old River at SR 4 (and New CCWD Intake)	18*	40	80	10	60	7%	8%	2%	6%	Dec	LTS
Clifton Court Forebay	27*	40	70	10	40	8%	8%	2%	4%	Dec	LTS
Delta-Mendota Canal Intake from Old River	26*	30	50	0	30	5%	6%	0%	3%	Dec	LTS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	10	40	20	60	1%	2%	2%	3%	Sep	LTS
Sacramento River at Collinsville	4	0	130	70	90	0%	2%	2%	2%	Sep	LTS
San Joaquin River at Jersey Point	14	30	150	40	80	3%	7%	4%	4%	Nov	LTS
San Joaquin River at Antioch	15	0	200	70	170	0%	4%	3%	4%	Oct	LTS
Suisun Bay at Port Chicago	5	-100	260	180	130	-1%	1%	2%	1%	Sep	LTS
Carquinez Strait at Martinez	6	-120	240	210	130	-1%	1%	1%	1%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.
[†] LTS - *All impacts within* ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >-10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-3b. Predicted Salinity Changes Between the No Action Alternative and Existing Conditions for Dry and Critical Years (Salinity Expressed as EC)

DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		MONTH OF MAXIMUM EC	IMPACT[†] ASSESSMENT
		AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)		
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	Jan	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	-10	-10	-10	-10	-5%	-4%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	0	0	0	0	0%	0%	0%	0%	Jan	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	40	40	0	10	9%	5%	0%	1%	Dec	LTS
Turner Cut	29	50	50	0	-20	10%	7%	0%	-3%	Jan	LTS
San Joaquin River at Prisoner's Point	12	20	70	10	30	4%	6%	2%	3%	Dec	LTS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	-20	-10	-30	-1%	-2%	-1%	-3%	Feb	LTS
San Joaquin River at Brandt Bridge	10	-10	-20	0	-20	-1%	-2%	0%	-2%	Feb	LTS
Middle River at Tracy Road	21	50	50	0	0	9%	5%	0%	0%	Jan	LTS
Grant Line Canal at Tracy Road	24	-10	-20	-10	-20	-1%	-2%	-1%	-2%	Feb	LTS
Old River at Tracy Road	17	-10	-20	0	-20	-1%	-2%	0%	-2%	Feb	LTS
Old River at Rock Slough	19	30	90	10	30	4%	7%	1%	2%	Dec	LTS
Contra Costa Canal Intake at Rock Slough	28*	40	90	10	30	6%	7%	1%	2%	Dec	LTS
Old River at SR 4 (and New CCWD Intake)	18*	50	80	10	30	8%	7%	2%	2%	Dec	LTS
Clifton Court Forebay	27*	60	70	0	10	10%	6%	0%	1%	Dec	LTS
Delta-Mendota Canal Intake from Old River	26*	40	50	0	10	6%	5%	0%	1%	Dec	LTS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	-10	-20	20	20	-1%	-1%	2%	1%	Sep	LTS
Sacramento River at Collinsville	4	-60	-20	60	20	-2%	0%	2%	0%	Sep	LTS
San Joaquin River at Jersey Point	14	10	150	30	90	1%	6%	2%	3%	Dec	LTS
San Joaquin River at Antioch	15	-60	30	50	-10	-2%	1%	2%	0%	Sep	LTS
Suisun Bay at Port Chicago	5	-210	0	190	0	-1%	0%	1%	0%	Sep	LTS
Carquinez Strait at Martinez	6	-230	0	210	-10	-1%	0%	1%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

[†] LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.

µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

the model analysis and is defined as less than significant.) During dry and critical years, Table 5.3-3b shows that these ranges increase by 0-60 μmhos/cm (0-10%) for the annual average and by 10-70 μmhos/cm (1-6%) on average for December.

Water quality for other constituents (other than salinity that is addressed above) would change under the No Action Alternative in response to the effects of population and land use changes, increased export demand, and the effects of future regulatory controls. According to modeling conducted by DWR (1998 DSM model run) the predicted frequency distribution of bromide at the Contra Costa Canal Intake on Rock Slough has a median concentration of about 250 ug/L under existing conditions, which would increase to about 300 ug/L under the No Action Alternative. At CCFB, the modeling indicated a median bromide concentration of 150 ug/L under existing conditions and about 200 ug/L under the No Action Alternative. These changes are primarily the result of increased export demand and associated increased salinity intrusion into the Delta.

Organic carbon concentration in the Delta is assumed to remain essentially unchanged under the No Action Alternative. According to MWD estimates, the median organic carbon concentration at the Harvey O. Banks Pumping Plant would be about 3.2 mg/L, and the 90th percentile concentration would be about 3.8 mg/L (see Section 3.7.2 in the Water Quality Program Plan). Under existing conditions, the mean concentration of DOC at the Banks Pumping Plant is about 3.7 mg/L (Table 5.3-2).

Project levee maintenance is assumed to continue in accordance with current requirements and practices, but no major rehabilitation efforts would be undertaken. Despite maintenance actions, levees could continue to deteriorate, increasing the risk of their failure due to seismic events, erosion, and overtopping. Such levee failures could threaten water quality at the CVP and SWP pumps, and at other water supply intake locations. The severity and extent of any degradation caused by the potential influx of ocean salinity (including bromide), TOC, soils, and sediment, and by the potential release of a variety of chemicals and wastes used or stored in areas protected by levees would depend on many factors. These factors include the season, hydrology, available reservoir storage, location of the breaks and storage, and extent of any flooding. In the worst case (foreseeable only in the event of a series of earthquake-induced west Delta levee failures that occurred during summer to late fall or during drought periods), water could become temporarily unusable for municipal and agricultural supplies for extended periods until the contaminants could be flushed from the system. The resultant pooling of ocean salts, including bromide, in the Delta would cause potentially significant adverse impacts on water users and could cause a prolonged interruption of supply from the state's predominant water source.

The growing imbalance between Delta-dependent water demands and the available supplies of good-quality water could be exacerbated in some regions. This could occur in the service areas if providers were required to replace good-quality Delta water with poorer quality water obtained from less desirable alternative sources. Regardless of the source of the degradation, resultant water quality impacts also could produce potentially significant adverse impacts on dependent water treatment costs, economic productivity, fish and wildlife habitats, public health, and social well-being.

5.3.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For water quality, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Program elements are similar under all Program alternatives, as described below. This section also discusses the environmental consequences of the Storage and Conveyance elements that are common to all alternatives—those related to construction. The environmental consequences of actions in the Storage and Conveyance elements that are not related to construction of facilities vary among Program alternatives, as described in Section 5.3.8.

The discussions below relate to all Program regions.

5.3.7.1 ECOSYSTEM RESTORATION PROGRAM

The Ecosystem Restoration Program involves expanding floodplains and creating wetland habitat in the Bay-Delta system, and altering the management of storage reservoirs to provide more water for environmental purposes. The program would result in both short- and long-term effects on water quality. The short-term effects would occur during and in the years immediately following construction.

Construction activities necessary to implement the Ecosystem Restoration Program include breaching and demolishing existing levees, and constructing new setback levees. Most of the construction activities would occur in dry conditions, but some construction in waterways would be necessary. Total suspended solids (TSS) is the primary contaminant of concern that would be affected by construction activities. Quantities of soil would be released into the water column during in-water construction, and flowing water would dislodge soil particles from new levees and wetlands during the initial water-soil contact period. Soil particles would increase the TSS content of Delta waters in the vicinity of construction activities. Nutrients and organic matter also are likely to be released during construction. Because some of the older levees may have been built with dredge spoils when environmental regulations were less stringent, there is a possibility that toxic substances could be released during their demolition. Before construction occurs, soils will be tested to determine potentially toxic substances. Such substances may be avoided or mitigated, depending on the type and concentration. In some cases, core sampling and testing will lead to engineered solutions to prevent toxic material exposure to the environment. If toxic sediments are to be exposed, an engineered cap could be placed that would prevent environmental exposure of that material. Impacts of the Ecosystem Restoration Program that are associated with construction can be reduced to a less-than-significant level.

The Ecosystem Restoration Program may participate in the removal of structures that contribute to blockages of fish migration (most typically dams). Various types of dams typically have captured sediment behind the dam that could be released if a dam were removed. Sediments captured behind dams may contain toxic compounds (such as mercury), which could cause adverse impacts if released to the environment. Prior to a sediment release, the sediment will be characterized and a mitigation plan will be designed to prevent or reduce the release of toxic material to levels that pose no environmental hazard. The mitigation plan may include avoidance of the project or modification of the project to eliminate the need to remove sediment. Disposal of contaminated sediment will be in compliance with all applicable solid waste disposal regulations.

The long-term effects of the Ecosystem Restoration Program include both beneficial and adverse changes in water quality. Expanding the floodplains and wetland areas in the Delta, in the northern portions of the Bay Region, and along the Sacramento and San Joaquin Rivers and their tributaries would restore some of the natural self-purification capacity of the waterways. Some contaminants are removed by various physical, chemical, and biological processes as river water flows through vegetated areas. The increased acreage of wetlands under the Ecosystem Restoration Program would increase the opportunity for these processes to occur. Also, much of the land that would be converted to wetlands or floodplain now is used for irrigated agriculture. Conversion of irrigated cropland or pasture to wetlands would reduce the discharge of nutrients and other agricultural chemicals into waterways, which also would benefit water quality in the Bay-Delta system.

Replacing irrigated cropland with wetlands could result in a net increase in water salinity because evaporation would increase. However, the conversion from irrigated crops to wetlands, also could reduce salinity due to the reduction or elimination of applied salts through fertilizer application. The concentration of TOC in river water also may change, but it is unknown whether concentrations would be increased or decreased. Wetlands have a demonstrated capacity to generate organic carbon. Inundation of soils could cause changes in the degree to which the organic content of organic (peat) soils is mobilized into Delta waters. Some theorize that the change from cropland to wetlands would extend the period in which water is in contact with peat soils, thus increasing TOC concentrations. Others theorize that opportunities for contact with peat soils would be reduced because sediment would be deposited in the wetlands, separating river water from direct contact with the underlying peat soils. Some studies currently are being conducted to evaluate how TOC is assimilated in the environment through microorganisms. Additional studies are needed to establish the relationship between management of riverside lands and TOC concentrations in river water.

If the Ecosystem Restoration Program causes a reduction in TOC concentrations, biological productivity in the Delta could be adversely affected—if carbon is the limiting ecological factor. The reduction in TOC concentration would improve the suitability of Delta waters as a drinking water source. If TOC concentration is increased by the Ecosystem Restoration Program, then biological productivity may be increased and the suitability of water for drinking water supply may be decreased. Until specific project plans are formulated, it is not possible to answer all questions concerning mitigation strategies for potential adverse changes in TOC. Mitigation strategies for TOC could include flooding and draining seasonal wetlands in a manner that does not contribute to TOC at the diversion facilities. Mitigation also could include providing treatment systems for discharges from constructed wetlands during certain periods of the year. Notwithstanding, CALFED is committed to adequate investigation of potential negative impacts of ecosystem restoration measures and to full mitigation of any such impacts as a condition of project implementation.

Creating shallow-water habitat in areas that would receive mercury from surface water sources has the potential to increase methyl mercury levels in the ecosystem. Mitigation would include avoiding the creation of shallow-water habitat in areas where mercury is apt to accumulate, or mercury-laden water and sediment, until potential impacts associated with mercury in water or sediment can be reduced to a less-than-significant level.

Under the Ecosystem Restoration Program, flow regimes in the Sacramento and San Joaquin Rivers, their tributaries, and the Delta would be established that emulate natural seasonal flows. These large flows would be allowed to pass through the Delta and on to San Francisco Bay. Their long-term effects would include lowering water salinity and temperature, and increasing dissolved oxygen concentrations in Delta waterways at certain times of the year. These effects would benefit water quality for ecosystem restoration.

5.3.7.2 WATER QUALITY PROGRAM

The Water Quality Program calls for a range of actions that would reduce the discharge to waterways of contaminants in municipal and industrial wastewater, urban and agricultural runoff, and drainage from abandoned mines. Water supply intakes would be relocated to areas with better water quality. Research and monitoring programs would be undertaken to improve understanding of the significance of various contaminants in water and the effectiveness of remedial actions. The actions are described in detail in the Water Quality Program Plan.

The long-term effect of the Water Quality Program would be to reduce the mass of some contaminants (for example, metals, pesticides, TSS, and nutrients) entering San Francisco Bay, the Sacramento-San Joaquin Delta, the Sacramento and San Joaquin Rivers, and other Bay-Delta tributaries—relative to the No Action Alternative. This reduction would, in turn, improve water quality in the Bay-Delta system relative to the No Action Alternative. The reduction cannot be quantitatively estimated because the effectiveness of many of the actions in the Water Quality Program is unknown.

It should be noted that—because urban development is expected to proceed rapidly in the Sacramento and San Joaquin Valleys between now and 2020—the reductions in discharge of some contaminants attributable to the Water Quality Program may be offset by increases attributable to urbanization. For example, the reduction in discharged metals attributable to those elements of the Water Quality Program that address discharges from abandoned mines likely would be offset by an increase in the discharge of metals in urban runoff.

A specific action addresses reducing the discharge of oxygen-demanding substances in the vicinity of the City of Stockton. As a result, this action would improve the dissolved oxygen content of waters in the southeast Delta. Another action addresses reducing the discharge of selenium from oil refineries, which would reduce selenium concentrations in the waters of San Francisco Bay.

Drinking water actions would benefit municipal water supply customers in the Central Valley and in the Other SWP and CVP Service Areas who obtain their water supplies from the Delta and its tributaries. Municipal and agricultural users of Delta water also would benefit from the water quality actions to relocate water supply intakes to areas with better water quality. The Water Quality Program would not result in any long-term adverse environmental impacts.

Some actions in the Water Quality Program involve construction (for example, increased treatment of municipal and industrial wastewater and urban runoff, and agricultural irrigation system improvements). Construction activities would occur in the Bay, Delta, Sacramento River, and San Joaquin River Regions. It is expected that the adverse impacts of construction on water quality, primarily the discharge of soil particles and consequent increase of TSS concentrations and the associated release of toxicants in the vicinity of construction sites, could be reduced to a less-than-significant level by the application of appropriate mitigation measures.

5.3.7.3 LEVEE SYSTEM INTEGRITY PROGRAM

The Levee System Integrity Program involves extensive construction to raise and strengthen levees in the Delta. The program would result in short-term adverse effects on water quality in the Delta. The program would result in long-term beneficial effects on water quality in the Delta and on the quality of water supplied to municipal and agricultural water users in the Central Valley and in the Other SWP and CVP Service Areas.

Waterside construction activities for the Levee System Integrity Program would result in short-term effects on water quality similar to the levee modifications components of the Ecosystem Restoration Program, except that they would occur only in the Delta. Local increases in the TSS content of waters in Delta channels are expected. Some increase in nutrient and TOC concentrations also may occur. It is expected that short-term construction impacts can be reduced to a less-than-significant level.

Toxic substances contained in old levees or in channel sediments could be released during waterside levee work or dredging. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. These mitigation strategies can reduce potentially significant impacts to a less-than-significant level.

If sediments for the purpose of levee system construction were obtained from non-local sources, such as the Bay, careful consideration would be taken to ensure that no adverse effects on water quality or natural resources would result. For example, Bay sediments may contain elevated levels of salts that would prevent their use without conducting additional monitoring and/or incorporating salinity control strategies.

If the levees are not improved, the risk of failure during earthquakes and floods or as a result of gradual structural deterioration is considerable. A catastrophic levee failure could cause saline waters from the Bay to penetrate deep into the Delta. This would be most pronounced in dry or critically dry years when the fresh-water flow from the Central Valley is insufficient to repel saline waters. Intrusion of sea water would result in a potentially significant adverse impact on beneficial uses of Delta waters, including municipal and agricultural water supply and possibly the protection of aquatic life. Water customers in the Central Valley and in the Other SWP and CVP Service Areas could be deprived of water from the Delta for months or years. The Levee System Integrity Program would reduce the risk of catastrophic levee failure and consequently the risk of a sudden deterioration in water quality. The Levee System Integrity Program would not result in any long-term adverse effects on water quality.

5.3.7.4 WATER USE EFFICIENCY PROGRAM

A number of measures in the Water Use Efficiency Program provide incentives for water conservation and reduce institutional barriers to water recycling. Because little construction would be involved, short-term adverse environmental impacts are considered less than significant.

The primary long-term effect of the Water Use Efficiency Program would be reducing the amount of water needed to support a given level of population and economic activity in California. Because diverting water from streams for human use generally results in adverse impacts on water quality (such as increased temperature and less dilution of contaminants), an increase in water use efficiency would result in an overall benefit to water quality. However, the beneficial effect would not be distributed evenly across all surface waters and may be partially offset by adverse impacts. Increased water use efficiency would adversely affect water quality when the volume of municipal wastewater or agricultural tailwater discharged to a stream is reduced but the mass load of salts and other contaminants in the discharge remains the same. This effect would be most pronounced in streams where municipal or agricultural discharges represent a substantial proportion of streamflow. However, since the Water Use Efficiency Program also is focusing on achieving benefits related to water quality and flow timing, it is expected that many of these potentially significant adverse effects would be avoided or offset by other water quality improvements.

The water quality benefits of the Water Use Efficiency Program primarily would occur in the Bay and Delta Regions, and in river reaches in the Central Valley downstream of municipal and agricultural water supply intakes. The quality of water diverted from the Delta could be improved, which could benefit municipal and agricultural water users in the Central Valley and in the Other SWP and CVP Service Areas. Any adverse effects of the Water Use Efficiency Program would occur most acutely in small streams in the Sacramento River and San Joaquin River Regions, downstream of municipal and agricultural wastewater discharges. In most cases, it is expected that the localized adverse water quality impacts of the Water Use Efficiency Program can be mitigated to a less-than-significant level by increasing treatment of wastewater before it is discharged to waterways, increasing fresh-water releases from reservoirs to provide more dilution water, or altering the timing of agricultural return flows to coincide with periods when receiving water bodies have greater assimilative capacity. Water use efficiency measures would not be applied in areas where adverse impacts, as determined by site-specific review, on water quality are significant and mitigation measures are impractical.

5.3.7.5 WATER TRANSFER PROGRAM

The Water Transfer Program proposes a framework of actions, policies, and processes that, collectively, would facilitate water transfers and further development of a statewide water transfers market. This could result in the transfer of water from areas of abundance to areas of scarcity. The program does not include specific water transfer proposals. These would occur between willing sellers and willing buyers as they do now. Little construction would be involved; consequently, short-term adverse impacts are considered less than significant.

Unlike the Water Use Efficiency Program, the Water Transfer Program would not reduce the total amount of water needed to support a given level of population and economic activity. Rather, it would temporarily or permanently reallocate water supplies among various users, including the environment.

Water transfers could affect water quality primarily through changes to river flow and water temperatures. In addition, the source of water for a transfer and the timing, magnitude, and pathway of each transfer would affect the potential for significant impacts. Beneficial water quality impacts are a function of the ability of a transfer to decrease the concentration of various contaminants through both increased streamflow and the potential for obtaining higher quality water from several sources. Because specific transfers can invoke both beneficial and adverse impacts, at times on the same resource, net effects must be considered on a case-by-case basis. Mitigation strategies described in Section 5.3.11 for water quality and in Section 5.4.11 for groundwater are expected to reduce any potentially significant adverse impacts on water quality to a less-than-significant level.

The Water Transfer Program could benefit the Other SWP and CVP Service Areas when water of higher quality than local sources is imported into the region through a water transfer. For example, water transferred into southern California from the Central Valley can be of better quality than existing sources imported from the Colorado River.

5.3.7.6 WATERSHED PROGRAM

The Watershed Program would provide technical and financial assistance to local watershed programs. It would support projects, including ecological restoration projects, that would reduce the discharge of contaminants from nonpoint sources to waterways. The contaminant most likely to be affected is TSS, but some reduction in the discharge of nutrients, pesticides, and pathogenic microorganisms also may occur. Because most of the nonpoint source control measures are likely to be nonstructural, little construction is expected. Consequently, short-term adverse impacts of the program on water quality are expected to be less than significant.

Long-term impacts of the Watershed Program on water quality are expected to be exclusively beneficial. By reducing the mass of pollutants reaching the Delta from tributary streams, the program would improve in-stream water quality and the quality of water diverted for municipal and agricultural use. In-stream water quality would be improved in the Sacramento River and San Joaquin River Regions, and the reduced contaminant load in Delta outflow would benefit the Bay Region. Improvements in the quality of water diverted from the Delta would benefit municipal and agricultural uses in the Central Valley and in the Other SWP and CVP Service Areas.

5.3.7.7 IMPACTS RELATED TO CONSTRUCTION FOR STORAGE AND CONVEYANCE ELEMENTS

The Program alternatives may include new storage projects. Water storage may occur in surface or groundwater reservoirs. The storage projects would result in short-term and long-term effects on water quality. The short-term effects on water quality from construction of surface water reservoirs primarily would result from ground disturbance and consequent increased soil erosion rates. Excess sediment could be discharged to streams or the Delta, depending on the location of proposed storage, from construction activities being performed in streams and from precipitation falling on exposed soils.

Groundwater storage projects could use injection wells or spreading basins to convey water to underground storage. Because construction of injection wells would involve little ground disturbance or increased soil erosion, minor adverse effects on water quality are expected.

Short-term impacts on water quality from surface water reservoir construction and related facilities would affect the Delta, Sacramento River, and San Joaquin River Regions. Short-term adverse effects on water quality from groundwater storage construction would affect the Sacramento River and San Joaquin River Regions. Mitigation is available to reduce all potentially significant impacts to a less-than-significant level.

Storing water in surface reservoirs may affect water quality in a number of ways. The reservoir pool would inundate previously dry lands. Depending on geologic characteristics, trace elements may be mobilized, particularly in the deeper parts of the reservoirs where dissolved oxygen concentrations may become depressed. Mercury compounds are present in rocks and sediment in the water column in some parts of the Sacramento Valley. Under certain conditions, these compounds may be converted into biologically available methyl mercury. Reservoirs in California generally experience algal blooms in the first years of operation due to mobilization of nutrients. Periodic blooms can continue indefinitely. Storing water in reservoirs on Delta islands could increase TOC production from the peat soils in the Delta. Uncertainties concerning how much TOC and what DBPs would be produced have not been resolved. Resolution of uncertainties depends on project-specific parameters that would affect the project results. CALFED has funded a study to address a portion of these uncertainties and likely will fund subsequent studies as uncertainties are better defined. Storing water within the Delta would allow more flexibility than south-of-Delta storage, with similar water quality effects (in terms of salinity) on the Bay and Delta.

Typically, surface water reservoirs would be used to store abundant spring flows for later release and use in dry months or years. Off-stream reservoirs would alter the hydrology of the intermittent or small perennial streams on which they are built. Spring flows would be reduced or eliminated compared to unimpaired flows, and flow in naturally dry periods would be increased. Because reservoirs trap sediment, the TSS content of water released into the downstream channel would be less than the TSS content of stream water prior to reservoir construction. The reduction in TSS content would be greatest during high-flow conditions. Nutrients and organic matter in particulate form also would be trapped in the reservoir, and their concentrations in stream water below the reservoir would be reduced. Depending on the design of the reservoir outlet, the dissolved oxygen content of released water could be less than that of the stream to which it is discharged, resulting in lowered oxygen in the stream. Conversely, when the reservoir is spilling, water may become supersaturated with oxygen and nitrogen.

During periods of low unimpaired streamflow, releasing water from reservoirs could substantially reduce water temperatures in the downstream river reaches. Water released from reservoirs initially would be cooler than unimpaired stream waters and would remain cooler due to the increased flow volume.

Groundwater storage would be used conjunctively with surface waters to meet various needs and demands for water. During periods of high streamflow, groundwater aquifers with available space would be artificially recharged with surface water, using spreading basins or injection wells. Water would be pumped from the aquifers to meet municipal and agricultural water demand when surface water supplies are limited. Pumped water may be used directly or returned to surface streams for diversion at a downstream location.

The quality of water diverted from surface streams, temporarily stored in the ground, and then withdrawn for use would be altered. Water pumped from the ground would contain less suspended solids, more dissolved solids, and generally higher nitrates than the source water. If the water is used directly by municipalities or for agricultural use, its suitability for use would be reduced somewhat by its increased mineral concentrations. If the water is pumped into a surface stream during low-flow periods, it would result in similar effects to those described for releasing water from surface reservoirs, with the possible addition of increased biological productivity due to the presence of nitrate.

The diversion of water into storage from the Sacramento River, San Joaquin River, or other large streams tributary to the Delta during high-flow periods would reduce the magnitude and duration of high flows. Although the effects of the diversions on in-stream water quality in the rivers and in the Delta would be minor, they could be of greater consequence to San Francisco Bay. Periodic high flows from the Delta profoundly affect salinity concentrations in the Bay and may play an important role in initiating water circulation in the South Bay. Increased diversion of water from the Delta for transfer to storage reservoirs via the California Aqueduct or the DMC could reduce Delta outflow and adversely affect water quality in San Francisco Bay.

Release of water down the Sacramento River, the San Joaquin River, or other major streams during low-flow periods would improve water quality in the rivers and in the Delta. Contaminants discharged by cities, industries, and agriculture would be diluted; and in-stream contaminant concentrations would be reduced in the rivers and in the Delta. Improved water quality in the Delta would benefit municipal and agricultural water users in the Delta, Central Valley, and the Other SWP and CVP Service Areas.

In-Delta storage may not benefit water quality within the Delta, depending on how water is conveyed to export facilities. Piping stored water to export facilities would bypass introduction of the water into the Delta, leaving more water coming from Delta tributaries to flow through the Delta. In-Delta storage would result in similar salinity effects on San Francisco Bay as other surface storage options.

All of the long-term adverse effects of surface and groundwater storage on water quality can be reduced to a less-than-significant level by various mitigation measures.

5.3.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

The generation of modeling results, to assist in predicting impacts, evolved in response to decisions on the Preferred Program Alternative and Alternatives 1, 2, and 3. Since spring 1997, there have been several DSM2 model runs, and assumptions for these runs have not been uniform. Recent modeling work includes the generation of a set of modeling runs that predict the ranges of impacts of each Program Alternative under a reasonable range of water management scenarios, referred to as bookends. The set of assumptions for the bookends include a range of water demands and regulatory requirements. The assumed ranges also were included in the No Action Alternative. A more detailed description of the bookends are in Sections 5.1.4.1 and 5.1.4.2 of Chapter 5.1. These results, although available and incorporated in this analysis, are considered preliminary.

For water quality, the Storage and Conveyance element actions that are not related to construction are integrated and result in environmental consequences that differ among the alternatives, as described below.

The salinity (expressed as EC) for each of these alternatives depends on other factors in addition to the factors associated with storage and water use scenarios. Other factors include local diversions within the Delta, local discharges, operable barrier placement and operation, and local water circulation patterns that are more finite than modeling detail can produce. The Preferred Program Alternative is modeled with barriers in place and with a diversion from the Sacramento River to the Lower Mokelumne River. If the diversion facility is not constructed, the EC modeling results would be similar to those presented under Alternative 1.

5.3.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

Delta Region

The Preferred Program Alternative is a phased process that does not approve the construction of the diversion facility from the Sacramento River unless certain criteria are met. The Preferred Program Alternative would function similarly to Alternative 1 if a diversion facility is not constructed. The remainder of this section, including tables and graphs describing the Preferred Program Alternative, assumes that a diversion facility is in place.

The four primary sources that transport contaminants into the Delta are San Francisco Bay, the Sacramento and San Joaquin Rivers, and waste discharges into the system. Other primary variables include high-quality inflows from tributaries, especially the Sacramento River and east side streams, and the timing and distribution of their flows throughout the Delta. The capacity of conveyance features and new storage facility capacities and locations (if any) will greatly influence the overall and localized water quality effects of the Preferred Program Alternative (and the other Program alternatives evaluated) on constituent sources and their circulation within the Delta, the Central Valley, and areas of use. The locations of key water quality simulation stations and the Delta subregions that they represent which are used to gauge the water quality effects of primary concern are shown in Figure 5.3-1. The subregions were delineated on the basis of common hydrodynamic and water quality characteristics that help to determine the water quality impacts of the Program alternatives.

Water quality conditions in the Delta would be best where and when good-quality water, primarily from the Sacramento River, flows in optimal patterns across the Delta to discharge to Suisun Bay and to the diversion pumps. During this process, whether the flows are natural or induced, they would continue to intermix with, dilute, and flush poorer quality water from the San Joaquin River and other channels containing constituents from point and nonpoint waste discharges. It is believed that to prevent increases

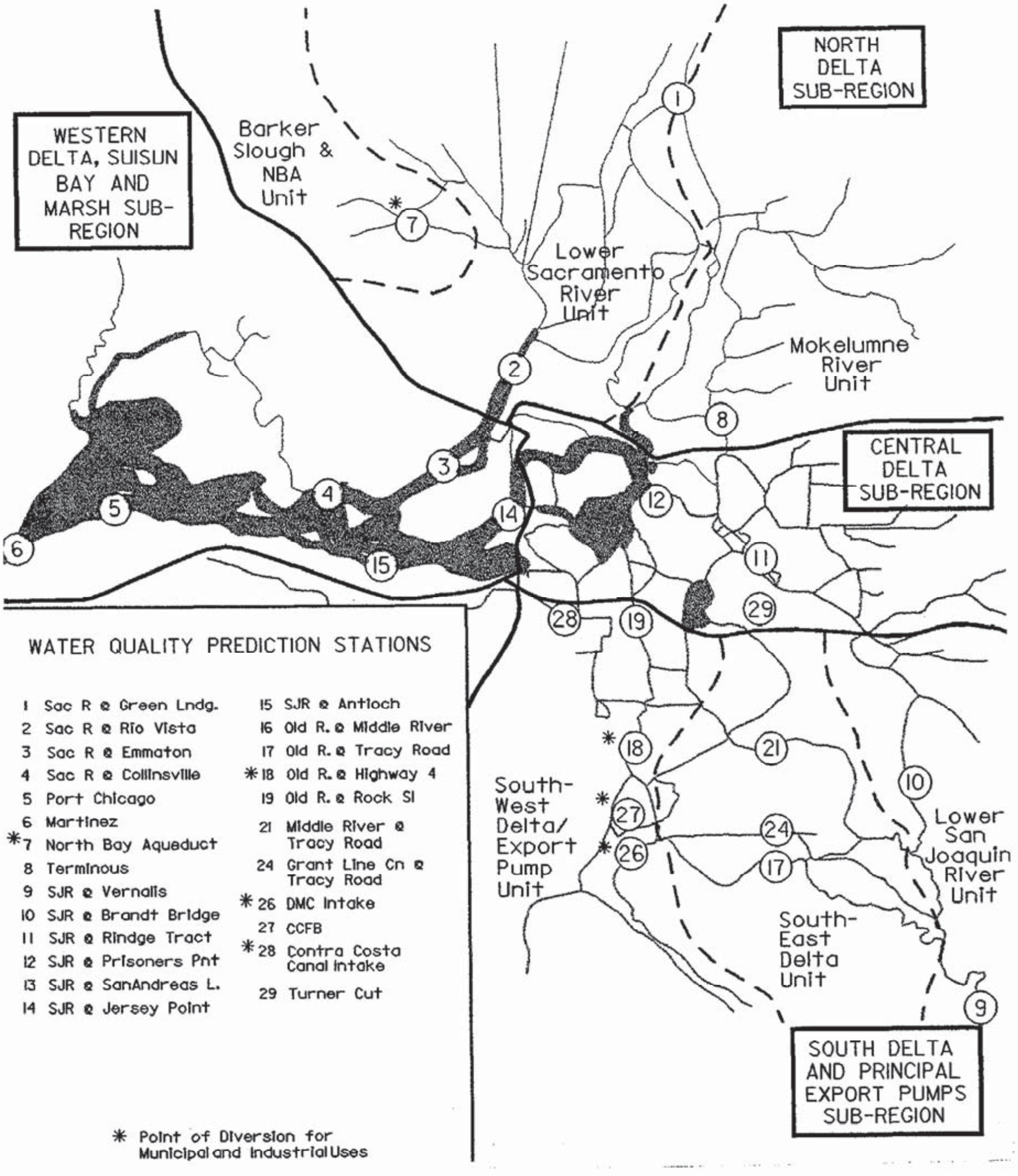


Figure 5.3-1. Key Delta Water Quality Simulation Stations and Delta Subregions

in salinity from ocean salt intrusion, net tidal flow reversals (especially negative QWEST flows) should be minimized. The actual water quality improvements achieved would depend on the capacities and configurations selected for the diversion facility on the Sacramento River, and other north Delta and south Delta channel modifications. (Note that if the diversion facility on the Sacramento River and other north Delta improvements were not constructed, the impacts would be similar to those for Alternative 1.) Water quality also would be affected by the number and type of south Delta water quality control facilities; Delta facility and pump operations; local discharges, including island drainage; and the locations, timing, and magnitudes of any additional flow releases from upstream reservoirs.

Table 5.3-4a summarizes the results of model predictions of average salinity changes (expressed as EC) throughout the Delta for the Preferred Program Alternative compared to the No Action Alternative for a representative long-term hydrologic sequence that includes all water-year types (See Section 5.2). Separate predictions are shown based on modeling assuming water management Criterion A without storage, and water management Criterion B with storage which define the bookends for the analysis of water quality. For both sets of criteria, changes are shown for the annual average value over the period of the simulation, and for the month of the year during which the salinity is the highest. Compared to the No Action Alternative, Table 5.3-4a shows that under the Preferred Program Alternative, salinity is projected to improve overall in the northeast Delta, in the central Delta, in the south and southwest Delta, and on the San Joaquin River in the west Delta (as indicated by Jersey Point). Salinity decreases of more than 10% are considered to be beneficial, as shown in the table. For example, at the intake to CCFB, the mean long-term salinity is projected to decrease by 10-110 μmhos/cm (2-21%), and the mean monthly salinity for December, the month of highest projected salinity, is projected to decrease by about 200-370 μmhos/cm (20-39%). Changes during other months could be both significant and larger. At the NBA intake in the North Delta Sub-Region, Table 5.3-4a indicates a negligible change in salinity. Changes in EC values are based on modeling and indicate an expected value based on model data. The actual values expected in the field depend on many factors, some of which are not included in the model. Therefore, EC values in a specific area should be read as approximate values for that area. Comparing EC values between alternatives indicates relative change between alternatives, when keeping all model assumptions the same.

In-Delta storage would not result in the same benefits that are associated with other storage. In general, in-Delta storage would improve the reliability of water to be exported and the quality of exported water. In doing so, water may be stored within the Delta and delivered to the export facilities during critical times for water quality or environmental purposes. Storage within the Delta has not been modeled specifically but, in terms of Delta water quality and Bay water quality, in-Delta storage should be considered to be similar to south-of-Delta storage. In-Delta storage would result in more operational flexibility than south-of-Delta storage, which could benefit Delta ecosystems.

During dry and critical years, Table 5.3-4b shows that the decreases in salinity become larger, ranging from 10 to 110 μmhos/cm (2-21%) for the long-term maximum salinity at CCFB, and from 200 to 370 μmhos/cm (20-39%) on average for the month of maximum salinity, December. Compared to the "all year" predictions, the only change in level of significance occurs at Grant Line Canal at Tracy Road where the change in EC is sufficiently large during September of dry and critical years to qualify as a beneficial effect. Significant improvements during months of maximum salinity are projected to occur during winter months from December through February, and most frequently during December and January. At the NBA intake in the North Delta Sub-Region, Table 5.3-4b indicates a negligible change in salinity.

Table 5.3-4a. Predicted Salinity Changes Between the Preferred Program Alternative and the No Action Alternative for All Water-Year Types (Salinity Expressed as EC)

DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
		AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)		
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Mokelumne River at Terminous	8	-10	-30	-10	-20	-6%	-14%	-6%	-9%	Jan	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-10	-220	-50	-330	-2%	-32%	-12%	-50%	Dec	LTS - B
Turner Cut	29	30	-110	0	-200	6%	-16%	0%	-31%	Jan	LTS - B
San Joaquin River at Prisoner's Point	12	-20	-230	-120	-430	-4%	-24%	-26%	-46%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	0	-10	0	-2%	0%	-2%	0%	Dec	LTS
San Joaquin River at Brandt Bridge	10	20	30	10	20	3%	4%	2%	3%	Dec	LTS
Middle River at Tracy Road	21	-10	-130	-70	-230	-2%	-16%	-15%	-29%	Jan	LTS - B
Grant Line Canal at Tracy Road	24	-20	0	-60	-10	-3%	0%	-10%	-1%	Dec	LTS
Old River at Tracy Road	17	-20	70	-70	-90	-3%	10%	-11%	-13%	Oct	LTS - B
Old River at Rock Slough	19	-20	-250	-140	-480	-3%	-21%	-24%	-42%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough	28*	-20	-250	-140	-470	-3%	-21%	-22%	-40%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	-30	-250	-120	-450	-5%	-23%	-22%	-43%	Dec	LTS - B
Clifton Court Forebay	27*	-10	-200	-110	-370	-2%	-20%	-21%	-39%	Dec	LTS - B
Delta-Mendota Canal Intake from Old River	26*	-20	-190	-90	-290	-3%	-21%	-16%	-33%	Dec	LTS - B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	20	-110	60	-80	2%	-5%	7%	-4%	Sep	LTS
Sacramento River at Collinsville	4	30	390	110	490	1%	7%	4%	9%	Oct	LTS
San Joaquin River at Jersey Point	14	30	-150	-120	-440	3%	-7%	-11%	-20%	Dec	LTS - B
San Joaquin River at Antioch	15	60	210	10	30	3%	4%	0%	1%	Oct	LTS
Suisun Bay at Port Chicago	5	-10	350	190	250	0%	2%	2%	1%	Sep	LTS
Carquinez Strait at Martinez	6	-20	400	370	420	0%	2%	2%	2%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-4b. Predicted Salinity Changes Between the No Action Alternative and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-10	0%	0%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	-10	-40	-10	-30	-5%	-17%	-5%	-13%	Feb	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-10	-280	-70	-410	-2%	-35%	-15%	-53%	Dec	LTS - B
Turner Cut	29	30	-190	-20	-320	5%	-23%	-4%	-43%	Jan.	LTS - B
San Joaquin River at Prisoner's Point	12	-30	-290	-160	-560	-5%	-25%	-30%	-50%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	0	-3%	0%	-3%	0%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	0	20	0	3%	0%	3%	0%	Feb	LTS
Middle River at Tracy Road	21	-20	-210	-100	-350	-3%	-21%	-19%	-37%	Jan.	LTS - B
Grant Line Canal at Tracy Road	24	-40	0	-90	0	-5%	0%	-12%	0%	N/A	LTS - B
Old River at Tracy Road	17	-50	0	-110	0	-7%	0%	-15%	0%	N/A	LTS - B
Old River at Rock Slough	19	-30	-300	-180	-610	-4%	-21%	-26%	-44%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough	28*	-30	-300	-180	-590	-4%	-21%	-25%	-43%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	-40	-310	-460	-560	-6%	-24%	-49%	-45%	Dec	LTS - B
Clifton Court Forebay	27*	-20	-230	-140	-460	-3%	-20%	-23%	-42%	Dec	LTS - B
Delta-Mendota Canal Intake from Old River	26*	-40	-210	-120	-350	-6%	-20%	-18%	-35%	Jan.	LTS - B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	30	-160	60	-200	3%	-6%	5%	-7%	Sep	LTS
Sacramento River at Collinsville	4	30	-210	80	-360	1%	-3%	2%	-5%	Sep	LTS
San Joaquin River at Jersey Point	14	0	-170	-180	-630	0%	-6%	-13%	-22%	Dec	LTS - B
San Joaquin River at Antioch	15	40	280	-60	10	1%	5%	-2%	0%	Oct	LTS
Suisun Bay at Port Chicago	5	-120	-20	140	-230	-1%	0%	1%	-1%	Sep	LTS
Carquinez Strait at Martinez	6	-140	-10	350	-30	-1%	0%	2%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - *Some impacts within ±10, some impacts <-10%*
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Overall, with the singular exception of the NBA, the Preferred Program Alternative is projected to improve in-Delta and export water quality and dependent beneficial uses because of the resultant increases in the flow of good-quality water from the north Delta (especially with new upstream storage). Other contributing factors include corresponding decreases in the quantities of sea-water intrusion and improved water circulation in affected Delta channels.

Potential improvements in Delta water quality compared to the No Action Alternative would be greatest in the central and south Delta, especially in the reach of the San Joaquin River in the central Delta where flows would enter from the north, and in Old River and other southwest Delta channels that convey water directly toward the pumps. A shift in export water quality based on reduced San Joaquin River flows entering the pumps would allow selenium in the San Joaquin River to enter the Delta and Bay.

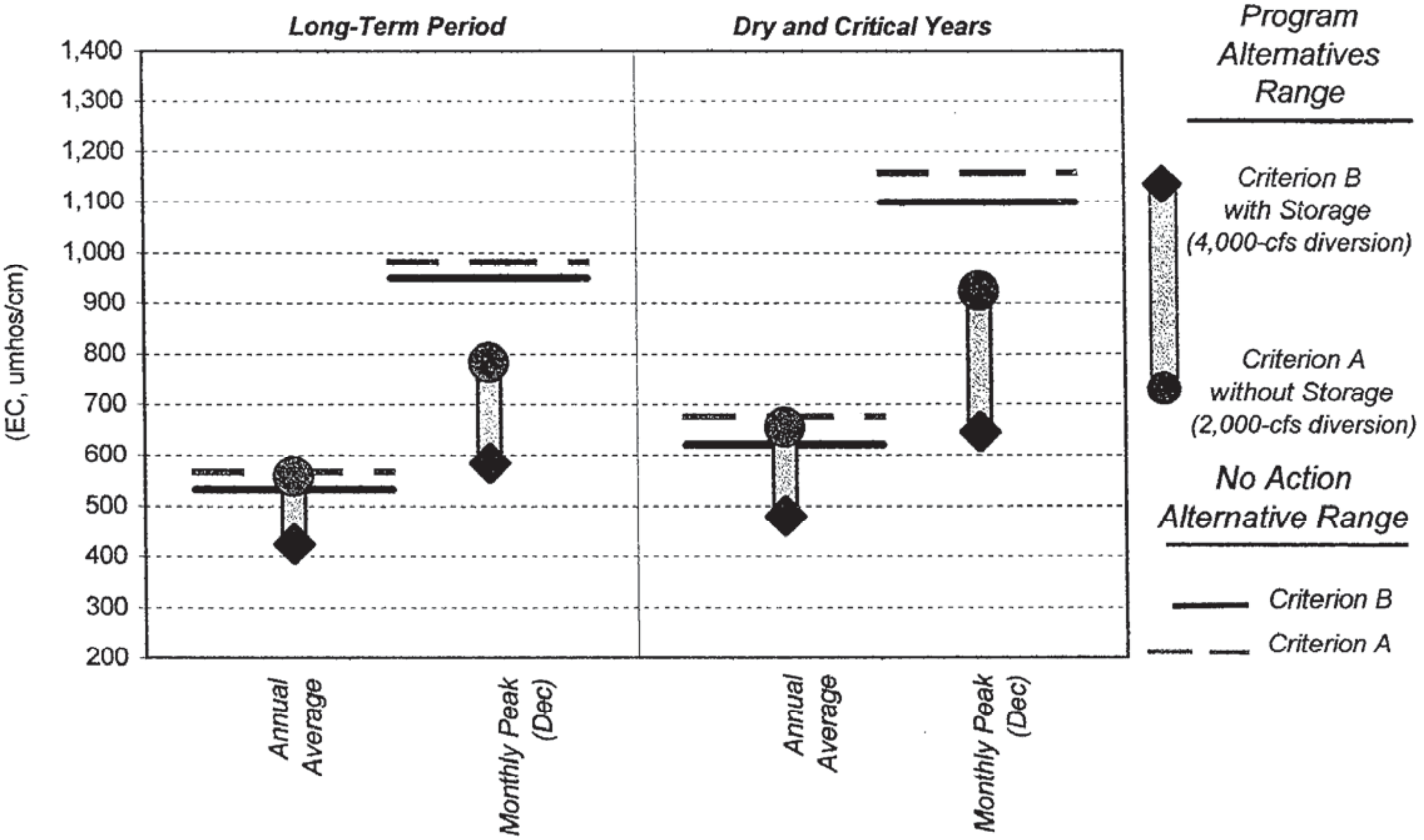
The actual magnitudes of the salinity changes would vary tidally, seasonally, and spatially throughout the Delta, depending on factors such as the mixtures of source waters attained at each location that result from variations in the pathways and timing of flows through Delta channels. The magnitude of the changes also would depend on variations in annual hydrology. In general, the improvements in water quality would increase during dry and critical years, and be attenuated during above-normal and wet years.

Ecosystem Restoration Program actions are proposed for portions of the Delta and Bay Regions that may result in coincidental beneficial water quality impacts, according to model results on concepts of several projects. Detailed studies of these projects have not been conducted, and further studies are being pursued (as part of Stage 1 implementation). If these projects meet the CALFED solution objectives, project-specific environmental evaluation and documentation will address the environmental impacts of individual projects. Should a project be considered for construction with beneficial water quality impacts as part of the project, these beneficial impacts may be considered as mitigation for other Program actions. Considering the preliminary nature of information about these projects, it is uncertain whether the projects will be able to reduce adverse salinity impacts to a less-than-significant level.

Average monthly salinities during the summer months would be slightly increased in the San Joaquin River, in the west Delta, and in Old River. Whereas the above-referenced tables show the salinity changes relative to the No Action Alternative, Figures 5.3-2 through 5.3-6 show the predicted ranges of mean annual and peak EC values for the Preferred Program Alternative and the No Action Alternative at the following five stations, respectively: Old River at CCFB, San Joaquin River at Prisoner's Point, San Joaquin River at Jersey Point, Middle River at Tracy Road, and Old River at Rock Slough. These locations were selected to be representative of locations in the central, south, and west Delta, including several key export locations.

The range of values for each alternative plotted in the figures are indicative of the range of uncertainty in potential outcomes considering variations in conveyance capacities, storage, hydrology, and water management and operations. At Old River at Rock Slough, the Preferred Program Alternative ranges for dry and critical years and the long term are distinctly lower and do not overlap with the No Action Alternative range. At the remaining selected stations, the ranges do overlap slightly; however, the Preferred Program Alternative ranges are still distinctly lower. This indicates that the EC values under the Preferred Program Alternative are definitively lower at all of the selected stations than those of the No Action Alternative. The distribution of the ranges (that is, increasing from Jersey Point to Middle River at Tracy Road and CCFB) can be explained by the increased effects of salinity intrusion associated with water management Criterion B with storage.

Figure 5.3-2. Ranges of Salinity (expressed as EC) at Clifton Court Forebay for the Preferred Program Alternative



Revised from June 1999 draft

Figure 5.3-3. Ranges of Salinity (expressed as EC) at Prisoner's Point for the Preferred Program Alternative

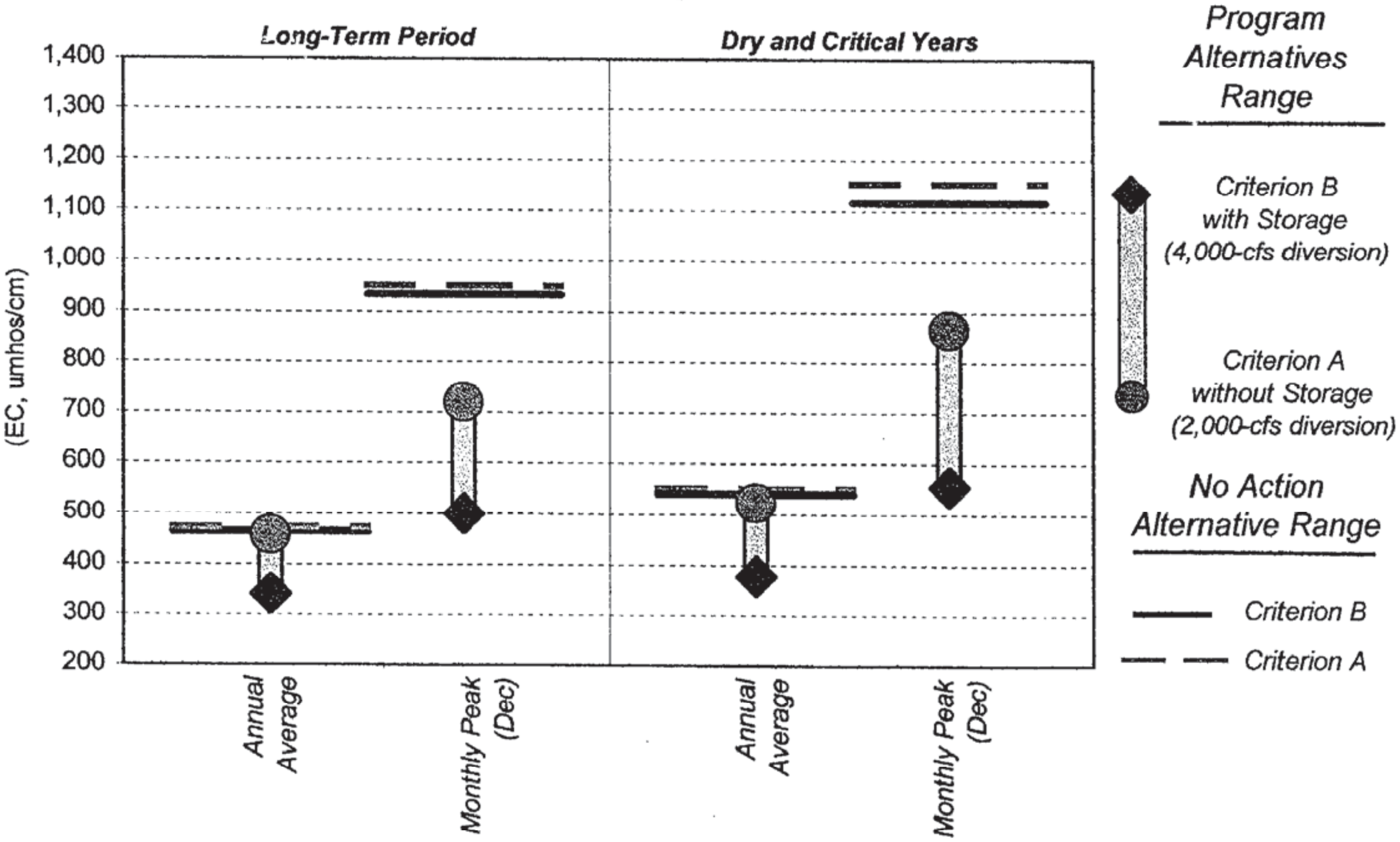


Figure 5.3-4. Ranges of Salinity (expressed as EC) at Jersey Point for the Preferred Program Alternative

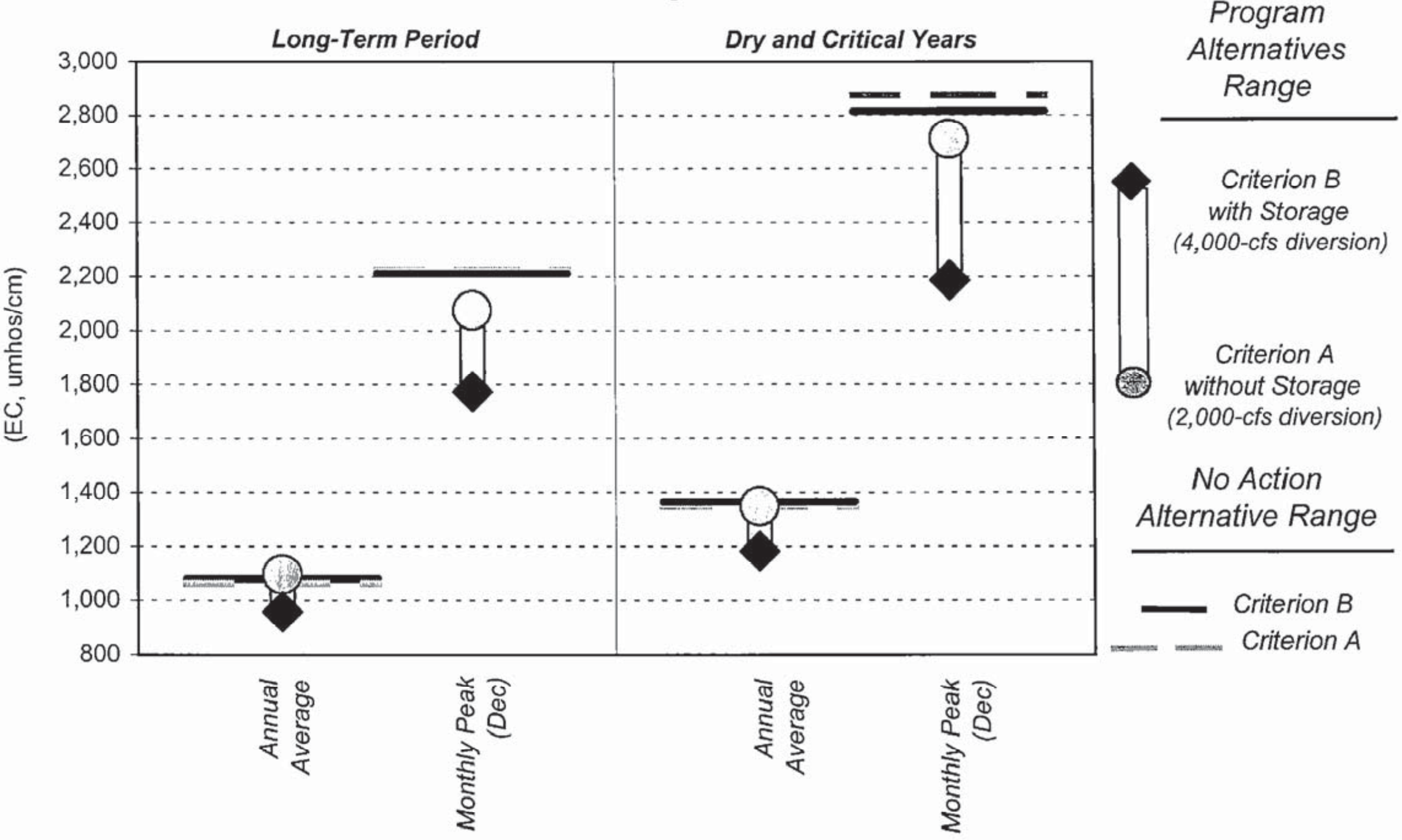
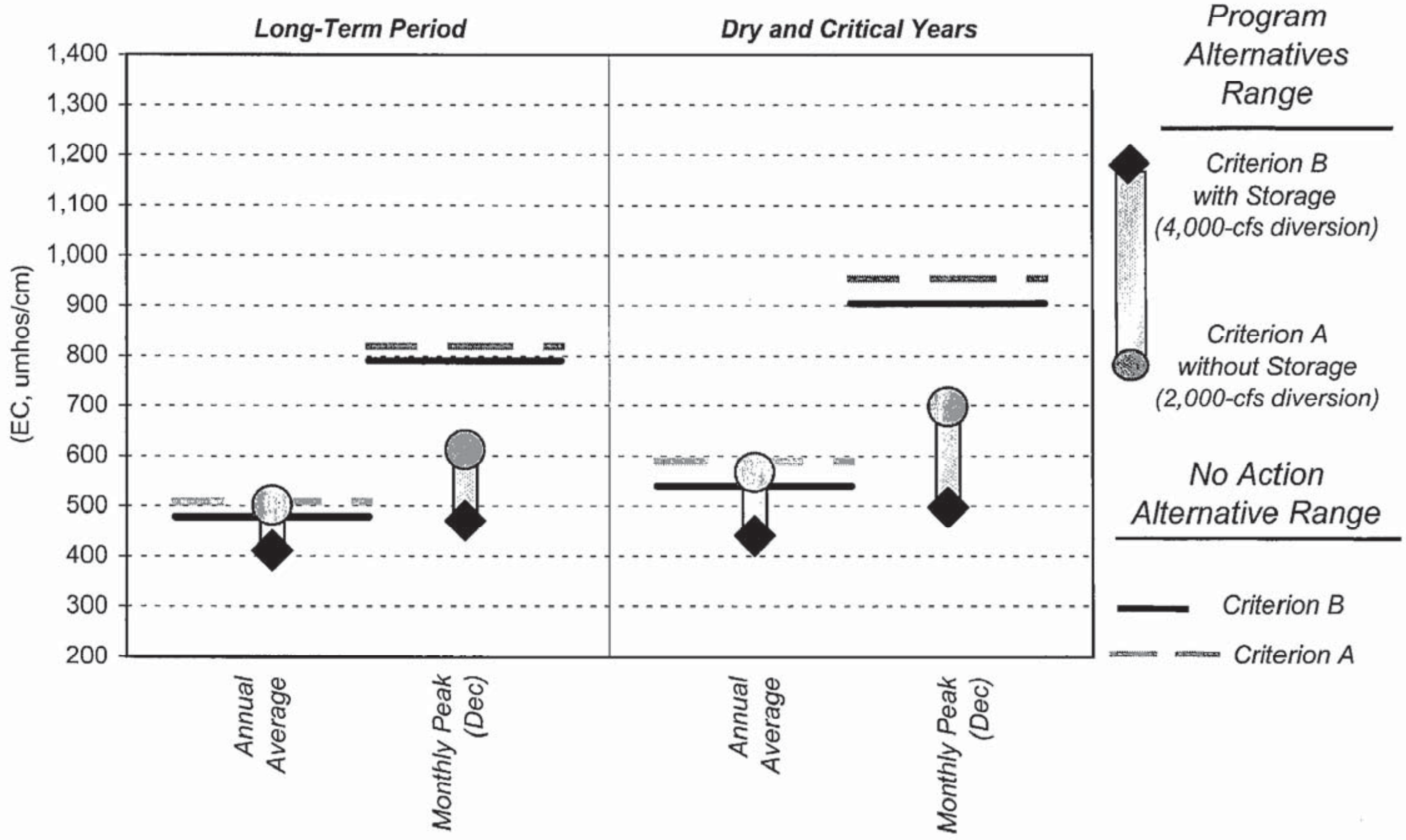
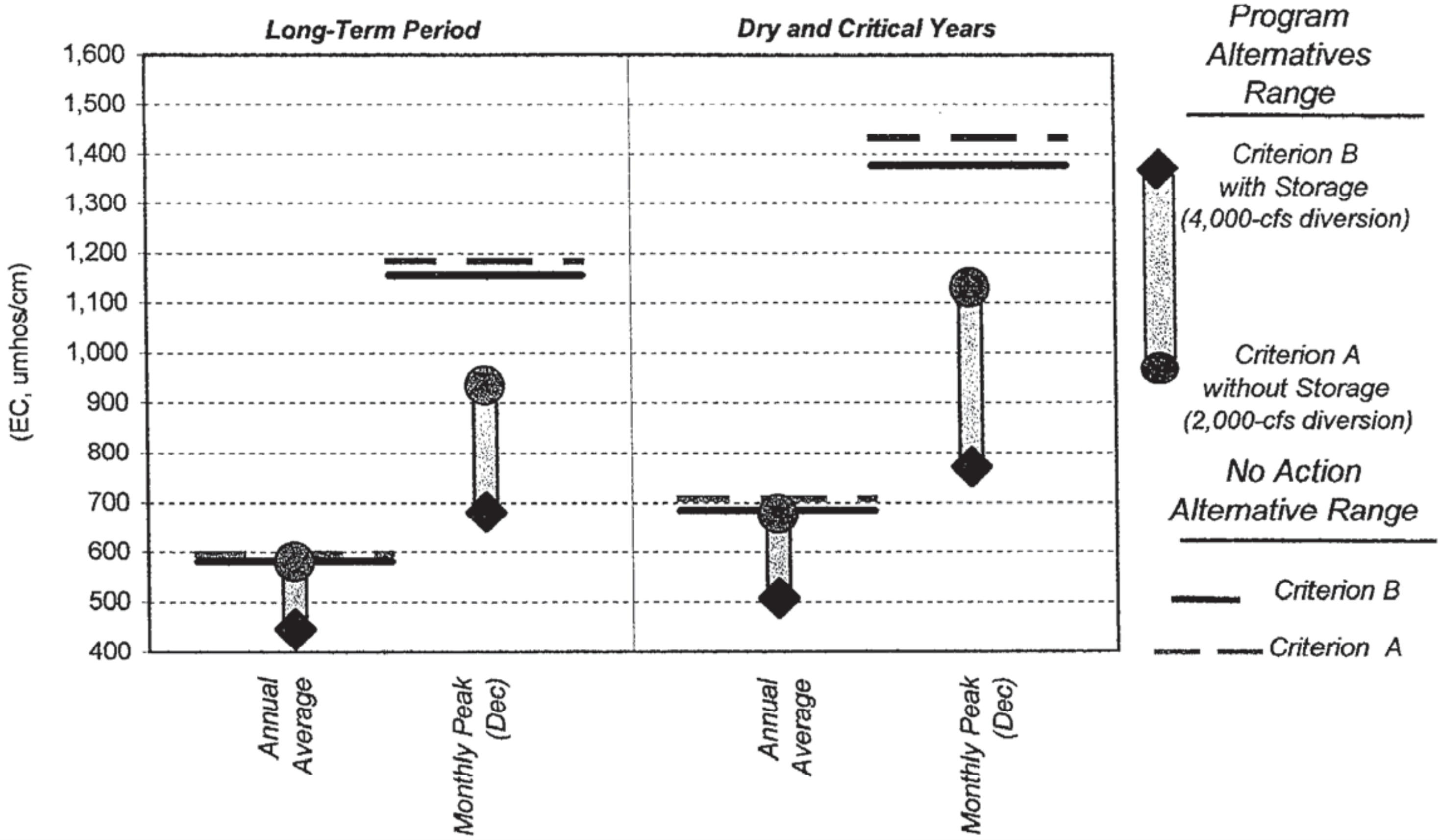


Figure 5.3-5. Ranges of Salinity (expressed as EC) at Middle River at Tracy Road for the Preferred Program Alternative



Revised from June 1999 draft

Figure 5.3-6. Ranges of Salinity (expressed as EC) at Rock Slough for the Preferred Program Alternative



The quality of water in the Delta depends in large part on how circulation patterns in the Delta affect the movement and mixing of constituents that originate from different sources—including in-Delta, Bay, and tributary sources. The effect of the Preferred Program Alternative on constituents, therefore, will vary—depending on how the alternative might alter the mixture of waters arriving at a given location.

The principal source of bromide in the Delta is San Francisco Bay. Although there is evidence that the current conditions in the Delta lead to significant recirculation of bromide via the DMC and the San Joaquin River, the origin of this bromide also is the Bay. To illustrate the extent of recirculation, bromide concentrations from January 1990 to March 1998 in the San Joaquin River averaged 310 ug/L, compared with 18 ug/L on the Sacramento River (see Section 3.7.1 in the Water Quality Program Plan). Bromide modeling conducted by DWR for Alternatives 1 and 2 predict that bromide concentrations potentially would be reduced, depending on the extent to which the alternative limits recirculation of San Joaquin River water and preferentially conveys Sacramento River water to the export facilities (Figures 10 and 11 in Appendix E of the Water Quality Program Plan and DWR, 1998a, unpublished data).

Data indicate that a major source of TOC at the export facilities is in-Delta drainage return (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will have limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, the Preferred Program Alternative includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at the export facilities.

Bay Region

The addition of new storage could improve water quality and dependent conditions for estuarine biological resources in the west Delta as a result of increased Delta outflows, especially during low-outflow periods.

With increased exports from the Delta, the Preferred Program Alternative could slightly reduce net Delta outflows, resulting in greater sea-water intrusion into the Bay and resultant increases in salinity, including bromide, in the San Francisco, San Pablo, and Suisun Bays (the Suisun Bay is contiguous with Delta channels and diversion points). However, these increases are projected to be less than significant.

Sacramento River Region

Without new storage, the Preferred Program Alternative is not expected to affect surface water flows in the Sacramento River Region or the resultant water quality conditions. Impacts on surface water quality in the Sacramento River Region would result from changes in streamflows due to releases from, and diversions to, storage; and from construction, operation, and maintenance of new off-stream storage facilities, if built.

With additional new storage, the Preferred Program Alternative could produce water quality benefits in the Sacramento River Region when reservoir releases are made. Releases of high-quality water from storage could result in increased flows during low-flow periods. These increases could result in dilution of constituents carried by the streams and could provide water quality benefits for municipal, agricultural, and ecosystem beneficial uses. The increased flows should not be sufficiently large to significantly accelerate channel scouring. Turbidities and suspended sediment deposition probably would be reduced overall.

Temperatures could increase or decrease in the Sacramento River if inflows of warmer or cooler waters occur from new off-stream reservoirs. For this reason, surface water releases from Sacramento tributary storage may be confined to those needed to meet consumptive uses in adjacent service areas in order to prevent temperature changes to the Sacramento River. For example, inflows of water 5 degrees warmer than the water in the trunk stream, at a rate equal to 10% of the flow in the trunk stream, could increase the average temperature of the trunk stream by about half a degree (Celsius or Fahrenheit). However, inflows to streams from off-tributary reservoirs would be uncommon. More frequently, stored water would be delivered to water users via canals, in exchange for reduced in-stream diversions. This would benefit in-stream conditions for indigenous aquatic life.

San Joaquin River Region

General impacts of storage and conveyance options on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region. However, the potential for significant changes in the quality (and quantity) of the water exported to the region as a result of decisions made during the term of this Program and other non-CALFED Programs mentioned under "Cumulative Impacts" in Section 5.3.10 is substantial. As indicated in Table 5.3-5a, the average annual improvement in the salinity of water exported to the San Joaquin Valley Region is projected to average from 2 to 39%, a small to potentially substantial benefit compared to the No Action Alternative.

The range of potential long-term water supply variations (possibly in the realm of 800 TAF of gains with new storage to 500 TAF of losses without new storage) and source-dependent water quality characteristics are sufficiently large to significantly alter prevailing water quality and the resultant salt balance in the SWP and CVP service areas and throughout the San Joaquin Valley. The effects of the potential variations would be most pronounced in those areas that are already deficient in both quality and quantity of water. Resultant changes in land use in the service areas that could secondarily affect water quality, water supply, demands, and beneficial uses of water resources would in turn depend on the magnitude of the variations in the delivered water supplies and their quality. Despite the variability, overall improvements in water quality in the areas served by exports would benefit municipal, agricultural, and ecological uses of the water. Improvements would reduce the salt loads entering the basin and reduce the amount of salt recirculation that occurs between the basin and the Delta.

Additional upstream storage capacity would produce additional beneficial impacts on export water quality. Releases of high-quality water from new upstream storage during periods when salinities and other constituents otherwise would be higher at the export pumps could reduce salinities in the SWP and CVP service areas in the valley further, depending on the locations and months of the releases—especially during dry and critical years. Additional off-aqueduct storage could afford opportunities for additional pumping to storage during high-outflow periods, when water quality is good and environmental constraints allow, for later use when Delta water quality or environmental conditions are less favorable.

Table 5.3-5a. *Predicted Salinity Changes Between Alternative 1 and the No Action Alternative for All Water-Year Types (Salinity Expressed as EC)*

DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
		AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)		
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	Jan	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	0	-10	0%	0%	0%	-3%	Mar	LTS
Mokelumne River at Terminous	8	0	0	0	0	0%	0%	0%	0%	Jan	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	20	20	40	50	5%	3%	10%	8%	Dec	LTS
Turner Cut	29	40	30	60	70	8%	4%	13%	11%	Jan	LTS - PS
San Joaquin River at Prisoner's Point	12	20	50	70	130	4%	5%	15%	14%	Dec	LTS - PS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	0	-10	0	-2%	0%	-2%	0%	Dec	LTS
San Joaquin River at Brandt Bridge	10	20	40	10	20	3%	6%	2%	3%	Dec	LTS
Middle River at Tracy Road	21	30	40	60	90	6%	5%	13%	11%	Jan	LTS - PS
Grant Line Canal at Tracy Road	24	-20	170	-20	180	-3%	24%	-3%	26%	Nov	LTS - PS
Old River at Tracy Road	17	-30	180	-30	190	-5%	26%	-5%	27%	Nov	LTS - PS
Old River at Rock Slough	19	20	50	80	150	3%	4%	14%	13%	Dec	LTS - PS
Contra Costa Canal Intake at Rock Slough	28*	20	40	70	130	3%	3%	11%	11%	Dec	LTS - PS
Old River at SR 4 (and New CCWD Intake)	18*	10	30	60	100	2%	3%	11%	9%	Dec	LTS - PS
Clifton Court Forebay	27*	30	70	70	140	5%	7%	13%	15%	Dec	LTS - PS
Delta-Mendota Canal Intake from Old River	26*	-10	70	20	100	-2%	8%	4%	12%	Nov	LTS - PS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	10	60	10	40	1%	3%	1%	2%	Sep	LTS
Sacramento River at Collinsville	4	-10	160	70	210	0%	3%	2%	4%	Sep	LTS
San Joaquin River at Jersey Point	14	40	120	160	290	4%	5%	15%	13%	Dec	LTS - PS
San Joaquin River at Antioch	15	20	180	140	270	1%	4%	6%	6%	Oct	LTS
Suisun Bay at Port Chicago	5	0	440	340	520	0%	2%	3%	3%	Sep	LTS
Carquinez Strait at Martinez	6	10	420	370	450	0%	2%	2%	2%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.
† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-5b. Predicted Salinity Changes Between Alternative 1 and the No Action Alternative for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	Jan.	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-10	0%	0%	-5%	-4%	Jan.	LTS
Mokelumne River at Terminous	8	0	0	0	-10	0%	0%	0%	-4%	Feb	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	40	30	60	80	8%	4%	13%	10%	Dec	LTS - PS
Turner Cut	29	60	40	80	100	11%	5%	16%	13%	Jan.	LTS - PS
San Joaquin River at Prisoner's Point	12	30	80	100	170	5%	7%	19%	15%	Dec	LTS - PS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	10	-3%	0%	-3%	1%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	0	20	10	3%	0%	3%	1%	Feb	LTS
Middle River at Tracy Road	21	30	60	80	160	5%	6%	15%	17%	Jan.	LTS - PS
Grant Line Canal at Tracy Road	24	-40	180	-50	170	-5%	23%	-7%	22%	Nov	LTS - PS
Old River at Tracy Road	17	-60	170	-60	180	-8%	22%	-8%	24%	Nov	LTS - PS
Old River at Rock Slough	19	30	80	110	190	4%	6%	16%	14%	Dec	LTS - PS
Contra Costa Canal Intake at Rock Slough	28*	30	70	100	180	4%	5%	14%	13%	Dec	LTS - PS
Old River at SR 4 (and New CCWD Intake)	18*	20	50	-210	140	3%	4%	-22%	11%	Dec	PS - B
Clifton Court Forebay	27*	40	90	100	270	6%	8%	16%	25%	Jan.	LTS - PS
Delta-Mendota Canal Intake from Old River	26*	-10	-40	20	70	-1%	-4%	3%	7%	Jan.	LTS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	10	40	-10	-80	1%	1%	-1%	-3%	Sep	LTS
Sacramento River at Collinsville	4	-40	40	40	-50	-1%	1%	1%	-1%	Sep	LTS
San Joaquin River at Jersey Point	14	40	200	210	390	3%	7%	15%	14%	Dec	LTS - PS
San Joaquin River at Antioch	15	-20	260	140	380	-1%	5%	4%	7%	Oct	LTS
Suisun Bay at Port Chicago	5	-120	60	310	50	-1%	0%	2%	0%	Sep	LTS
Carquinez Strait at Martinez	6	-110	10	360	10	-1%	0%	2%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = *Less than significant.*
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Other SWP and CVP Service Areas

The Preferred Program Alternative could benefit export water quality outside the Central Valley. Benefits could result from the changes in flow and salinity patterns throughout the Delta, as described for the Delta Region. Benefits and potential impacts could be somewhat similar to those described above for the water service areas in the San Joaquin Valley, although more of these service areas are served by SWP exports from CCFB than from the CVP. However, increased fresh-water inflows from additional upstream releases from storage would be needed to produce optimal beneficial effects in these areas.

A variation of the Preferred Program Alternative would extend the intake for the NBA. Construction of such a modification would improve the quality of water exported through the NBA. Presently, organic carbon in NBA exports is the most significant source of water quality degradation for the North Bay municipalities using the water, as it promotes formation of harmful chemical byproducts in the drinking water disinfection process. Moving the intake to an alternative water source might reduce water available from the water source for other users.

Additional upstream storage capacity would produce increased beneficial impacts on export water quality. Releases of high-quality water from new upstream storage during periods when salinities and other constituents would otherwise be higher at the export pumps could reduce salinities in the Other SWP and CVP Service Areas somewhat further, depending on the location and month of the releases—especially during dry and critical years. During these times, service areas such as the San Felipe Division of the CVP would benefit in two ways: (1) both agricultural and municipal supplies would benefit from lower salinities, while (2) the municipal supplies would also benefit from lower bromide levels. Additional off-aqueduct storage could afford opportunities for additional pumping for storage during high outflow periods when water quality is good and environmental constraints allow, for later use when Delta water quality or environmental conditions are less favorable.

Simulations of bromide concentrations at key Delta export facilities were calculated based on fingerprint modeling data for the alternatives completed in 1998. The data were analyzed for dry and critical years, the most critical times of high bromide concentrations. The data were updated for the most recent model results, using the bromide-to-EC ratios in the older modeling exercise and the EC values generated in the latest model exercise. Based on changes in EC, bromide concentrations would not differ significantly between Alternative 2 and the Preferred Program Alternative with the diversion facility on the Sacramento River option in place. Without the diversion facility, bromide concentrations under the Preferred Program Alternative would be more comparable to Alternative 1. Bromide concentrations from the two alternatives should be referenced for an estimate of bromide concentrations anticipated in the Preferred Program Alternative.

5.3.8.2 ALTERNATIVE 1

Delta Region

Water quality conditions in the Delta would be best where and when good-quality water, primarily from the Sacramento River, flows in optimal patterns across the Delta to discharge to Suisun Bay and to the diversion pumps. The actual water quality improvements achieved would depend on the capacities and configurations selected for north Delta and south Delta channel modifications. Water quality also would be affected by the number and type of south Delta water quality control facilities; Delta facility and pump operations; local discharges, including island drainage; and the locations, timing, and magnitudes of any additional flow releases from upstream reservoirs.

Table 5.3-5a summarizes the results of model predictions of salinity changes (expressed as EC) throughout the Delta for Alternative 1 compared to the No Action Alternative for a representative long-term hydrologic sequence that includes all water-year types (see Section 5.2). Separate predictions are shown based on modeling assuming water management Criterion A without storage, and water management Criterion B with storage which define the bookends for the analysis of water quality. For both sets of criteria, changes are shown for the annual average value over the period of the simulation and for the month of the year when salinity is the highest. Changes in EC values are based on modeling and indicate an expected value based on model data. The actual values expected in the field depend on many factors, some of which are not included in the model. Therefore, EC values in a specific area should be read as approximate values for that area. Comparing EC values between alternatives indicates relative change between alternatives, when keeping all model assumptions the same.

Compared to the No Action Alternative, Table 5.3-5a shows that under Alternative 1, salinity is projected to be significantly affected in the central Delta, in the south Delta, and in the San Joaquin River in the west Delta (as indicated by Jersey Point). For example, at CCFB, the mean long-term salinity is projected to increase by 30-70 μmhos/cm (5-13%), and the mean monthly salinity for December , the month of highest projected salinities, is projected to increase by about 70-140 μmhos/cm (7-15%). During dry and critical years, Table 5.3-5b shows that these ranges increase to 40-100 μmhos/cm (6-16%) for the long term and to 90-270 μmhos/cm (8-25%) on average for the month of maximum salinity, January. Changes during other months could be both significant and larger. Alternative 1 would potentially degrade overall in-Delta and export water quality and dependent beneficial uses because of the resultant increases in sea-water intrusion (see Figures 5.2-36 and 37 in Section 5.2). This degradation is projected to occur despite the increased potential for reservoir releases and increased inflows of better quality water across the Delta from the Mokelumne and Sacramento Rivers southward, and the potentially improved water circulation in affected Delta channels.

The actual magnitudes of the salinity changes would vary tidally, seasonally, and spatially throughout the Delta, depending on factors such as the mixtures of source waters attained at each location that result from variations in the pathways and timing of flows through Delta channels. The magnitude of the changes also would depend on variations in annual hydrology. In general, the magnitude of impacts would be increased in dry and critical years, and attenuated in above-normal and wet years.

Whereas the above tables show the salinity changes relative to the No Action Alternative, Figures 5.3-7 through 5.3-11 show the ranges of predicted mean annual and peak EC values (μs/cm) for Alternative 1 and the No Action Alternative at the following five stations respectively: Old River at CCFB, San Joaquin River at Prisoner's Point, San Joaquin River at Jersey Point, Middle River at Tracy Road, and Old River at Rock Slough. These locations were selected to be representative of locations in the central, south, and west Delta, including export locations.

The range of values for each alternative indicated in the figures are indicative of the range of uncertainty. In general, the ranges do not overlap, indicating that EC values under Alternative 1 are distinctly different (and higher) than under the No Action Alternative. The distribution of the ranges (that is, decreasing

Figure 5.3-7. Ranges of Salinity (expressed as EC) at Clifton Court Forebay for Alternative 1

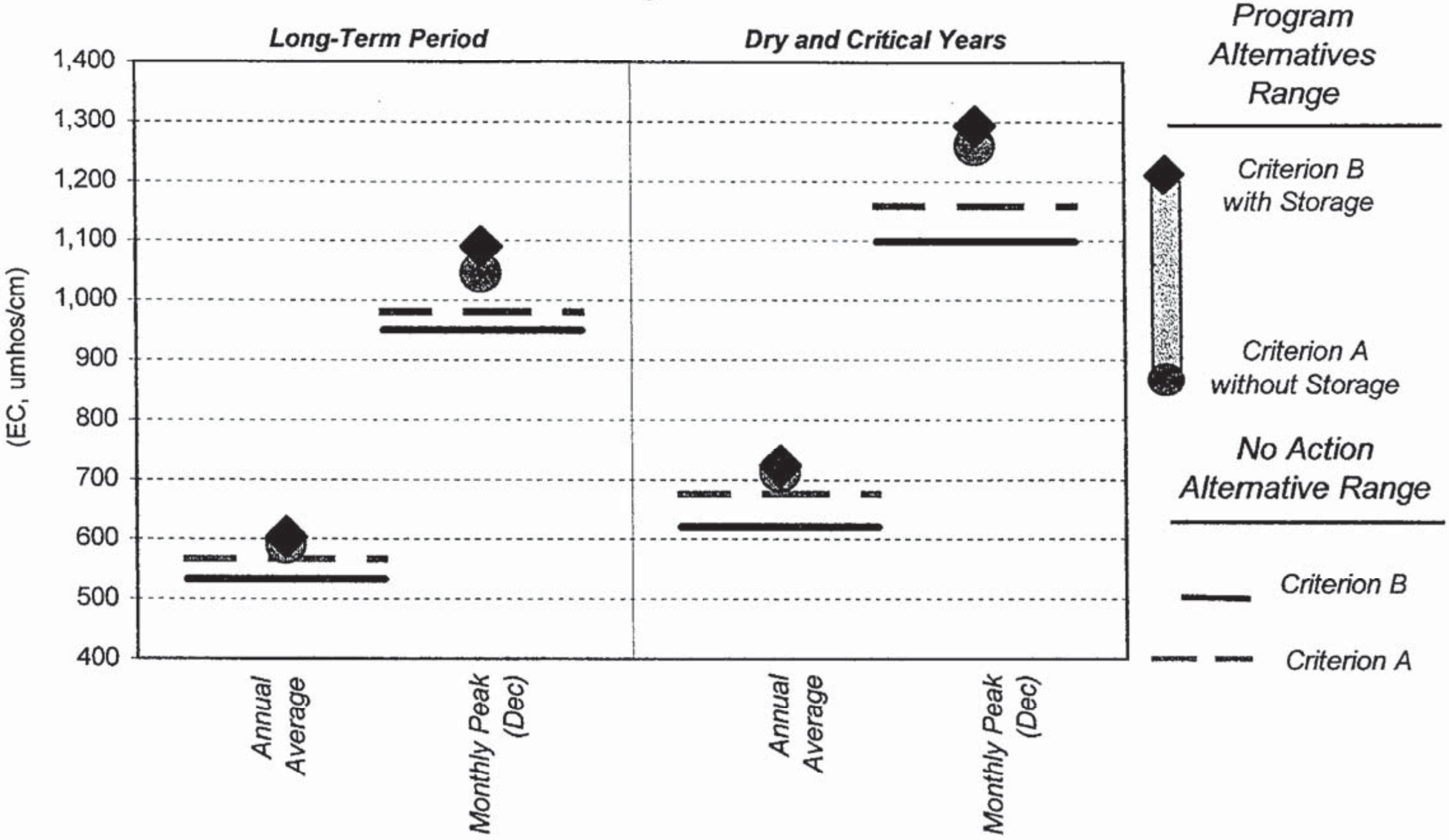


Figure 5.3-8. Ranges of Salinity (expressed as EC) at Prisoner's Point for Alternative 1

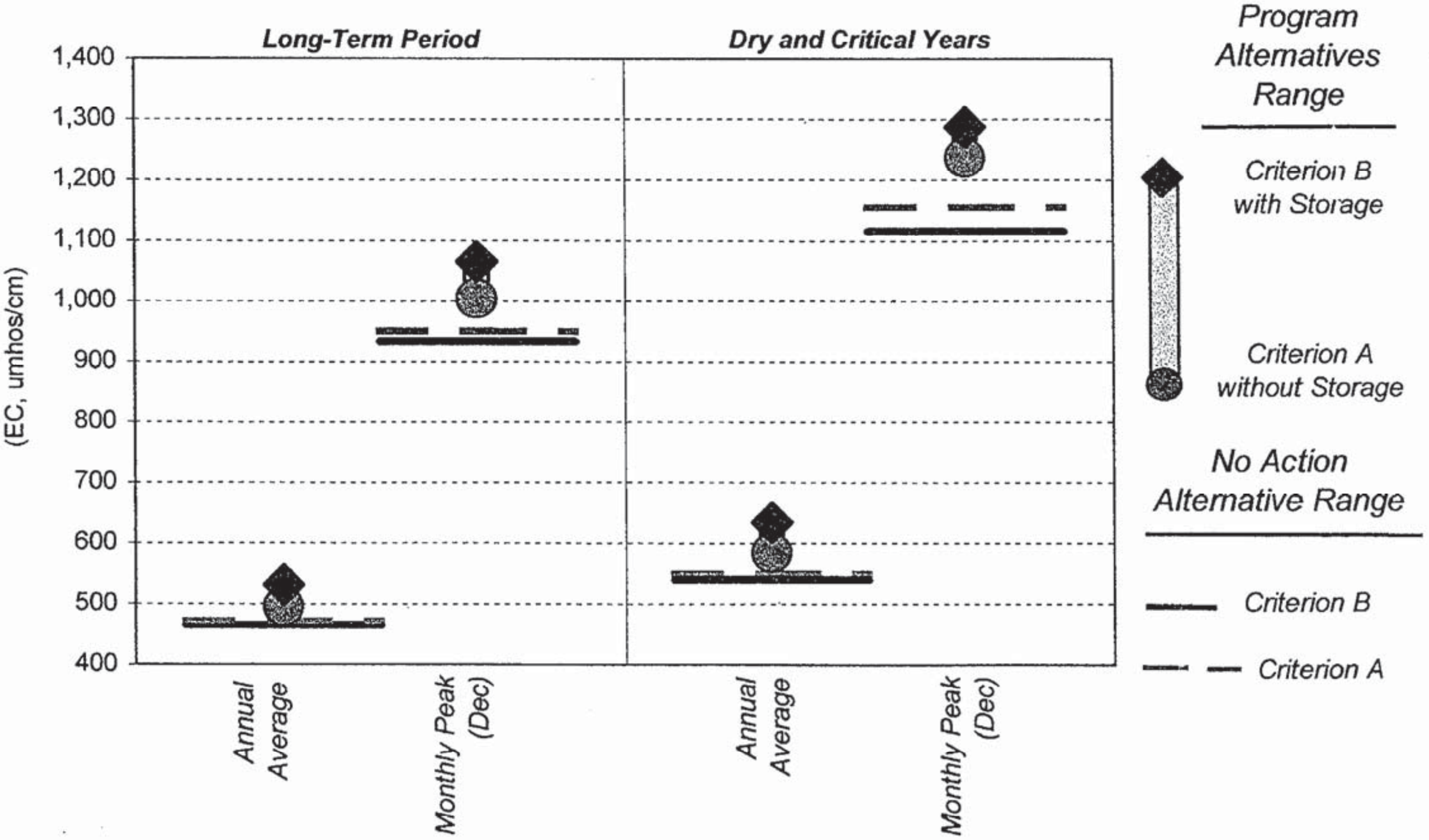


Figure 5.3-9. Ranges of Salinity (expressed as EC) at Jersey Point for Alternative 1

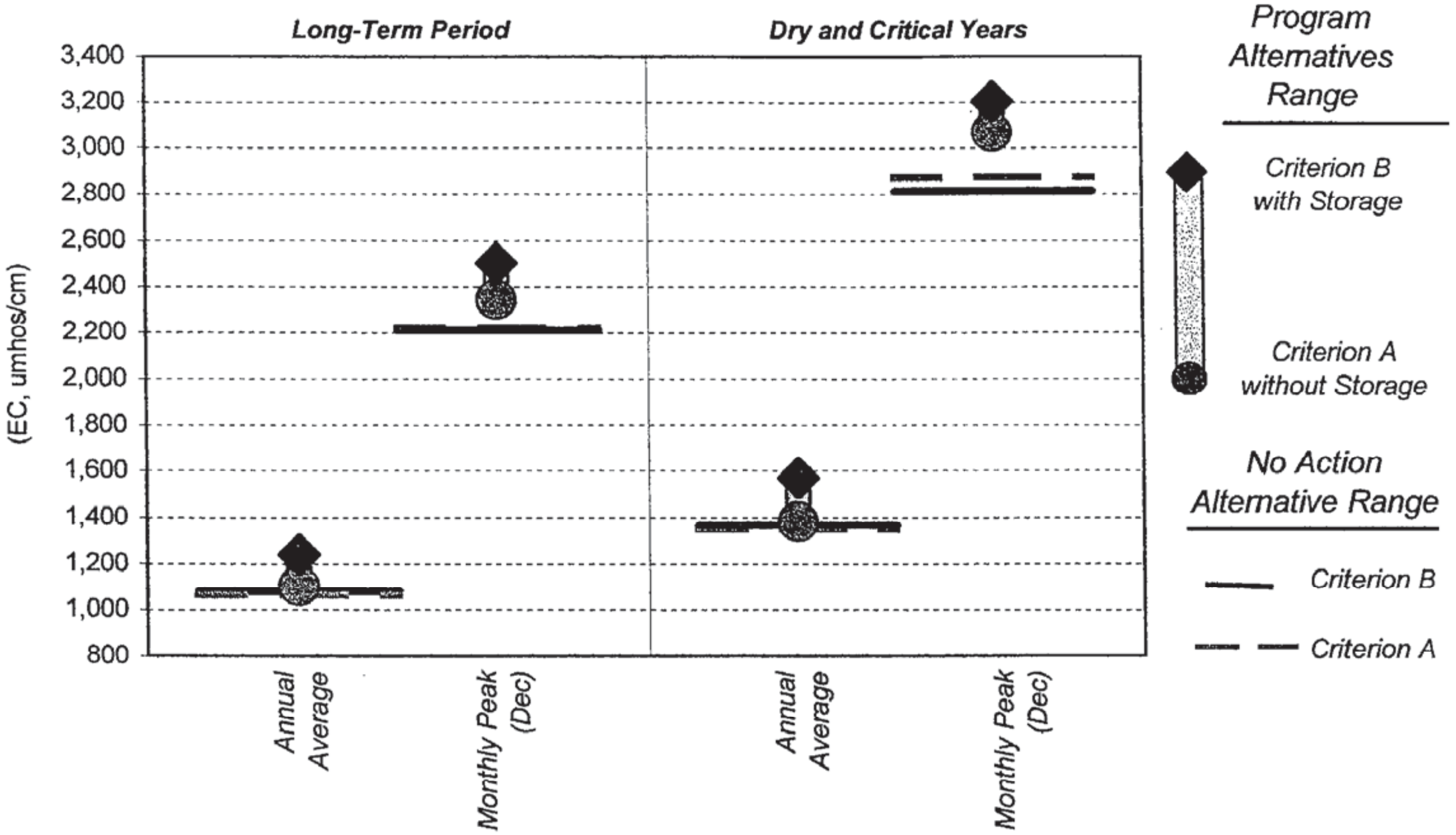
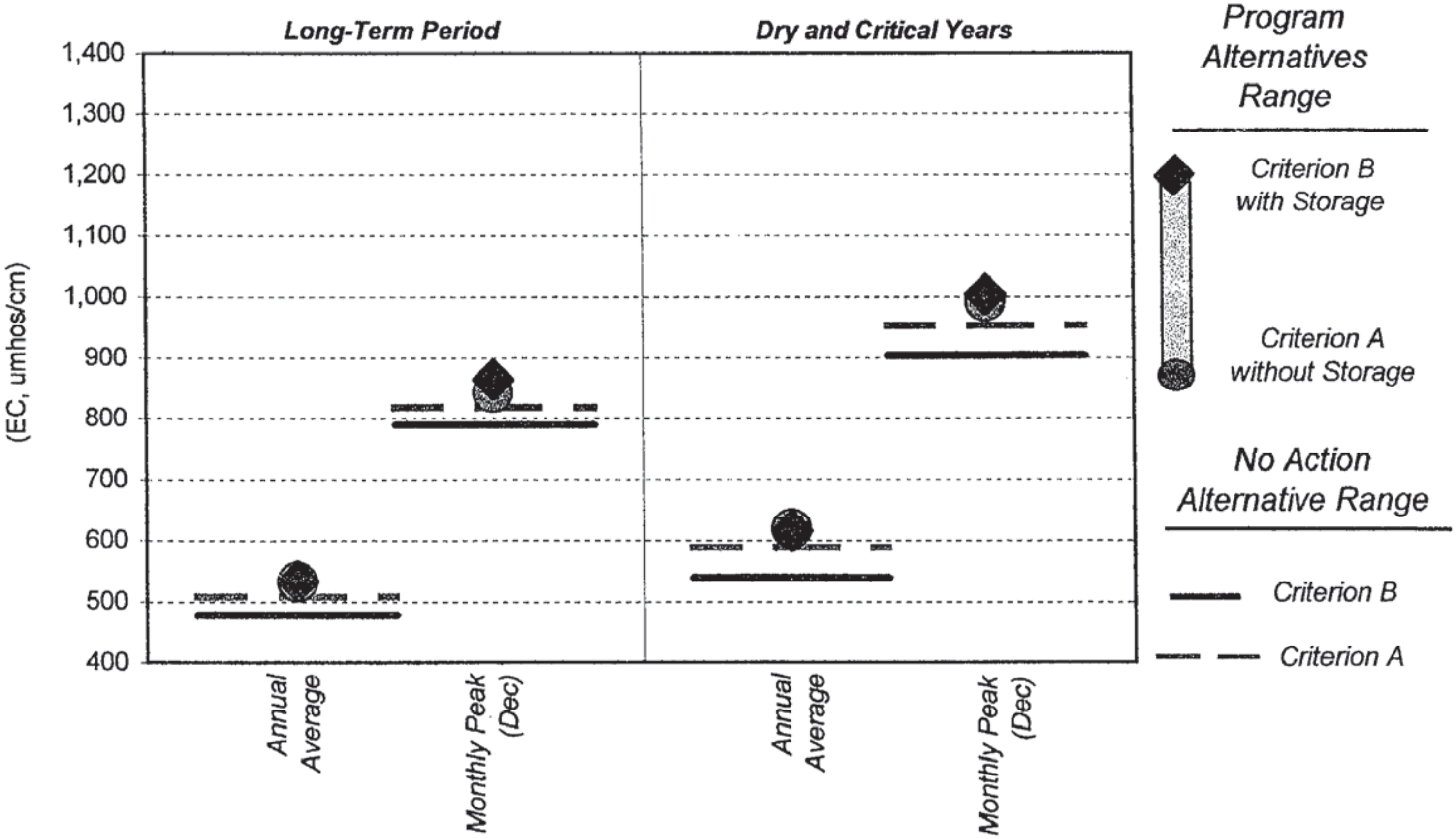
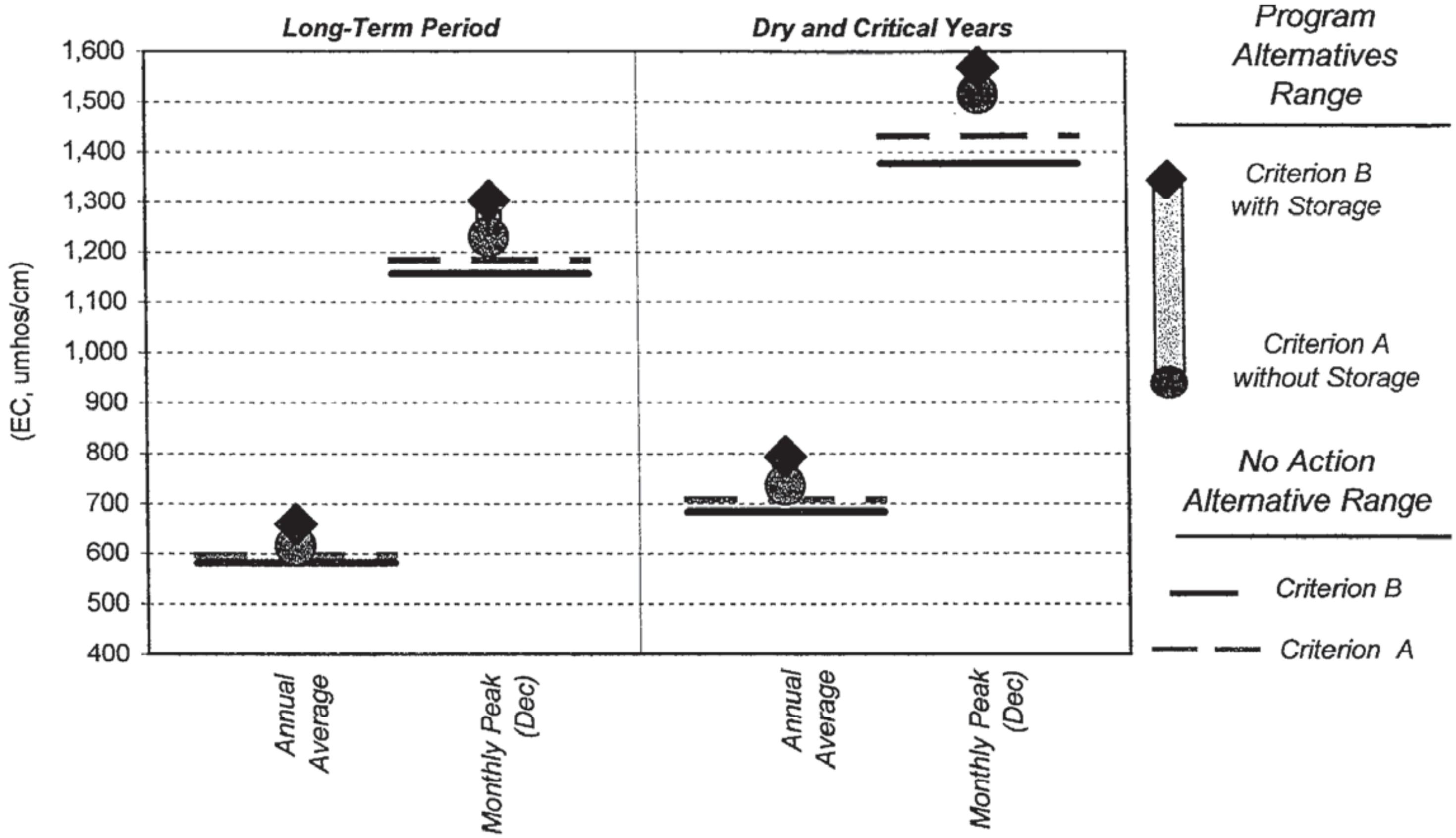


Figure 5.3-10. Ranges of Salinity (expressed as EC) at Middle River at Tracy Road for Alternative 1



Revised from June 1999 draft

Figure 5.3-11. Ranges of Salinity (expressed as EC) at Rock Slough for Alternative 1



from Jersey Point to Middle River at Tracy Road and CCFB) can be explained by the increased effects of salinity intrusion associated with water management Criterion B with storage.

As discussed for the Preferred Program Alternative, the quality of water in the Delta depends in large part on how circulation patterns in the Delta affect the movement and mixing of constituents that originate from different sources—including in-Delta, Bay, and tributary. The effect of the Alternative 1 on constituents, therefore, will vary—depending on how the alternative might alter the mixture of waters arriving at a given location.

Modeling indicates that, under Alternative 1, mean bromide concentrations at CCFB are predicted to be about 330 ug/L, compared to about 300 ug/L under the No Action Alternative. Under Alternative 1, therefore, mean bromide concentrations at the export facilities in the south Delta are predicted to increase by about 10%.

Data indicate that a major source of TOC at the export facilities is in-Delta drainage return (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will have limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, Alternative 1 includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at the export facilities.

The actual magnitudes of monthly variations in salinity, including bromide, from No Action Alternative conditions would depend on annual, seasonal, and geographically determined differences in the proportion of sea water present. Bromide is of particular concern to municipal water users because it is an inorganic precursor to several of the most potentially harmful known DBPs (for example, bromodichloromethane, bromate, and brominated halo-acetic acids—known for their roles as carcinogens and potential causes of increased birth defects).

Bay Region

With increased exports from the Delta, Alternative 1 could result in potentially significant impacts by reducing net Delta outflows, resulting in greater sea-water intrusion into the Bay. This could result in increases in salinity, including bromide, in San Francisco, San Pablo, and Suisun Bays.

The addition of new storage could improve water quality and dependent conditions for estuarine biological resources in the west Delta as a result of increased Delta outflows, especially during low-outflow periods.

Sacramento River Region

Impacts on water quality associated with Alternative 1 in the Sacramento River Region would be similar to those described for the Preferred Program Alternative.

San Joaquin River Region

General impacts of storage and conveyance options on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region under the Preferred Program Alternative. However, the potential for significant changes in the quality (and quantity) of the water exported to the region as a result of decisions made during the term of this Program is great, and other non-CALFED programs also will produce effects (see "Cumulative Impacts" in Section 5.3.10). As indicated in Table 5.3-5a, the average annual increase in the salinity of water exported to the San Joaquin River Region via the DMC (assuming an intertie with CCFB) compared to the No Action Alternative is projected to range from -2 to 13% for long term averages. The resultant net change in salt loads delivered to the valley is more difficult to project because it also would depend on changes in water deliveries, the locations where the water is applied, and source control actions taken. However, the effect would be to increase salt loads and the resultant recirculation of salts in the San Joaquin Valley.

The range of potential long-term water supply variations (possibly in the realm of 800 TAF of gains with new storage to 500 TAF of losses without new storage) and source-dependent water quality characteristics are sufficiently large to significantly degrade prevailing water quality and the resultant salt balance in the SWP and CVP service areas and throughout the San Joaquin Valley. The effects of the potential variations would be most pronounced in those areas that are already deficient in both quality and quantity of water. Resultant changes in land use in the service areas that could secondarily affect water quality, water supply, demands, and beneficial uses of water resources would in turn depend on the magnitude of the reductions in the quality of delivered water supplies. Despite the variability, overall degradation of water quality in the areas served by exports would adversely affect municipal, agricultural, and ecological uses of the water.

Other SWP and CVP Service Areas

Alternative 1 also could result in detrimental impacts on export water quality outside the Central Valley. Impacts on export water quality could result from the changes in flow and salinity patterns throughout the Delta as described above for the Delta Region. Potential impacts would be similar to but less than those described for the water service areas in the San Joaquin Valley. Increased fresh-water inflows from additional upstream releases from storage could reduce the magnitude of the effects in these areas.

Additional off-aqueduct storage could afford opportunities for additional pumping for storage during high-outflow periods when water quality is better and environmental constraints allow, for later use when Delta water quality or environmental conditions are less favorable.

Simulations of bromide concentrations at key Delta export facilities were calculated based on fingerprint modeling data for the alternatives completed in 1998. The data were analyzed for dry and critical years, the most critical times of high bromide concentrations. The data were updated for the most recent model results, using the bromide-to-EC ratios in the older modeling exercise and the EC values generated in the latest model exercise. Based on changes in EC, bromide concentrations would not differ significantly between the No Action Alternative and Alternative 1. The bromide concentrations at Contra Costa Canal under Alternative 1 are expected to be about 2.0 mg/L under both Criterion A and Criterion B scenarios during December, the month of highest projected bromide levels. The annual average bromide concentrations are projected to range from 0.64 to 0.89 mg/L under Criterion A and Criterion B, respectively.

At CCFB the peak bromide concentrations are projected to range from 1.2 to 1.3 mg/L under Criterion A and Criterion B, respectively. The annual bromide concentrations are projected to be about 0.64 mg/L for both Criterion A and Criterion B.

5.3.8.3 ALTERNATIVE 2

Delta Region

Based on the results of model runs, Alternative 2 generally would improve in-Delta and export water quality, and dependent beneficial uses because of the resultant increased inflows of higher quality water from the Sacramento River and north Delta, and the improved circulation in Delta channels. Potential improvements to Delta water quality would be greatest in the channels that convey water directly toward the pumps (primarily Old and Middle Rivers) and in the San Joaquin River in the central Delta. Potential improvements would be least in distant channels or areas that are isolated by constricted channels and reduced circulation. The magnitude of the changes would vary continuously throughout the Delta and would depend on the mixtures of source waters that result at each location, the pathways and timing of flows through Delta channels, and the locations and magnitudes of local discharges. Water quality improvements would be greatest where good-quality Sacramento River waters are drawn across the Delta (intermixing with San Joaquin River and other channel flows) to feed flows into the channels leading toward the diversion pumps. The amounts of improvement achieved would depend on the capacities of any north Delta and south Delta channel modifications and the locations, timing, and magnitude of any additional flow releases from upstream reservoirs. A shift in export water quality based on reduced San Joaquin River flows entering the pumps would allow selenium in the San Joaquin River to enter the Delta and Bay. Changes in EC values are based on modeling and indicate an expected value based on model data. The actual values expected in the field depend on many factors, some of which are not included in the model. Therefore, EC values in a specific area should be read as approximate values for that area. Comparing EC values between alternatives indicates relative change between alternatives, when keeping all model assumptions the same.

Table 5.3-6a summarizes the results of model predictions of salinity changes (expressed as EC) throughout the Delta for Alternative 2 compared to the No Action Alternative for a representative long-term hydrologic sequence that includes all water-year types (see Section 5.2). Separate predictions are shown based on modeling assuming water management Criterion A without storage, and water management Criterion B with storage, which define the bookends for the analysis of water quality. For both sets of criteria, changes are shown for the annual average value over the period of the simulation and for the month of the year when salinity is the highest.

Compared to the No Action Alternative, Table 5.3-6a shows that under Alternative 2, salinity is projected to improve throughout most of the Delta and at the export facilities. For example, at CCFB, the mean long-term salinity is projected to decrease by 140-180 μmhos/cm (25-34%), and the mean monthly salinity for December, the month of highest projected salinities, is projected to decrease by 470-560 μmhos/cm (48-59%). During dry and critical years, Table 5.3-6b shows that salinity is projected to decrease by 170-220 μmhos/cm (25-35%) for the long term, and to decrease by 560-660 μmhos/cm (48-60%) on average for the month of maximum salinity, December. The improvement in water quality is caused by increased flows of higher quality water across the Delta from the Mokelumne and Sacramento Rivers southward, and the improved water circulation in affected Delta channels. Based on these comparisons, potential

Table 5.3-6a. Predicted Salinity Changes Between Alternative 2 and the No Action Alternative for All Water-Year Types (Salinity Expressed as EC)

DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
		AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT [†] ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	Jan	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	10	0	-50	0%	3%	0%	-15%	Mar	B
Mokelumne River at Terminous	8	0	-20	-10	-50	0%	-9%	-6%	-23%	Jan	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-50	-360	-70	-410	-12%	-53%	-17%	-62%	Dec	B
Turner Cut	29	10	-180	0	-300	2%	-26%	0%	-46%	Jan	LTS - B
San Joaquin River at Prisoner's Point	12	-140	-540	-230	-680	-30%	-57%	-50%	-73%	Dec	B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	0	40	170	-2%	0%	6%	24%	Aug	LTS - PS
San Joaquin River at Brandt Bridge	10	20	30	50	-10	3%	4%	8%	-1%	Dec	LTS
Middle River at Tracy Road	21	-80	-380	-120	-460	-16%	-47%	-25%	-58%	Jan	B
Grant Line Canal at Tracy Road	24	-50	-150	-30	-230	-8%	-21%	-5%	-33%	Nov	LTS - B
Old River at Tracy Road	17	-60	-130	-30	-210	-10%	-18%	-5%	-30%	Nov	LTS - B
Old River at Rock Slough	19	-180	-610	-270	-780	-30%	-52%	-46%	-67%	Dec	B
Contra Costa Canal Intake at Rock Slough	28*	-180	-590	-270	-760	-28%	-49%	-43%	-65%	Dec	B
Old River at SR 4 (and New CCWD Intake)	18*	-160	-550	-230	-700	-27%	-51%	-41%	-66%	Dec	B
Clifton Court Forebay	27*	-140	-470	-180	-560	-25%	-48%	-34%	-59%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-100	-340	-210	-500	-17%	-37%	-37%	-56%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	50	-30	260	510	6%	-1%	29%	25%	Sep	LTS - PS
Sacramento River at Collinsville	4	50	-70	200	410	2%	-1%	7%	7%	Sep	LTS
San Joaquin River at Jersey Point	14	-210	-700	-460	-1270	-20%	-31%	-43%	-57%	Dec	B
San Joaquin River at Antioch	15	-70	-60	-310	-800	-3%	-1%	-13%	-17%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-190	170	60	350	-2%	1%	0%	2%	Sep	LTS
Carquinez Strait at Martinez	6	-40	390	160	380	0%	2%	1%	2%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.
[†] LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-6b. Predicted Salinity Changes Between Alternative 2 and the No Action Alternative for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	**STATION NO.**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**MONTH OF MAXIMUM EC**	**IMPACT † ASSESSMENT**
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	0	10	10	-40	0%	4%	5%	-16%	Mar	LTS - B
Mokelumne River at Terminous	8	0	-30	-20	-60	0%	-13%	-11%	-26%	Feb	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-60	-450	-90	-500	-12%	-56%	-20%	-65%	Dec	B
Turner Cut	29	0	-310	-10	-440	0%	-38%	-2%	-59%	Jan.	LTS - B
San Joaquin River at Prisoner's Point	12	-180	-670	-290	-840	-33%	-58%	-54%	-75%	Dec	B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	70	280	-3%	0%	9%	35%	Aug	LTS - PS
San Joaquin River at Brandt Bridge	10	20	0	80	-40	3%	0%	11%	-5%	Feb	LTS - PS
Middle River at Tracy Road	21	-110	-420	-160	-570	-19%	-43%	-30%	-61%	Jan.	B
Grant Line Canal at Tracy Road	24	-80	0	-40	-30	-11%	0%	-5%	-3%	Feb	LTS - B
Old River at Tracy Road	17	-90	0	-40	-30	-12%	0%	-5%	-3%	Feb	LTS - B
Old River at Rock Slough	19	-220	-740	-340	-950	-31%	-52%	-50%	-69%	Dec	B
Contra Costa Canal Intake at Rock Slough	28*	-220	-720	-330	-920	-29%	-51%	-46%	-68%	Dec	B
Old River at SR 4 (and New CCWD Intake)	18*	-200	-670	-590	-840	-29%	-52%	-62%	-68%	Dec	B
Clifton Court Forebay	27*	-170	-560	-220	-660	-25%	-48%	-35%	-60%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-120	-410	-260	-590	-17%	-38%	-39%	-58%	Jan.	B
WESTERN DELTA, SUISUN BAY AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	50	-100	310	500	4%	-4%	26%	18%	Sep	LTS - PS
Sacramento River at Collinsville	4	20	-230	180	250	1%	-3%	5%	3%	Sep	LTS
San Joaquin River at Jersey Point	14	-280	-890	-580	-1610	-21%	-31%	-42%	-57%	Dec	B
San Joaquin River at Antioch	15	-130	-80	-450	-990	-4%	-1%	-14%	-18%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-350	-220	-100	-40	-2%	-1%	-1%	0%	Sep	LTS
Carquinez Strait at Martinez	6	-170	-20	10	10	-1%	0%	0%	0%	N/A	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† *LTS - All impacts within ±10%*
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

benefits to Delta water quality compared to the No Action Alternative would be greatest in the south Delta, especially in Old River and in other southwest Delta channels that convey water directly toward the pumps. Salinities also would be substantially reduced in Middle River in the southeast Delta, and also in the south Delta channels where circulation could be further improved by the installation of optional tidal flow control facilities. Salinities would be reduced in the San Joaquin River in the west Delta, where the intrusion of ocean salts from the Bay would be lessened by reductions in net tidal flow reversals.

Potentially significant adverse impacts on average annual salinities would be restricted primarily to Vernalis and to the lower Sacramento River (for example, Emmaton) due to the diversion of upstream flows into the central and south Delta.

Whereas the above tables show the salinity changes relative to the No Action Alternative, Figures 5.3-12 through 5.3-16 show the range of predicted mean annual and peak EC values (μs/cm) for Alternative 2 and the No Action Alternative at the following five stations respectively: Old River at CCFB, San Joaquin River at Prisoner's Point, San Joaquin River at Jersey Point, Middle River at Tracy Road, and Old River at Rock Slough. These locations were selected to be representative of locations in the central, south, and west Delta, including export locations.

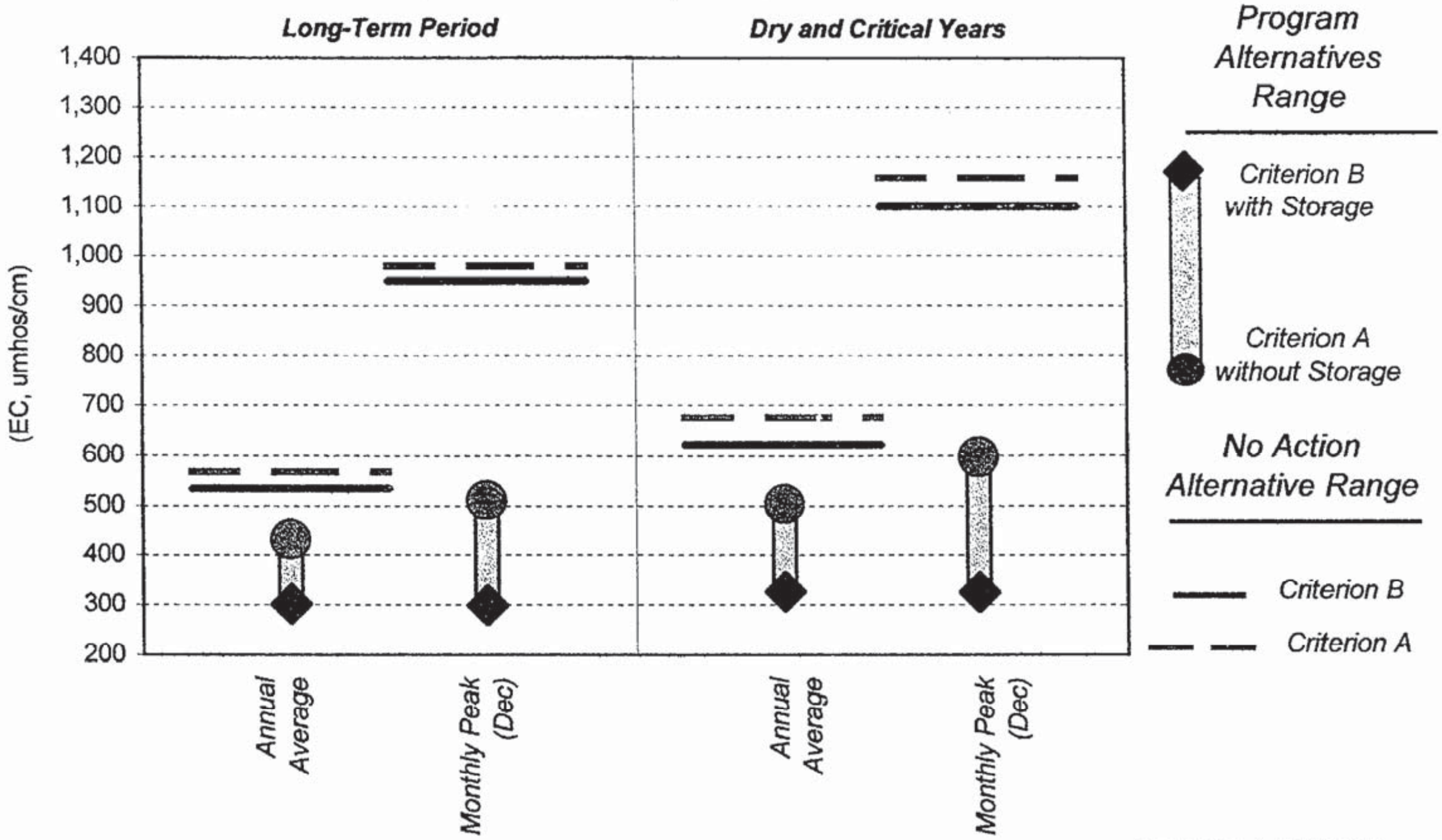
The range of values for each alternative indicated in the figures are indicative of the range of uncertainty. In general, the ranges do not overlap, indicating that EC values under Alternative 2 are distinctly different (and lower) than under the No Action Alternative. Although improvements are indicated at all five stations, the effects of improved conveyance are seen most dramatically at the San Joaquin River at Jersey Point. These figures also show that this alternative performs even better during dry and critical years.

As discussed for the Preferred Program Alternative, the quality of water in the Delta depends in large part on how circulation patterns in the Delta affect the movement and mixing of constituents originating from different sources, including in-Delta sources, Bay sources, and tributary sources. The effect of Alternative 2 on constituents therefore will vary, depending on how the alternative might alter the mixture of waters arriving at a given location.

Modeling indicates that, under Alternative 2, mean bromide concentrations at CCFB are predicted to be about 150 ug/L, compared to about 300 ug/L under the No Action Alternative. Under Alternative 2, therefore, mean bromide concentrations at the export facilities in the south Delta are predicted to decrease by about 50%.

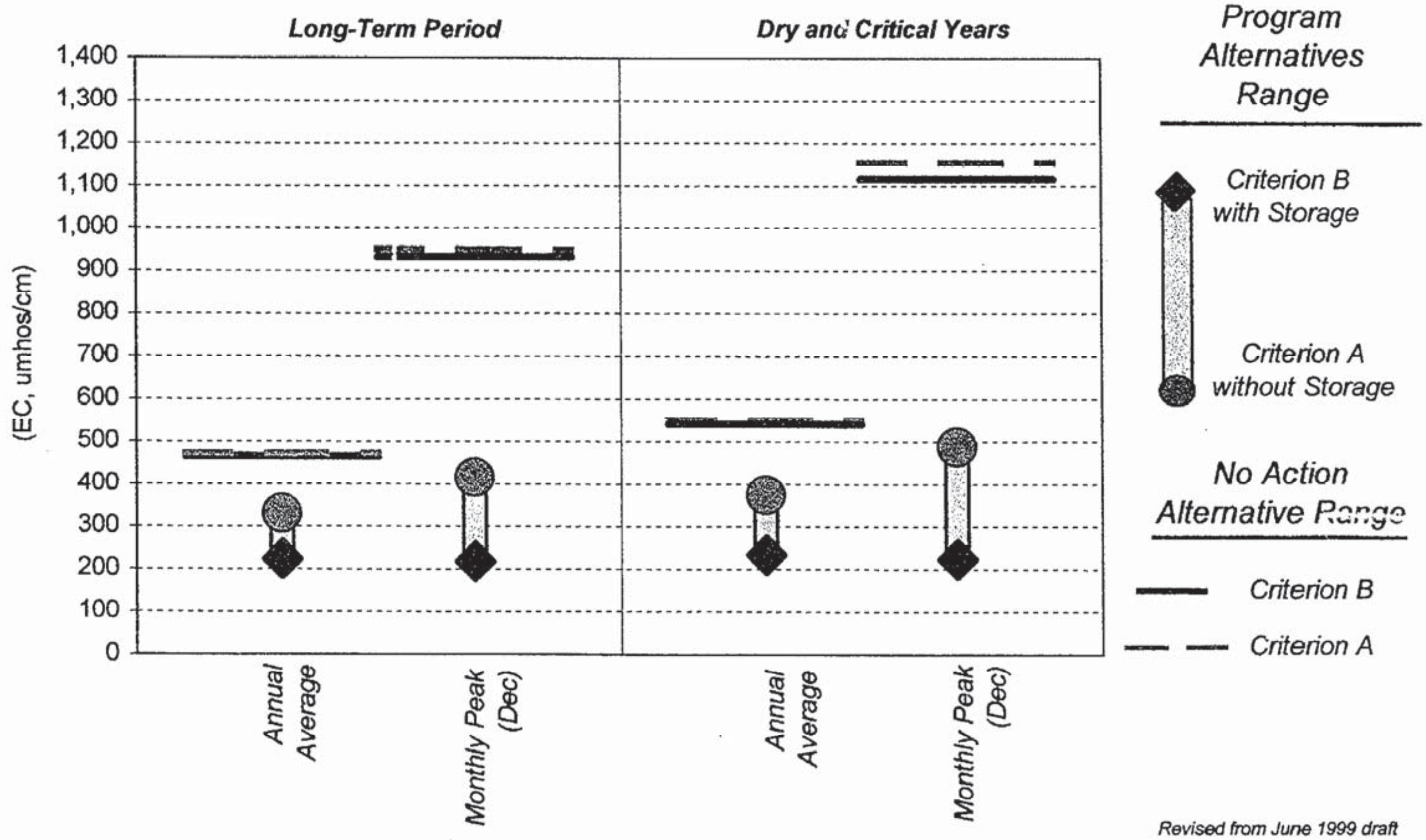
Data indicate that a major source of TOC at the export facilities is in-Delta drainage return (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will have limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, Alternative 2 includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at the export facilities.

Figure 5.3-12. Ranges of Salinity (expressed as EC) at Clifton Court Forebay for Alternative 2



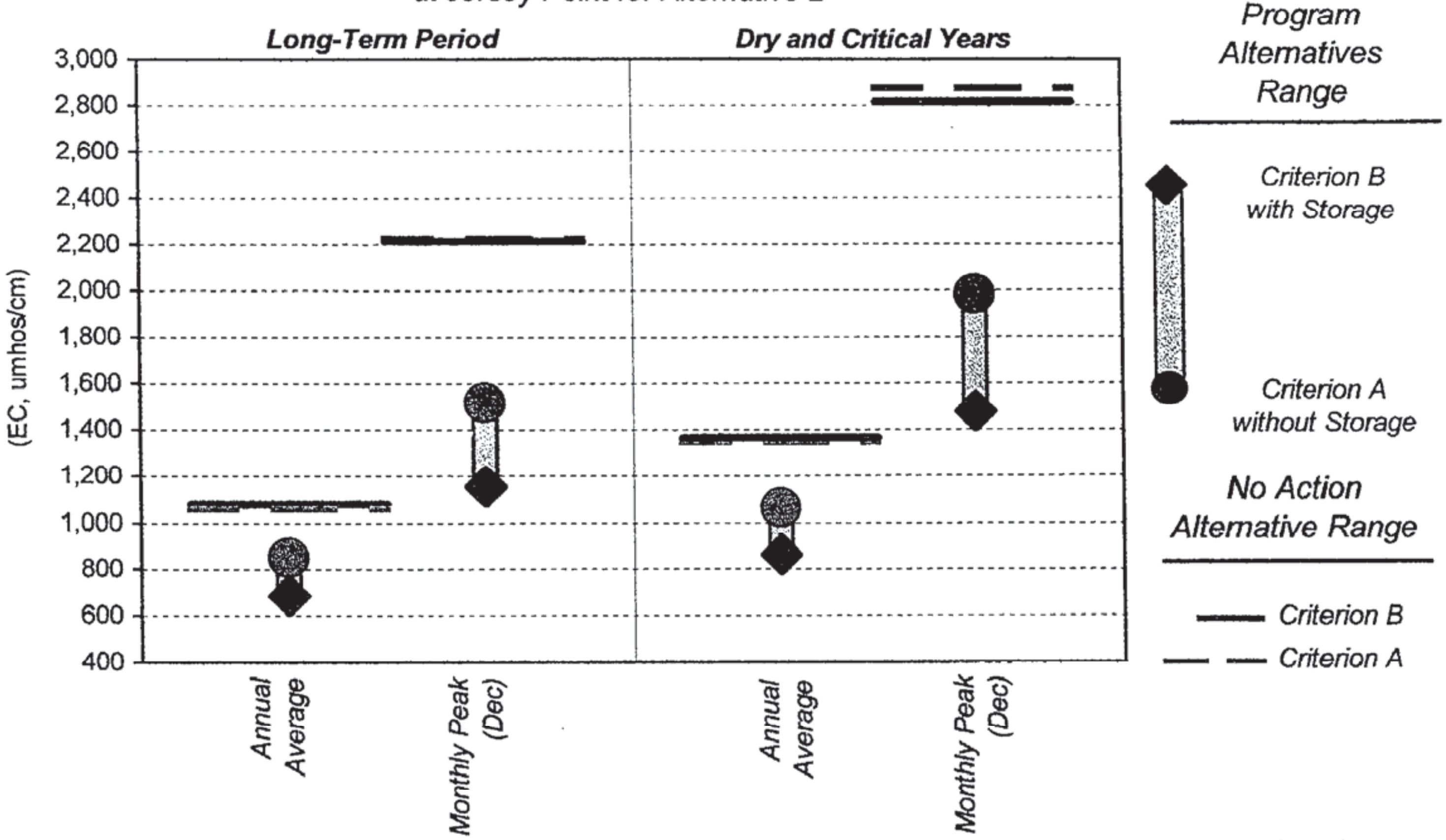
Revised from June 1999 draft

Figure 5.3-13. Ranges of Salinity (expressed as EC) at Prisoner's Point for Alternative 2



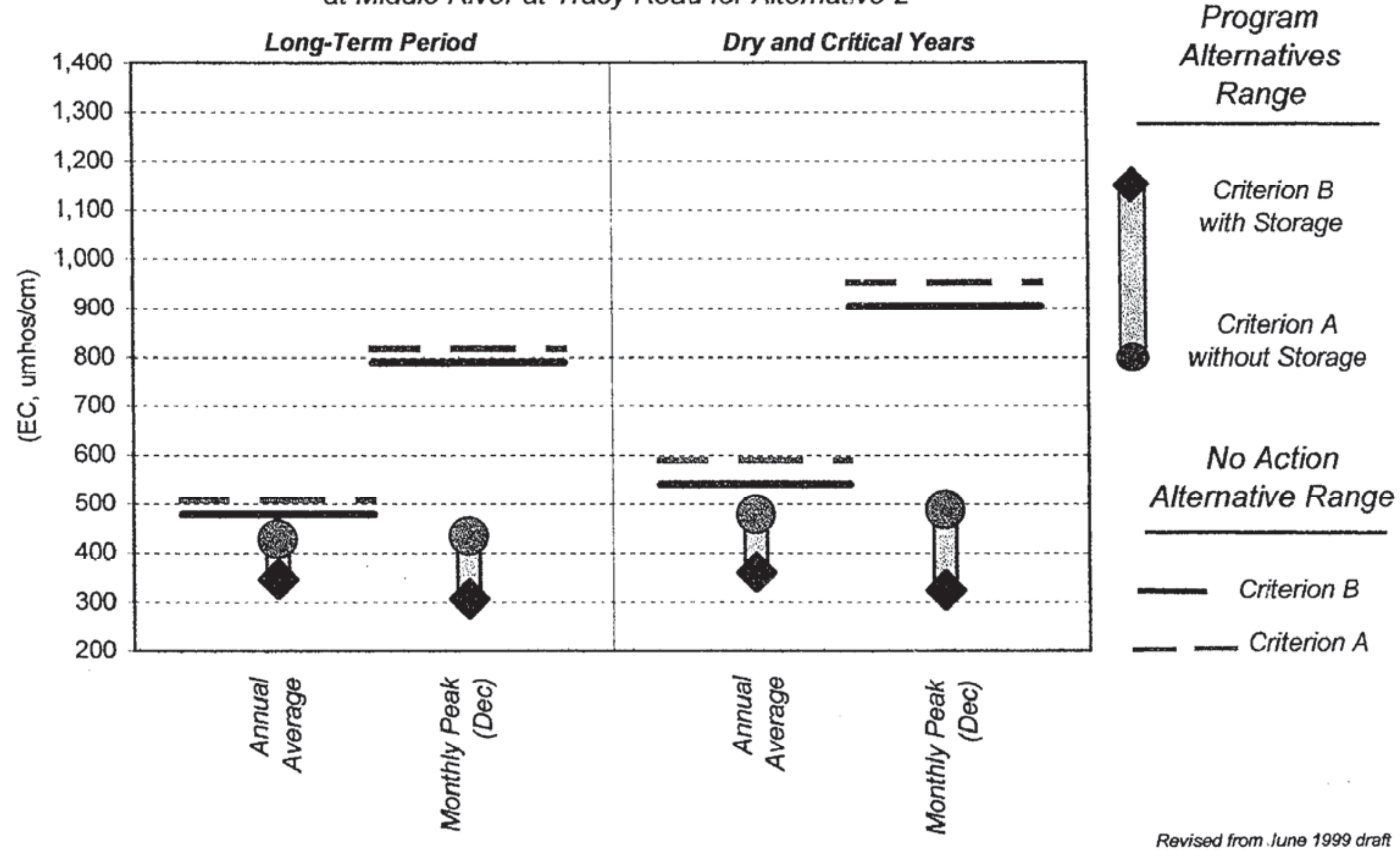
Revised from June 1999 draft

Figure 5.3-14. Ranges of Salinity (expressed as EC) at Jersey Point for Alternative 2



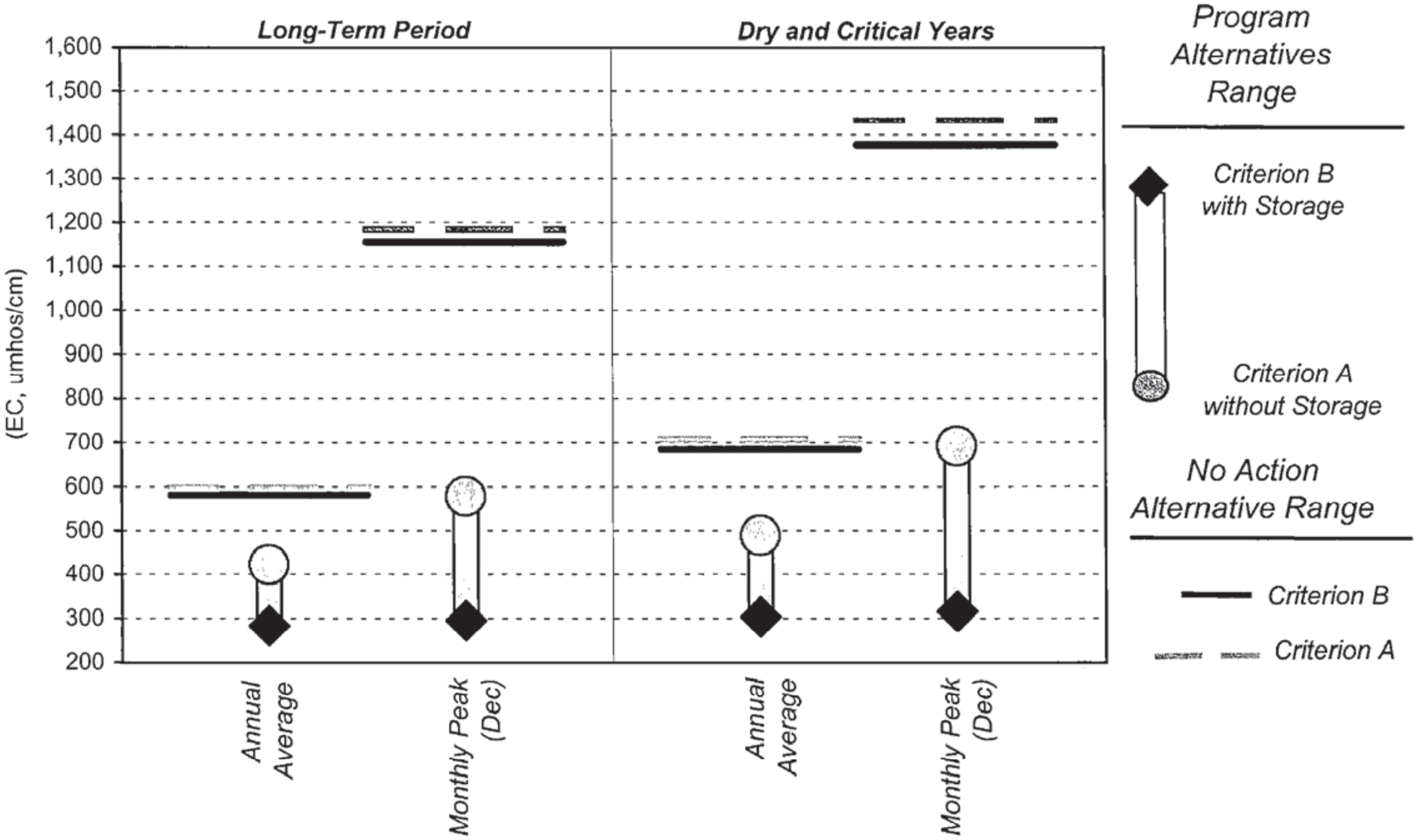
Revised from June 1999 draft

Figure 5.3-15. Ranges of Salinity (expressed as EC) at Middle River at Tracy Road for Alternative 2



Revised from June 1999 draft

Figure 5.3-16. Ranges of Salinity (expressed as EC) at Rock Slough for Alternative 2



Bay Region

With increased exports from the Delta, Alternative 2 could result in potentially significant impacts by reducing net Delta outflows, resulting in greater sea-water intrusion into the Bay. This could result in increases in salinity in San Francisco, San Pablo, and Suisun Bays.

The addition of new storage could improve water quality in the west Delta as a result of increased Delta outflows, especially during low-outflow periods.

Sacramento River Region

Impacts of Alternative 2 in the Sacramento River Region would be similar to those described for the Preferred Program Alternative.

San Joaquin River Region

General impacts of the Storage and Conveyance elements on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region. However, the potential for significant changes in the quality (and quantity) of the water exported to the region as a result of decisions made during the term of this Program is great, and other non-CALFED programs also will produce effects (see "Cumulative Impacts" in Section 5.3.10). As indicated in Table 5.3-6a, there is a significant projected decrease in salinity (ranging from 17 to 37%) of water exported to the San Joaquin River. The resultant net change in salt loads delivered to the San Joaquin Valley is difficult to project because it would depend on water delivery operations, and other factors; however, based on this analysis alone, long-term salinity loads to the Valley could be significantly reduced. Overall improvements in water quality in the areas served by exports would benefit municipal, agricultural, and ecological uses of the water. Improvements also would reduce salt loads entering the basin and reduce the amount of salt recirculation that occurs between the basin and the Delta.

Other SWP and CVP Service Areas

Alternative 2 also would result in beneficial impacts on export water quality outside the Central Valley. Benefits would result from the improved export water quality as described for the Delta Region. Benefits and potential impacts would be similar to those described earlier for the water service areas in the San Joaquin Valley. Overall water quality improvement benefits should be somewhat greater because more of these service areas are served by SWP exports from CCFB, which receives higher quality water than the CVP.

Simulations of bromide concentrations at key Delta export facilities were calculated based on fingerprint modeling data for the alternatives completed in 1998. The data were analyzed for dry and critical years, the most critical times of high bromide concentrations. The data were updated for the most recent model results, using the bromide-to-EC ratios in the older modeling exercise and the EC values generated in the latest model exercise. Based on changes in EC, bromide concentrations would not differ significantly between the No Action Alternative and Alternative 1. The bromide concentrations at Contra Costa

Canal under Alternative 2 are expected to range from 0.59 to 0.44 mg/L under Criterion A and Criterion B, respectively, during December, the month of highest projected bromide levels. These concentrations represent a 71% and 78% drop, respectively, from the bromide concentrations under Alternative 1. The annual average bromide concentrations are projected to range from 0.38 to 0.30 mg/L under Criterion A and Criterion B, respectively. These concentrations represent a 39% and 66% drop, respectively, from concentrations in Alternative 1.

At CCFB, the peak bromide concentrations are projected to range from 0.39 to 0.30 mg/L under Criterion A and Criterion B, respectively. These concentrations represent a projected 68% and 76% drop, respectively, in bromide compared to Alternative 1. The annual bromide concentrations are projected to range from 0.36 to 0.27, respectively, for Criterion A and Criterion B. These concentrations represent a 43% and 58% drop, respectively, in bromide compared to Alternative 1.

5.3.8.4 ALTERNATIVE 3

Delta Region

Water quality would be affected by the capacity of the isolated facility, the number and type of south Delta water quality control facilities; Delta facility and pump operations; local discharges; and the locations, timing, and magnitudes of any additional flow releases from upstream reservoirs.

Water quality conditions in the Delta would be best where and when good-quality water, primarily from the Sacramento River, can be at least partially tapped to flow in optimal patterns through the Delta to discharge to Suisun Bay and toward the diversion pumps. The actual water quality improvements achieved would depend on the capacities and configurations selected for north Delta and south Delta channel modifications. A shift in export water quality based on reduced San Joaquin River flows entering the pumps would allow selenium in the San Joaquin River to enter the Delta and Bay. Changes in EC values are based on modeling and indicate an expected value based on model data. The actual values expected in the field depend on many factors, some of which are not included in the model. Therefore, EC values in a specific area should be read as approximate values for that area. Comparing EC values between alternatives indicates relative change between alternatives, when keeping all model assumptions the same.

Consistent with prior analysis, Table 5.3-7a summarizes the results of model predictions of average salinity changes (expressed as EC) throughout the Delta for Alternative 3 compared to the No Action Alternative for a representative long-term hydrologic sequence that includes all water-year types. Separate sets of predictions are shown based on modeling assuming water management Criterion A without storage, and water management Criterion B with storage, which define the bookends for the analysis of water quality. For both sets of criteria, changes are shown for the annual average value over the period of the simulation, and for the month of the year when salinity is the highest. Salinity increases or decreases of more than 10% are considered to be significantly adverse or beneficial, respectively, as shown in the table.

Compared to the No Action Alternative, Table 5.3-7a shows that under Alternative 3, salinities are projected to increase in the northeast Delta (especially in the lower Mokelumne River), at most stations in the central Delta, and in the south Delta in Middle River at Tracy Road. For example, on the San Joaquin River at Turner Cut, the mean long-term salinity is projected to increase by 110-130 µmhos/cm

Table 5.3-7a. Predicted Salinity Changes Between Alternative 3 and the No Action Alternative for All Water-Year Types (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough*	7*	0	0	0	0	0%	0%	0%	0%		LTS
Mokelumne River at Terminous	8	30	50	30	40	17%	23%	17%	19%	Jan	PS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	90	-50	80	-50	21%	-7%	20%	-8%	Dec	LTS - PS
Turner Cut	29	130	90	110	40	27%	13%	25%	6%	Jan	LTS - PS
San Joaquin River at Prisoner's Point	12	-120	-530	-30	-250	-25%	-56%	-6%	-27%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-10	0	-10	0	-2%	0%	-2%	0%	N/A	LTS
San Joaquin River at Brandt Bridge	10	20	30	10	10	3%	4%	2%	1%	Dec	LTS
Middle River at Tracy Road	21	80	-50	30	-50	16%	-6%	6%	-6%	Jan	LTS - PS
Grant Line Canal at Tracy Road	24	-10	0	-40	0	-2%	0%	-6%	0%	N/A	LTS
Old River at Tracy Road	17	-10	10	-40	0	-2%	1%	-6%	0%	Dec	LTS
Old River at Rock Slough	19	-140	-650	-50	-320	-23%	-55%	-9%	-28%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough*	28*	-130	-610	-50	-320	-20%	-50%	-8%	-27%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	-80	-480	-30	-280	-14%	-44%	-5%	-26%	Dec	LTS - B
Clifton Court Forebay*	27*	-390	-830	-280	-640	-69%	-85%	-53%	-67%	Dec	B
Delta-Mendota Canal Intake from Old River*	26*	-240	-480	-90	-260	-40%	-53%	-16%	-29%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	-100	-790	90	-340	-11%	-39%	10%	-17%	Sep	LTS - B
Sacramento River at Collinsville	4	-500	-2030	170	-700	-18%	-36%	6%	-12%	Sep	LTS - B
San Joaquin River at Jersey Point	14	-590	-1550	-190	-670	-56%	-68%	-18%	-30%	Nov	B
San Joaquin River at Antioch	15	-800	-1620	-20	20	-34%	-33%	-1%	0%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-670	-1730	410	-370	-6%	-9%	3%	-2%	Sep	LTS
Carquinez Strait at Martinez	6	-520	-1250	500	-190	-3%	-5%	3%	-1%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-7b. Predicted Salinity Changes Between Alternative 3 and the No Action Alternative for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	**STATION NO.**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**MONTH OF MAXIMUM EC**	**IMPACT † ASSESSMENT**
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%		LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough*	7*	0	0	-10	-10	0%	0%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	30	60	40	60	16%	26%	21%	26%	Jan	PS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	110	-120	110	-60	22%	-15%	24%	-8%	Dec	LTS - PS
Turner Cut	29	150	150	150	170	26%	20%	29%	26%	Feb	PS
San Joaquin River at Prisoner's Point	12	-170	-700	-50	-350	-31%	-61%	-9%	-31%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	10	-3%	0%	-3%	1%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	0	20	10	3%	0%	3%	1%	Feb	LTS
Middle River at Tracy Road	21	110	-100	40	-80	19%	-10%	7%	-9%	Jan.	LTS - PS
Grant Line Canal at Tracy Road	24	-10	0	-60	10	-1%	0%	-8%	1%	Feb	LTS
Old River at Tracy Road	17	-10	10	-70	10	-1%	1%	-9%	1%	Feb	LTS
Old River at Rock Slough	19	-180	-840	-60	-420	-25%	-59%	-9%	-31%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough*	28*	-160	-800	-60	-420	-21%	-56%	-8%	-31%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)*	18*	-110	-650	-40	-360	-16%	-50%	-6%	-29%	Dec	LTS - B
Clifton Court Forebay*	27*	-490	-1000	-360	-790	-72%	-86%	-58%	-72%	Dec	B
Delta-Mendota Canal Intake from Old River*	26*	-290	-570	-140	-380	-41%	-53%	-21%	-37%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	-150	-1240	80	-780	-13%	-45%	7%	-28%	Sep	LTS - B
Sacramento River at Collinsville	4	-690	-2870	100	-1700	-18%	-40%	3%	-24%	Sep	LTS - B
San Joaquin River at Jersey Point	14	-780	-2030	-280	-870	-58%	-71%	-21%	-31%	Dec	B
San Joaquin River at Antioch	15	-1080	-1700	-150	130	-34%	-30%	-5%	2%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-910	-2590	320	-1450	-6%	-13%	2%	-7%	Sep	LTS - B
Carquinez Strait at Martinez	6	-740	-2040	420	-1120	-4%	-8%	2%	-4%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.
† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

(25-29%); and the mean monthly salinity for January, the month of highest project salinities, is projected to increase by about 40-90 μmhos/cm (6-13%).

Salinities are projected to decrease and produce beneficial effects in the southwest Delta, all export locations, and throughout the west Delta most of the time. For example, on Old River at Rock Slough, the mean long term salinity is projected to decrease by 50-140 μmhos/cm (9-23%), and the mean monthly salinity for December, the month of highest projected salinities, is projected to decrease by about 320-610 μmhos/cm (27-50%).

During dry and critical years, Table 5.3-7b shows that the increases in salinity at Turner Cut and the decreases in salinity on Old River near the intake to the Contra Costa Canal off Rock Slough become even larger. They range from increases of 150 μmhos/cm (26-29%) for the long term and from 150 to 170 μmhos/cm (20-26%) on average for the month of February to decreases of 60-180 μmhos/cm (9-25%) for the long term and from 420 to 840 μmhos/cm (31-59%) on average for the month of December. The increases in salinity cause one impact assessment adjective in the table to change from less than significant to beneficial in Suisun Bay at Port Chicago in September. Significant improvements during months of maximum salinity are projected to occur during December, or from September through October. However, changes during other months may be both significant and larger.

Water quality is projected to improve most dramatically at CCFB due to the transfer of high-quality water from the vicinity of Hood both around and through the Delta to be blended with Old River water at ratios varying from 50:50 to 95:05. Long-term improvements are projected to range from 280 to 390 μmhos/cm (53-69%), and monthly improvements are projected to range from 640 to 830 μmhos/cm (67-85%) during December, the month of maximum salinity concentrations.

Through careful water management, Alternative 3 is projected to improve both in-Delta and export water quality and dependent beneficial uses because of the overall resultant increases in the flow and export of good-quality water from the north Delta (especially with new upstream storage). Other contributing factors include corresponding decreases in the quantities of sea-water intrusion caused by reverse flows in the west Delta, and improved water circulation in many affected Delta channels.

Potential improvements in Delta water quality compared to the No Action Alternative would be greatest in the southwest Delta, especially in the Old River and the other southwest Delta channels that convey water directly toward the export pumps.

The actual magnitudes of the salinity changes would vary tidally, seasonally, and spatially throughout the Delta, depending on factors such as the mixtures of source waters attained at each location that result from variations in the pathways and timing of flows through Delta channels. The magnitude of the changes also would depend on variations in annual hydrology. In general, the improvements in water quality would increase during dry and critical years, and be attenuated during above-normal and wet years.

Whereas the above tables show the salinity changes relative to the No Action Alternative, Figures 5.3-17 through 5.3-21 show the predicted ranges of mean annual and peak EC values (μs/cm) for Alternative 3 and the No Action Alternative at the following five stations respectively: Old River at CCFB, San Joaquin River at Prisoner's Point, San Joaquin River at Jersey Point, Middle River at Tracy Road, and Old River at Rock Slough. These locations were selected to be representative of locations in the central, south, and west Delta, including several key export locations.

Figure 5.3-17. Ranges of Salinity (expressed as EC) at Clifton Court Forebay for Alternative 3

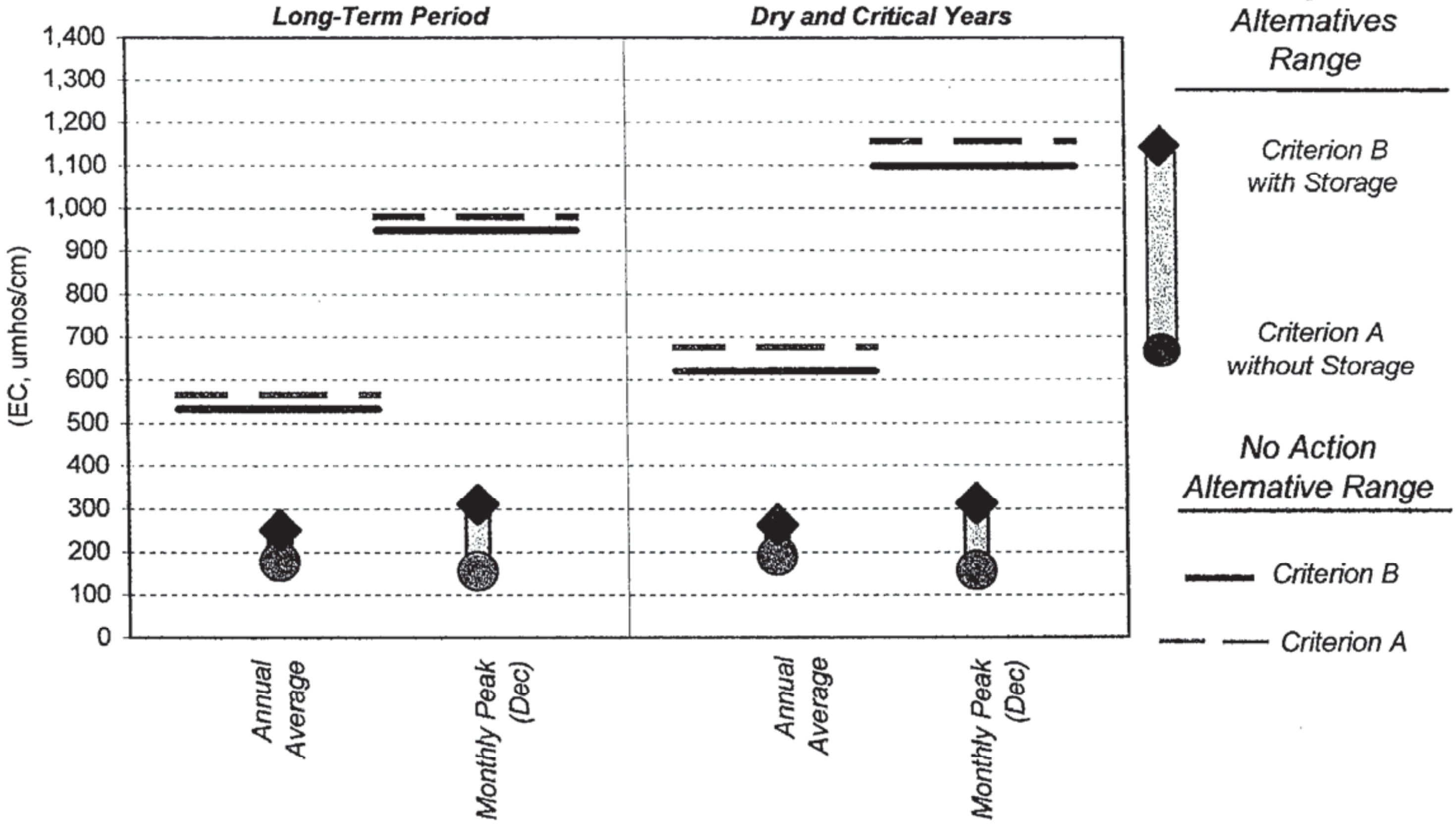


Figure 5.3-18. Ranges of Salinity (expressed as EC) at Prisoner's Point for Alternative 3

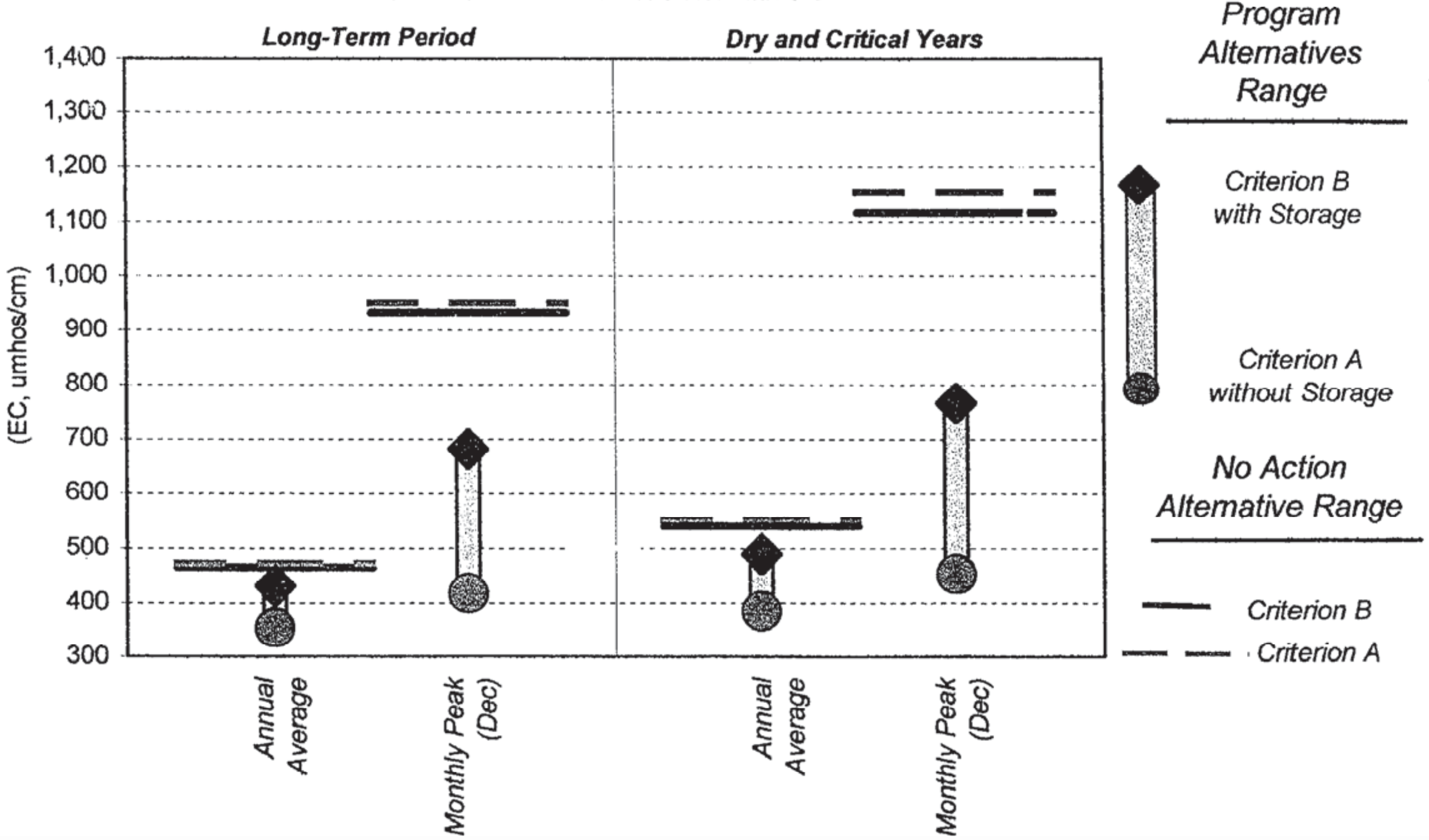
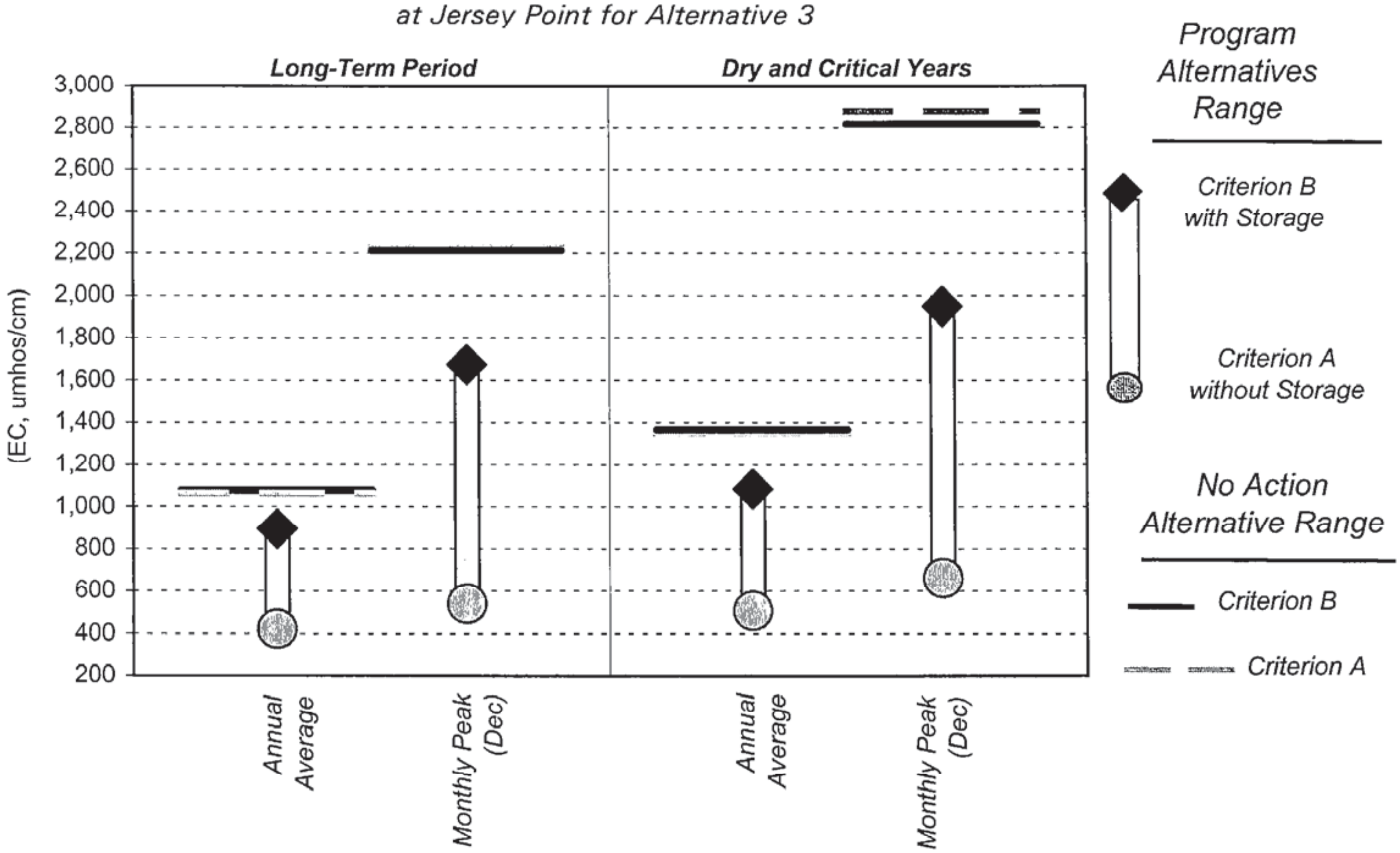
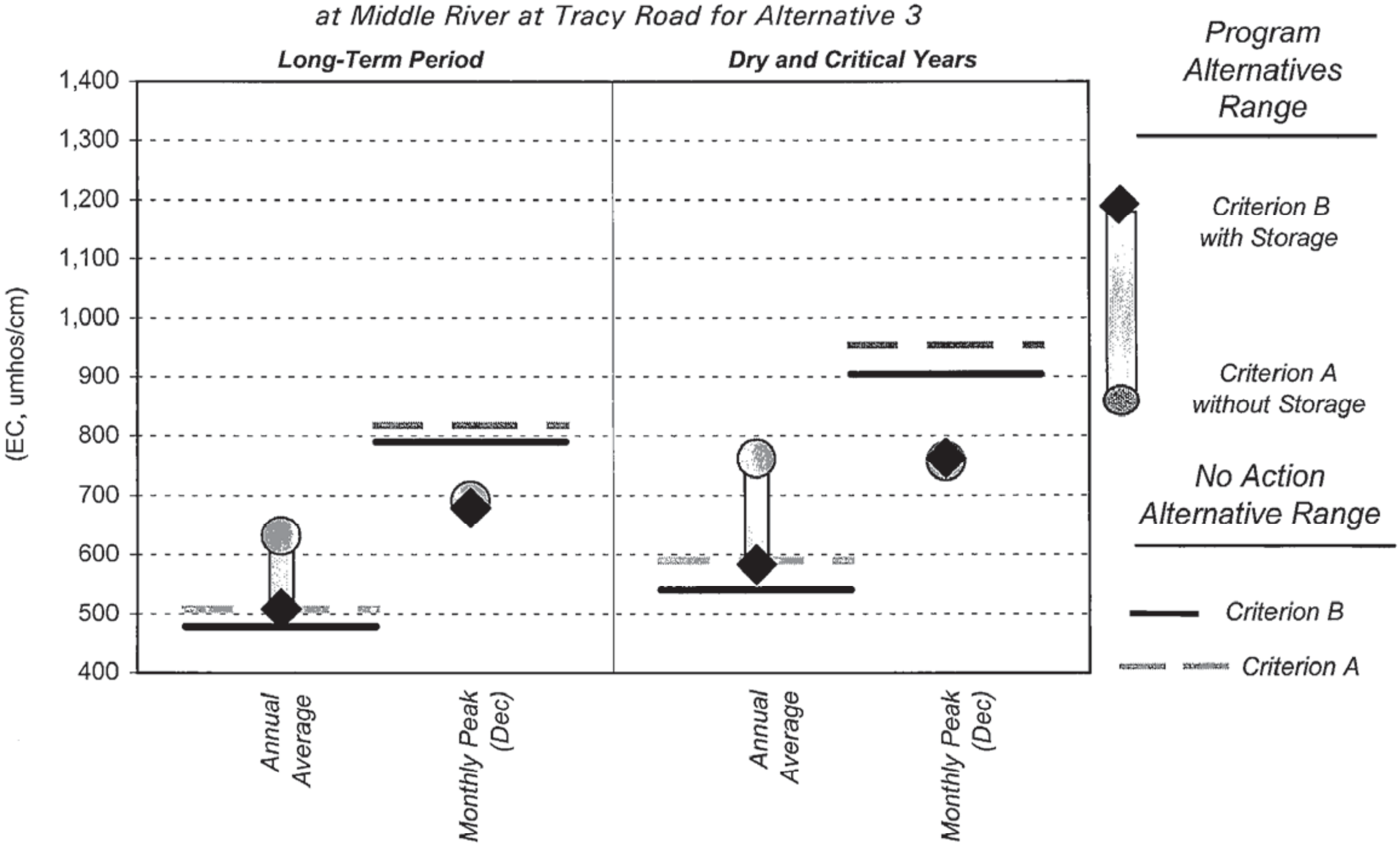


Figure 5.3-19. Ranges of Salinity (expressed as EC) at Jersey Point for Alternative 3



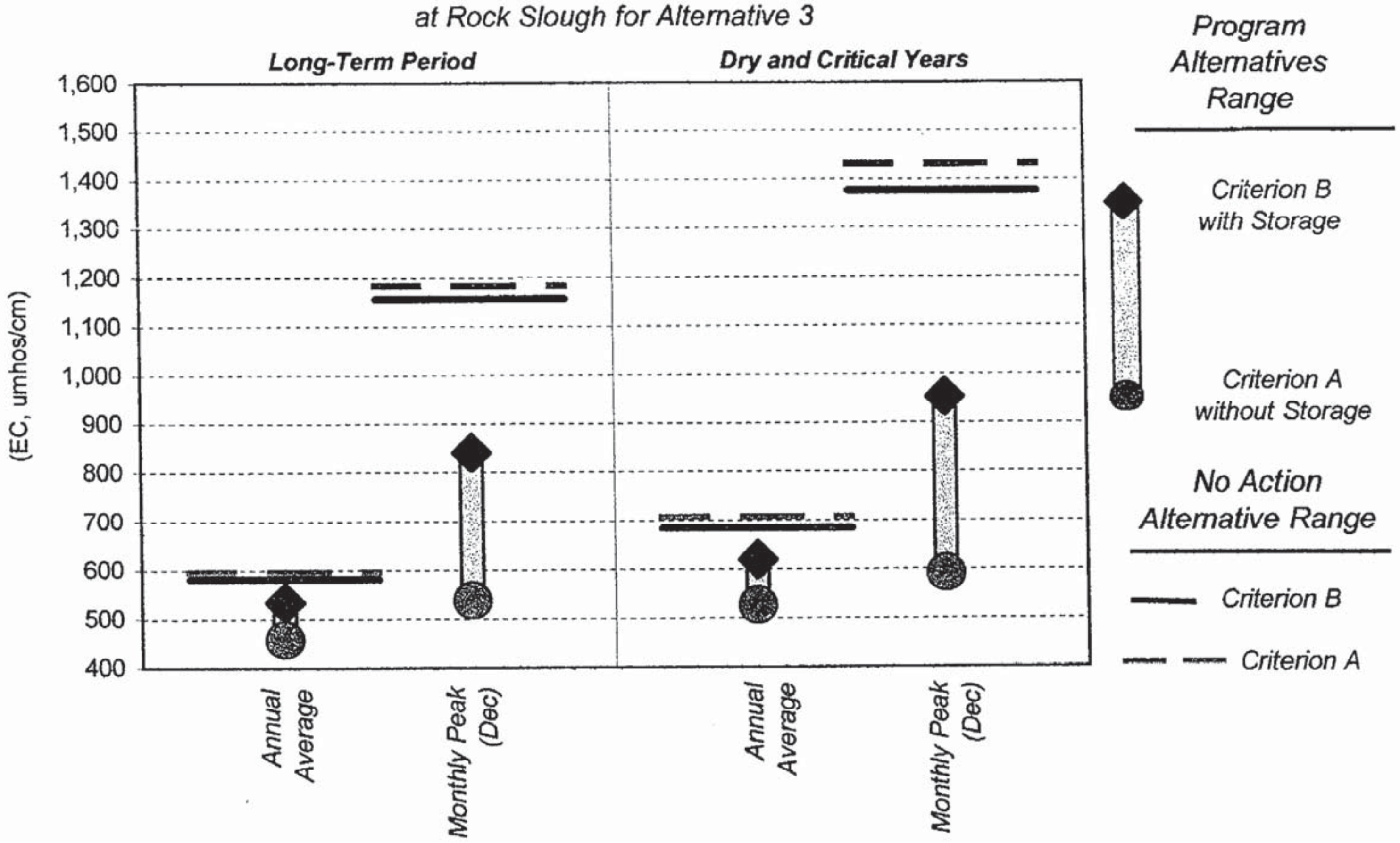
Revised from June 1999 draft

Figure 5.3-20. Ranges of Salinity (expressed as EC) at Middle River at Tracy Road for Alternative 3



Revised from June 1999 draft

Figure 5.3-21. Ranges of Salinity (expressed as EC) at Rock Slough for Alternative 3



The range of values for each alternative plotted in the figures are indicative of the range of uncertainty in potential outcomes considering variations in conveyance capacities, storage, hydrology, and water management and operations. At Middle River at Tracy Road Bridge, the Preferred Program Alternative ranges for the long term overlap with the No Action Alternative range and are somewhat higher. The monthly peak ranges at Middle River at Tracy Road Bridge and all ranges at the remaining selected stations do not overlap, and the Alternative 3 ranges (in the southwest Delta, west Delta, and San Joaquin in the central Delta) are distinctly lower than those of the No Action Alternative. This indicates that the EC values under Alternative 3 are definitively lower at these stations than those of the No Action Alternative. The distribution of the ranges (that is, decreasing from Jersey Point to Middle River at Tracy Road and CCFB) can be explained by the decreased effects of salinity intrusion associated with water management Criterion B with storage.

As discussed for the Preferred Program Alternative, the quality of water in the Delta depends in large part on how circulation patterns in the Delta affect the movement and mixing of constituents originating from different sources, including in-Delta sources, Bay sources, and tributary sources. The effect of Alternative 3 on constituents therefore will vary, depending on how the alternative might alter the mixture of waters arriving at a given location.

Modeling indicates that, under Alternative 3, mean bromide concentrations are predicted to be about 40 ug/L at CCFB, compared to about 300 ug/L under the No Action Alternative (about 90% reduction); and about 350 ug/L at Contra Costa Canal Intake at Rock Slough, compared to about 450 ug/L under the No Action Alternative (about a 30% reduction).

Bay Region

With increased exports from the Delta, Alternative 3 could slightly reduce net Delta outflows, resulting in greater sea-water intrusion into the Bay and resultant increases in salinity in San Francisco, San Pablo, and Suisun Bays (Suisun Bay is contiguous with Delta channels and diversion points). However, these increases are projected to be less than significant because of the application of environmental and water quality standards would preclude any facility operations that could cause adverse impacts in the Bay Region.

The addition of new storage could improve water quality and dependent conditions for estuarine biological resources in the west Delta as a result of increased Delta outflows, especially during low-outflow periods.

Sacramento River Region

Impacts on water quality associated with Alternative 3 in the Sacramento River Region would be similar to those described for the Preferred Program Alternative.

San Joaquin River Region

General impacts of storage and conveyance options on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region under the Preferred Program Alternative. However, as indicated in Table 5.3-7a, the average annual decrease in the salinity of water exported to the San Joaquin River Region via the California Aqueduct and the DMC compared to the No Action Alternative is projected to range from 16 to 74% over the long term (see table for predicted ECs). The resultant net reduction in salt loads delivered to the valley is more difficult to project because it also would depend on changes in water deliveries, the locations where the water is applied, and source control actions taken. However, the overall effect would be to dramatically decrease salt loads and the resultant recirculation of salts in the San Joaquin Valley and River.

Use of the isolated facility would reduce the recirculation of contaminants contained in San Joaquin River flows by greatly reducing the return of river outflows to the vicinity of the export pumps. Instead, San Joaquin River flows would drain in a more natural pattern toward the Bay and the ocean. The resultant low salinity and associated constituent concentrations in the exported water would greatly reduce demands on treatment technologies; reduce costs; enable more efficient use to be made of existing supplies; and increase the potential for conjunctive use, source water blending, wastewater reuse, and recycling.

Additional upstream storage capacity could reduce adverse impacts and could even produce additional beneficial impacts on export water quality. Releases of high-quality water from new upstream storage during periods when salinities and other constituents otherwise would be higher at the export pumps could reduce salt loads in the SWP and CVP service areas in the valley further, depending on the locations and timing of the releases—and especially during dry and critical years. Additional off-aqueduct storage could afford opportunities for additional pumping to storage during high-outflow periods, when water quality is good and environmental constraints allow, for later use when Delta water quality or environmental conditions are less favorable.

Other SWP and CVP Service Areas

Potential impacts and benefits on water quality in the Other SWP and CVP Service Areas would be similar to those described for the water service areas in the San Joaquin Valley.

Additional off-aqueduct storage could afford opportunities for additional pumping for storage during high outflow periods when water quality is highest and environmental constraints allow, for later use when Delta water quality or environmental conditions are less favorable.

Alternative 3 has the potential to produce the best water quality for export to the service areas of all the alternatives because much of the exported water would be diverted from the Sacramento River via the isolated facility and would not be subject to degradation in the Delta. Tables 5.3-7a and 5.3-7b show the comparative mean annual salinities (expressed as EC) of each of the primary points for out-of-basin export diversion from the Delta for the management criterion. With the isolated system, water also could be pumped from the Delta when environmental constraints and water quality standards permit, and periods of poorer water quality could be largely avoided. Water quality benefits could be enhanced still further by releases from new or enlarged storage facilities. The low salinity and associated constituent concentrations that would be achievable would further reduce the demands on treatment technologies;

reduce costs; enable more efficient use to be made of existing supplies; and further increase the potential for conjunctive use, source water blending, wastewater reuse and recycling.

Simulations of bromide concentrations at key Delta export facilities were calculated based on fingerprint modeling data for the alternatives completed in 1998. The data were analyzed for dry and critical years, the most critical times of high bromide concentrations. The data were updated for the most recent model results, using the bromide-to-EC ratios in the older modeling exercise and the EC values generated in the latest model exercise. Based on changes in EC, bromide concentrations would not differ significantly between the No Action Alternative and Alternative 1. The bromide concentrations at Contra Costa Canal under Alternative A are expected to range from 0.51 to 0.76 mg/L under Criterion A and Criterion B, respectively, during December, the month of highest projected bromide levels. These concentrations represent a 75% and 63% drop, respectively, in bromide compared to Alternative 1. The annual average bromide concentrations are projected to range from 0.43 to 0.46 mg/L under Criterion A and Criterion B, respectively. These concentrations represent a 48% and 52% drop, respectively, in bromide compared to Alternative 1.

Concentrations of bromide at CCFB under Alternative 3 would be roughly equivalent to concentrations of bromide in the Sacramento River, assuming very little mixing of Sacramento River water with Delta water near the forebay. Bromide concentrations in the Sacramento River are negligible.

5.3.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

5.3.9.1 PREFERRED PROGRAM ALTERNATIVE

This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions were generally the same impacts as those identified in Sections 5.3.7 and 5.3.8, which compares the Program alternatives to the No Action Alternative. Additionally, the comparison of the Program alternatives to existing conditions did not identify any additional potentially significant environmental consequences that were not identified in the comparison of Program alternatives to the No Action Alternative.

Table 5.3-8a summarizes the results of model simulations of average annual salinity (expressed as EC) throughout the Delta for the Preferred Program Alternative compared to existing conditions. Table 5.3-8b summarizes the results of model simulations of average annual EC during dry and critical years throughout the Delta for the Preferred Program Alternative compared to existing conditions. The Preferred Program Alternative would lower salinity levels at most locations in the Delta and in most water years as compared to existing conditions.

The Preferred Program Alternative would lower salinity levels at most locations in the Delta and in most water years as compared to existing conditions. The effects of the Preferred Program Alternative, when compared to both existing conditions and the No Action Alternative, are similar. However, the improvement in salinity concentrations is more pronounced when the comparison is made to the No Action Alternative. Under the No Action Alternative, water quality will deteriorate relative to existing conditions. Therefore, the No Action Alternative allows more room for improvement in salinity levels. In other words, the water quality benefits of the Preferred Program Alternative will be more apparent if it is implemented 20 years from now, rather than today.

The overall geographic variations in the improvements and Delta locations where the changes were less than significant may be observed by comparing Table 5.3-8a with Table 5.3-4a. The differences between the comparisons of average annual ECs for the Preferred Program Alternative with average annual existing conditions, and annual ECs for the Preferred Program Alternative during dry and critical years with existing conditions during dry and critical years generally were less than significant.

As discussed earlier, the effect of the Preferred Program Alternative on constituents will vary, depending on how the alternative might alter the mixture of waters arriving at a given location.

Bromide modeling conducted by DWR for Alternatives 1 and 2 predict that bromide concentrations would be significantly reduced, depending on the extent to which the alternative limits recirculation of San Joaquin River water and preferentially conveys Sacramento River water to the export facilities (Figures 10 and 11 in Appendix E of the Water Quality Program Plan and DWR, 1998a, unpublished data). South Delta improvements associated with the Preferred Program Alternative should limit recirculation effects. If the diversion facility on the Sacramento River is constructed as part of the Preferred Program Alternative, along with channel modifications on the Mokelumne River, bromide water quality would improve at the export facilities.

Data indicate that a major source of TOC at the export facilities is in-Delta drainage return (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will result in limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, the Preferred Program Alternative includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at export facilities.

5.3.9.2 ALTERNATIVE 1

Delta Region

Potentially beneficial and adverse impacts from implementing Alternative 1 when compared to existing conditions are generally the same as identified in Section 5.3.8.2, where Alternative 1 is compared to the No Action Alternative. Additionally, the comparison of Alternative 1 to existing conditions did not identify any additional potentially significant environmental consequences that were not identified in Section 5.3.8.2.

Table 5.3.9a summarizes the results of model predictions of salinity changes (expressed as EC) throughout the Delta for Alternative 1 compared to existing conditions for a representative long-term hydrologic sequence that includes all water-year types (see Section 5.2). Separate predictions are shown based on modeling assuming water management Criterion A (without storage) and water management Criterion B (with storage), which define the bookends for the analysis of water quality. For both sets of criteria,

Table 5.3-8a. *Predicted Salinity Changes Between the Preferred Program Alternative and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)*

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT[†] ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	0	0%	0%	-4%	0%	N/A	LTS
Mokelumne River at Terminous	8	-10	-30	-10	-20	-6%	-14%	-6%	-9%	Jan	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	20	-180	-50	-300	5%	-28%	-12%	-47%	Dec	LTS - B
Turner Cut	29	70	-70	0	-200	16%	-11%	0%	-31%	Jan	PS - B
San Joaquin River at Prisoner's Point	12	10	-160	-110	-380	2%	-18%	-24%	-43%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	-10	-3%	0%	-3%	-1%	Dec	LTS
San Joaquin River at Brandt Bridge	10	10	10	10	10	2%	1%	2%	1%	Dec	LTS
Middle River at Tracy Road	21	30	-90	-60	-210	6%	-12%	-13%	-27%	Jan	LTS - B
Grant Line Canal at Tracy Road	24	-30	0	-70	-10	-5%	0%	-11%	-1%	Dec	LTS - B
Old River at Tracy Road	17	-30	70	-80	-100	-5%	10%	-13%	-14%	Oct	LTS - B
Old River at Rock Slough	19	20	-160	-120	-410	4%	-15%	-21%	-37%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough	28*	20	-160	-120	-410	3%	-14%	-19%	-37%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	20	-170	-110	-390	4%	-17%	-20%	-39%	Dec	LTS - B
Clifton Court Forebay	27*	40	-130	-100	-330	8%	-14%	-19%	-36%	Dec	LTS - B
Delta-Mendota Canal Intake from Old River	26*	10	-140	-90	-260	2%	-16%	-16%	-30%	Dec	LTS - B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	30	-70	80	-20	3%	-4%	9%	-1%	Sep	LTS
Sacramento River at Collinsville	4	30	600	180	690	1%	11%	6%	13%	Oct	LTS - PS
San Joaquin River at Jersey Point	14	60	10	-80	-300	6%	0%	-8%	-14%	Dec	LTS - B
San Joaquin River at Antioch	15	60	410	70	190	3%	9%	3%	4%	Oct	LTS
Suisun Bay at Port Chicago	5	-110	610	-20	380	-1%	3%	2%	-1%	Sep	LTS
Carquinez Strait at Martinez	6	-140	640	580	550	-1%	3%	3%	2%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-8b. Predicted Salinity Changes Between the Preferred Program Alternative and Existing Conditions for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION A WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough*	7*	0	0	-10	-10	0%	0%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	-10	-40	-10	-40	-5%	-17%	-5%	-17%	Feb	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	30	-240	-70	-400	7%	-31%	-15%	-52%	Dec	LTS - B
Turner Cut	29	80	-140	-20	-330	16%	-18%	-4%	-43%	Jan	PS - B
San Joaquin River at Prisoner's Point	12	-10	-220	-150	-530	-2%	-20%	-28%	-49%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-30	-20	-30	-20	-4%	-2%	-4%	-2%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	-10	20	-10	3%	-1%	3%	-1%	Feb	LTS
Middle River at Tracy Road	21	30	-160	-100	-350	6%	-17%	-19%	-37%	Jan	LTS - B
Grant Line Canal at Tracy Road	24	-60	-20	-100	-20	-8%	-2%	-13%	-2%	Feb	LTS - B
Old River at Tracy Road	17	-60	-20	-130	-20	-8%	-2%	-17%	-2%	Feb	LTS - B
Old River at Rock Slough	19	0	-210	-170	-570	0%	-16%	-25%	-42%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough*	28*	10	-220	-160	-560	1%	-16%	-23%	-42%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)*	18*	10	-220	-150	-530	2%	-18%	-23%	-44%	Dec	LTS - B
Clifton Court Forebay*	27*	40	-160	-140	-450	6%	-15%	-23%	-41%	Dec	LTS - B
Delta-Mendota Canal Intake from Old River*	26*	10	-180	-130	-360	1%	-18%	-19%	-36%	Jan	LTS - B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	20	-180	80	-180	2%	-7%	7%	-7%	Sep	LTS
Sacramento River at Collinsville	4	-20	-230	140	-340	-1%	-3%	4%	-5%	Sep	LTS
San Joaquin River at Jersey Point	14	10	-10	-160	-540	1%	0%	-12%	-20%	Dec	LTS - B
San Joaquin River at Antioch	15	-20	460	-10	120	-1%	9%	0%	2%	Oct	LTS
Suisun Bay at Port Chicago	5	-330	-20	330	-230	-2%	0%	2%	-1%	Sep	LTS
Carquinez Strait at Martinez	6	-370	-10	560	-40	-2%	0%	3%	0%	N/A	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-9a. Predicted Salinity Changes Between Alternative 1 and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-10	0%	0%	-4%	-3%	Mar	LTS
Mokelumne River at Terminous	8	0	0	0	0	0%	0%	0%	0%	N/A	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	50	20	40	20	12%	3%	10%	3%	Nov	LTS - PS
Turner Cut	29	80	70	60	60	18%	11%	13%	9%	Jan	LTS - PS
San Joaquin River at Prisoner's Point	12	50	130	80	190	11%	15%	18%	22%	Dec	PS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	0	-3%	0%	-3%	0%	N/A	LTS
San Joaquin River at Brandt Bridge	10	10	10	10	10	2%	1%	2%	1%	Dec	LTS
Middle River at Tracy Road	21	60	80	60	120	13%	10%	13%	16%	Jan	LTS - PS
Grant Line Canal at Tracy Road	24	-30	10	-30	0	-5%	1%	-5%	0%	Dec	LTS
Old River at Tracy Road	17	-30	10	-30	10	-5%	1%	-5%	1%	Dec	LTS
Old River at Rock Slough	19	50	140	100	210	9%	13%	18%	19%	Dec	LTS - PS
Contra Costa Canal Intake at Rock Slough	28*	50	130	90	190	8%	12%	15%	17%	Dec	LTS - PS
Old River at SR 4 (and New CCWD Intake)	18*	50	110	80	160	9%	11%	15%	16%	Dec	LTS - PS
Clifton Court Forebay	27*	70	140	80	180	13%	15%	15%	20%	Dec	PS
Delta-Mendota Canal Intake from Old River	26*	30	20	20	50	5%	2%	4%	6%	Dec	LTS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	10	110	30	100	1%	6%	3%	5%	Sep	LTS
Sacramento River at Collinsville	4	-10	280	130	300	0%	5%	5%	5%	Sep	LTS
San Joaquin River at Jersey Point	14	70	200	200	360	7%	9%	19%	17%	Nov	LTS - PS
San Joaquin River at Antioch	15	10	380	200	430	0%	8%	8%	9%	Oct	LTS
Suisun Bay at Port Chicago	5	-100	690	520	650	-1%	4%	4%	4%	Sep	LTS
Carquinez Strait at Martinez	6	-110	650	580	580	-1%	3%	3%	2%	Sep	LTS

Notes:

* *Indicates diversion points for municipal and industrial use.*
† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-9b. Predicted Salinity Changes Between Alternative 1 and Existing Conditions for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT [†] ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-20	0%	0%	-5%	-8%	Mar	LTS
Mokelumne River at Terminous	8	0	0	0	0	0%	0%	0%	0%	N/A	LTS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	80	70	60	80	18%	9%	13%	10%	Dec	LTS - PS
Turner Cut	29	110	80	70	90	21%	10%	14%	12%	Jan	LTS - PS
San Joaquin River at Prisoner's Point	12	50	150	110	200	9%	14%	21%	18%	Dec	LTS - PS
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-30	-20	-30	-20	-4%	-2%	-4%	-2%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	-10	20	-10	3%	-1%	3%	-1%	Feb	LTS
Middle River at Tracy Road	21	70	110	80	170	13%	12%	15%	18%	Jan	PS
Grant Line Canal at Tracy Road	24	-60	-20	-60	-10	-8%	-2%	-8%	-1%	Feb	LTS
Old River at Tracy Road	17	-70	-20	-80	-10	-9%	-2%	-10%	-1%	Feb	LTS
Old River at Rock Slough	19	60	170	120	230	9%	13%	18%	17%	Dec	LTS - PS
Contra Costa Canal Intake at Rock Slough	28*	70	160	110	200	10%	12%	16%	15%	Dec	LTS - PS
Old River at SR 4 (and New CCWD Intake)	18*	70	140	100	170	11%	12%	16%	14%	Dec	PS
Clifton Court Forebay	27*	100	170	110	210	16%	16%	18%	19%	Dec	PS
Delta-Mendota Canal Intake from Old River	26*	30	20	20	40	4%	2%	3%	4%	Dec	LTS
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	0	20	10	-50	0%	1%	1%	-2%	Sep	LTS
Sacramento River at Collinsville	4	-100	30	100	-30	-3%	0%	3%	0%	N/A	LTS
San Joaquin River at Jersey Point	14	50	350	230	480	4%	13%	17%	18%	Dec	LTS - PS
San Joaquin River at Antioch	15	-70	180	190	220	-2%	3%	6%	4%	Sep	LTS
Suisun Bay at Port Chicago	5	-330	60	500	50	-2%	0%	3%	0%	Sep	LTS
Carquinez Strait at Martinez	6	-340	10	570	0	-2%	0%	3%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

[†] LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

changes are shown for the annual average value over the period of the simulation and for the month of the year during which the higher salinities are projected.

Compared to existing conditions, Table 5.3.9a shows that under Alternative 1, salinity is projected to be significantly affected in the central Delta, in the south Delta, and in the San Joaquin River in the west Delta (as indicated by Jersey Point). For example, at CCFB, the mean long-term salinity is projected to increase by 70-80 μmhos/cm (13-15%), and the mean monthly salinity for December is projected to increase by about 140-180 μmhos/cm (15-20%). During dry and critical years, Table 5.3.9b shows that these ranges increase from 100 to 110 μmhos/cm (16-18%) for the long term and from 170 to 210 μmhos/cm (16-19%) on average for the month of December. Alternative 1 would potentially degrade overall in-Delta and export water quality and dependent beneficial uses because of the resultant increases in sea-water intrusion (see Figures 5.2-36 and 5.2-37 in Section 5.2). This degradation is projected to occur despite the increased potential for reservoir releases and increased inflows of better quality water across the Delta from the Mokelumne and Sacramento Rivers southward, and the potentially improved water circulation in affected Delta channels.

The actual magnitudes of the salinity changes would vary tidally, seasonally, and spatially throughout the Delta, depending on factors such as the mixtures of source waters attained at each location that result from variations in the pathways and timing of flows through Delta channels. The magnitude of the changes also would vary from variations in annual hydrology. In general, the magnitude of impacts would be increased in dry and critical years, and attenuated in above-normal and wet years.

As described earlier, bromide modeling conducted by DWR for Alternatives 1 and 2 predict that bromide concentrations would be significantly reduced, depending on the extent to which the alternative limits recirculation of San Joaquin River water and preferentially conveys Sacramento River water to the export facilities.

As with salinity, the actual magnitudes of monthly variations in bromide would depend on annual, seasonal, and geographically determined differences in the proportion of sea water present. Bromide is of particular concern to municipal water users because it is an inorganic precursor to several of the most potentially harmful known DBPs (for example, bromodichloromethane, bromate, and brominated haloacetic acids—known for their roles as carcinogens and potential causes of increased birth defects).

Data indicate that in-Delta drainage return is a major source of TOC at the export facilities (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will have limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, the Preferred Program Alternative includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at export facilities.

Bay Region

With increased exports from the Delta, Alternative 1 could result in potentially significant impacts by reducing net Delta outflows, resulting in greater sea-water intrusion into the Bay. This could result in increases in salinity in San Francisco, San Pablo, and Suisun Bays.

The addition of new storage could improve water quality and dependent conditions for estuarine biological resources in the west Delta as a result of increased Delta outflows, especially during low-outflow periods.

Sacramento River Region

Impacts on water quality associated with Alternative 1 in the Sacramento River Region would be similar to those described for the Preferred Program Alternative.

San Joaquin River Region

When comparing Alternative 1 to existing conditions, general impacts of storage and conveyance options on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region under the Preferred Program Alternative. However, the potential for significant changes in the quality (and quantity) of the water exported to the region as a result of decisions made during the term of this Program is great, and other non-CALFED programs also will produce effects (see "Cumulative Impacts" in Section 5.3.10). As indicated in Table 5.3-9a, the average annual increase in the salinity of water exported to the San Joaquin River Region via the DMC (assuming an intertie with CCFB) compared to existing conditions is projected to range from 2 to 20% for long-term averages. The resultant net change in salt loads delivered to the valley is more difficult to project because it also would depend on changes in water deliveries, the locations where the water is applied, and source control actions taken. However, the effect would be to increase salt loads and the resultant recirculation of salts in the San Joaquin Valley.

The range of potential long-term water supply variations (possibly in the realm of 790 TAF of gains with new storage to 270 TAF without new storage) and source-dependent water quality characteristics are sufficiently large to significantly degrade prevailing water quality and the resultant salt balance in the SWP and CVP service areas and throughout the San Joaquin Valley. The effects of the potential variations would be most pronounced in those areas that are already deficient in both quality and quantity of water. Resultant changes in land use in the service areas that could secondarily affect water quality, water supply, demands, and beneficial uses of water resources would in turn depend on the magnitude of the reductions in the quality of delivered water supplies. Despite the variability, overall degradation of water quality in the areas served by exports would adversely affect municipal, agricultural, and ecological uses of the water.

Other SWP and CVP Service Areas

Alternative 1 also could result in detrimental impacts on export water quality outside the Central Valley. Impacts on export water quality could result from the changes in flow and salinity patterns throughout the Delta as described above for the Delta Region. Potential impacts would be similar to but less than those described for the water service areas in the San Joaquin Valley.

5.3.9.3 ALTERNATIVE 2

Delta Region

Potentially beneficial and adverse impacts from implementing Alternative 2 when compared to existing conditions are generally the same as identified in Section 5.3.8.3, where Alternative 2 is compared to the No Action Alternative. Except at Collinsville, the comparison of Alternative 2 to existing conditions did not identify any additional potentially significant environmental consequences that were not identified in Section 5.3.8.3.

Table 5.3-10a summarizes the results of model predictions of salinity changes (expressed as EC) throughout the Delta for Alternative 2 compared to the existing conditions for a representative long-term hydrologic sequence that includes all water-year types (see Section 5.2). Separate predictions are shown based on modeling assuming water management Criterion A(without storage), and water management Criterion B(with storage), which define the bookends for the analysis of water quality. For both sets of criteria, changes are shown for the annual average value over the period of the simulation and for the month of the year when salinity is the highest.

Compared to existing conditions, Table 5.3-10a shows that under Alternative 2, salinity is projected to improve throughout the Delta and at the export facilities. For example, at CCFB, the mean long-term salinity is projected to decrease by 90-190 μmhos/cm (17-36%), and the mean monthly salinity for December is projected to decrease by 400-510 μmhos/cm (44-56%). During dry and critical years, Table 5.3-10b shows that salinity is projected to decrease by 110-240 μmhos/cm (18-39%) for dry and critical years, and to decrease by 490-630 μmhos/cm (45-58%) on average for the month of December. The improvement in water quality is caused by increased flows of higher quality water across the Delta from the Mokelumne and Sacramento Rivers southward, and the improved water circulation in affected Delta channels.

Potentially significant adverse impacts on average annual salinities would be restricted primarily to the lower Sacramento River (for example, Emmaton) due to the diversion of upstream flows into the central and south Delta.

As stated earlier, bromide modeling conducted by DWR for Alternatives 1 and 2 predict that bromide concentrations would be significantly reduced, depending on the extent to which the alternative limits recirculation of San Joaquin River water and preferentially conveys Sacramento River water to the export facilities.

Data indicate that in-Delta drainage return is a major source of TOC at the export facilities (see Section 3.7.2 in the Water Quality Program Plan). Therefore, any conveyance alternative that relies on through-Delta conveyance will have limited effects on TOC concentrations. Control of organic carbon at the source, namely island drainage treatment, is therefore the primary option to consider. As an early implementation action, the Preferred Program Alternative includes pilot testing of treatment methods that, if proven to be technically and economically feasible, could lead to reductions in TOC at export facilities.

Bay Region

With increased exports from the Delta, Alternative 2 could result in potentially significant impacts by reducing net Delta outflows, resulting in greater sea-water intrusion into the Bay. This could result in increases in salinity in San Francisco, San Pablo, and Suisun Bays.

Sacramento River Region

Impacts of Alternative 2 in the Sacramento River Region would be similar to those described for the Preferred Program Alternative.

San Joaquin River Region

General impacts of storage and conveyance options on upstream water quality in the San Joaquin River Region are expected to be similar to those described for the Sacramento River Region. However, the potential for significant changes in the quality (and quantity) of the water exported to the region as a result of decisions made during the term of this Program is great, and other non-CALFED programs also will produce effects (see "Cumulative Impacts" in Section 5.3.10).

As indicated in Table 5.3-10a, a significant long-term decrease in the salinity (ranging at the DMC from 11 to 36%) of water exported to the San Joaquin River Region is projected under Alternative 2. The resultant net change in salt loads delivered to the San Joaquin River Valley is difficult to project because it would depend on water delivery operations, and other factors; however, based on this analysis alone, long-term salinity loads to the Valley could be significantly reduced. Overall improvements in water quality in the areas served by exports would benefit municipal, agricultural, and ecological uses of the water. Improvements also would reduce the amount of salt recirculation that occurs between the basin and the Delta.

Other SWP and CVP Service Areas

Alternative 2 also would result in beneficial impacts on export water quality outside the Central Valley. Benefits would result from the improved export water quality as described for the Delta Region. Benefits and potential impacts would be similar to those described earlier for the water service areas in the San Joaquin Valley. Overall water quality improvement benefits should be somewhat greater because more of these service areas are served by SWP exports from CCFB, which receives higher quality water than the CVP.

5.3.9.4 ALTERNATIVE 3

Table 5.3-11a summarizes the results of model simulations of average annual salinity (expressed as EC) throughout the Delta for Alternative 3 compared to existing conditions. Table 5.3-11b summarizes the results of model simulations of average annual EC during dry and critical years throughout the Delta for

Table 5.3-10a. Predicted Salinity Changes Between Alternative 2 and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	**STATION NO.**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (μmhos/cm)**	**MONTH OF MAXIMUM EC (μmhos/cm)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**AVERAGE MONTHLY CHANGE (%)**	**MONTH OF MAXIMUM EC (%)**	**MONTH OF MAXIMUM EC**	**IMPACT † ASSESSMENT**
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	0	0	0%	0%	0%	0%	Mar	LTS
Mokelumne River at Terminous	8	0	-20	-10	-30	0%	-9%	-6%	-14%	Jan	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-20	-320	-80	-370	-5%	-50%	-20%	-58%	Dec	LTS - B
Turner Cut	29	40	-150	-20	-260	9%	-23%	-4%	-40%	Jan	LTS - B
San Joaquin River at Prisoner's Point	12	-120	-460	-190	-570	-27%	-53%	-42%	-65%	Dec	B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	0	-3%	0%	-3%	0%	N/A	LTS
San Joaquin River at Brandt Bridge	10	10	10	10	10	2%	1%	2%	1%	Dec	LTS
Middle River at Tracy Road	21	-40	-220	-110	-320	-8%	-29%	-23%	-42%	Jan	LTS - B
Grant Line Canal at Tracy Road	24	-60	-10	-80	-20	-10%	-1%	-13%	-3%	Dec	LTS - B
Old River at Tracy Road	17	-70	-80	-100	-120	-11%	-11%	-16%	-17%	Sep	B
Old River at Rock Slough	19	-140	-520	-230	-650	-25%	-48%	-41%	-59%	Dec	B
Contra Costa Canal Intake at Rock Slough	28*	-140	-500	-230	-630	-23%	-45%	-37%	-56%	Dec	B
Old River at SR 4 (and New CCWD Intake)	18*	-120	-590	-200	-640	-22%	-59%	-37%	-64%	Dec	B
Clifton Court Forebay	27*	-90	-400	-190	-510	-17%	-44%	-36%	-56%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-60	-290	-130	-350	-11%	-34%	-23%	-41%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	60	20	160	210	7%	1%	18%	11%	Sep	LTS - PS
Sacramento River at Collinsville	4	40	800	280	930	1%	15%	10%	18%	Oct	LTS - PS
San Joaquin River at Jersey Point	14	-180	-550	-350	-920	-17%	-27%	-34%	-44%	Dec	B
San Joaquin River at Antioch	15	-70	140	-100	-110	-3%	3%	-4%	-2%	Oct	LTS
Suisun Bay at Port Chicago	5	-290	420	400	420	-2%	2%	3%	2%	Sep	LTS
Carquinez Strait at Martinez	6	-160	630	570	560	-1%	3%	3%	2%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-10b. Predicted Salinity Changes Between Alternative 2 and Existing Conditions for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT [†] ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-10	0%	0%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	0	-30	-20	-50	0%	-13%	-11%	-22%	Feb	LTS - B
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	-30	-410	-110	-480	-7%	-54%	-24%	-63%	Dec	LTS - B
Turner Cut	29	50	-270	-50	-430	10%	-35%	-10%	-56%	Jan	LTS - B
San Joaquin River at Prisoner's Point	12	-160	-600	-250	-730	-30%	-55%	-47%	-67%	Dec	B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-30	-20	-30	-20	-4%	-2%	-4%	-2%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	-10	20	-10	3%	-1%	3%	-1%	Feb	LTS
Middle River at Tracy Road	21	-60	-370	-160	-510	-11%	-39%	-30%	-54%	Jan	B
Grant Line Canal at Tracy Road	24	-90	-20	-120	-10	-12%	-2%	-16%	-1%	Feb	LTS - B
Old River at Tracy Road	17	-100	-20	-150	-10	-13%	-2%	-20%	-1%	Feb	LTS - B
Old River at Rock Slough	19	-190	-650	-300	-830	-28%	-48%	-45%	-62%	Dec	B
Contra Costa Canal Intake at Rock Slough	28*	-180	-630	-300	-800	-26%	-47%	-43%	-60%	Dec	B
Old River at SR 4 (and New CCWD Intake)	18*	-150	-590	-270	-740	-23%	-49%	-42%	-61%	Dec	B
Clifton Court Forebay	27*	-110	-490	-240	-630	-18%	-45%	-39%	-58%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-80	-360	-180	-450	-12%	-35%	-27%	-44%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	40	-120	170	60	3%	-4%	14%	2%	Sep	LTS - PS
Sacramento River at Collinsville	4	-40	-250	260	-90	-1%	-3%	7%	-1%	Sep	LTS
San Joaquin River at Jersey Point	14	-270	-740	-480	-1240	-20%	-27%	-36%	-46%	Dec	B
San Joaquin River at Antioch	15	-190	110	-220	-230	-6%	2%	-7%	-4%	Oct	LTS
Suisun Bay at Port Chicago	5	-550	-220	360	-170	-4%	-1%	2%	-1%	Sep	LTS
Carquinez Strait at Martinez	6	-400	-20	550	-40	-2%	0%	3%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

[†] LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-11a. Predicted Salinity Changes Between Alternative 3 and Existing Conditions for All Water-Year Types (Salinity Expressed as EC)

DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
		AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (μmhos/cm)	MONTH OF MAXIMUM EC (μmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)		
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
North Bay Aqueduct Intake at Barker Slough	7*	0	-10	-10	0	0%	-3%	-4%	0%	Mar	LTS
Mokelumne River at Terminous	8	30	50	30	40	17%	23%	17%	19%	Jan	PS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	120	-10	80	-20	30%	-2%	20%	-3%	Dec	LTS - PS
Turner Cut	29	170	130	110	40	38%	20%	25%	6%	Jan	LTS - PS
San Joaquin River at Prisoner's Point	12	-100	-460	-20	-190	-22%	-53%	-4%	-22%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-20	0	-20	-10	-3%	0%	-3%	-1%	Dec	LTS
San Joaquin River at Brandt Bridge	10	10	0	10	0	2%	0%	2%	0%	N/A	LTS
Middle River at Tracy Road	21	120	-10	40	-30	25%	-1%	8%	-4%	Jan	LTS - PS
Grant Line Canal at Tracy Road	24	-10	0	-40	-10	-2%	0%	-6%	-1%	Dec	LTS
Old River at Tracy Road	17	-10	0	-50	-10	-2%	0%	-8%	-1%	Dec	LTS
Old River at Rock Slough	19	-110	-560	-30	-250	-20%	-51%	-5%	-23%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough	28*	-90	-520	-30	-260	-15%	-46%	-5%	-23%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	-40	-400	-20	-220	-7%	-40%	-4%	-22%	Dec	LTS - B
Clifton Court Forebay	27*	-350	-760	-270	-600	-67%	-83%	-52%	-66%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-210	-430	-90	-240	-38%	-50%	-16%	-28%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	-90	-750	110	-290	-10%	-38%	13%	-15%	Sep	PS - B
Sacramento River at Collinsville	4	-500	-1900	240	-610	-18%	-34%	9%	-11%	Sep	LTS - B
San Joaquin River at Jersey Point	14	-560	-1410	-140	-590	-54%	-66%	-14%	-28%	Nov	B
San Joaquin River at Antioch	15	-800	-1420	40	180	-34%	-30%	2%	4%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-760	-1470	590	-240	-6%	-8%	5%	-1%	Sep	LTS
Carquinez Strait at Martinez	6	-640	-1010	710	-60	-4%	-4%	4%	0%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
μmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Table 5.3-11b. Predicted Salinity Changes Between Alternative 3 and Existing Conditions for Dry and Critical Years (Salinity Expressed as EC)

		CRITERION A NO STORAGE		CRITERION B WITH STORAGE		CRITERION A NO STORAGE		CRITERION B WITH STORAGE			
DELTA/SUISUN BAY SUB-REGION AND LOCATION	STATION NO.	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (µmhos/cm)	MONTH OF MAXIMUM EC (µmhos/cm)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	AVERAGE MONTHLY CHANGE (%)	MONTH OF MAXIMUM EC (%)	MONTH OF MAXIMUM EC	IMPACT † ASSESSMENT
NORTH DELTA SUB-REGION											
Sacramento River at Greene's Landing	1	0	0	0	0	0%	0%	0%	0%	N/A	LTS
Sacramento River at Rio Vista	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
North Bay Aqueduct Intake at Barker Slough	7*	0	0	-10	-10	0%	0%	-5%	-4%	Mar	LTS
Mokelumne River at Terminous	8	30	60	40	50	16%	26%	21%	22%	Jan	PS
CENTRAL DELTA SUB-REGION											
San Joaquin River at Ridge Tract	11	150	-80	110	-50	33%	-10%	24%	-7%	Dec	LTS - PS
Turner Cut	29	200	210	150	150	39%	31%	29%	22%	Feb	PS
San Joaquin River at Prisoner's Point	12	-150	-630	-40	-320	-28%	-58%	-8%	-30%	Dec	LTS - B
SOUTH DELTA AND PRINCIPAL EXPORT PUMPS SUB-REGION											
San Joaquin River at Vernalis	9	-30	-20	-30	-20	-4%	-2%	-4%	-2%	Feb	LTS
San Joaquin River at Brandt Bridge	10	20	-10	20	-10	3%	-1%	3%	-1%	Feb	LTS
Middle River at Tracy Road	21	160	-50	40	-80	30%	-5%	7%	-9%	Jan	LTS - PS
Grant Line Canal at Tracy Road	24	-20	-20	-80	-10	-3%	-2%	-10%	-1%	Feb	LTS
Old River at Tracy Road	17	-20	-10	-80	-20	-3%	-1%	-10%	-2%	Feb	LTS
Old River at Rock Slough	19	-150	-750	-50	-390	-22%	-56%	-7%	-29%	Dec	LTS - B
Contra Costa Canal Intake at Rock Slough	28*	-120	-710	-50	-400	-17%	-53%	-7%	-30%	Dec	LTS - B
Old River at SR 4 (and New CCWD Intake)	18*	-60	-560	-30	-330	-9%	-46%	-5%	-27%	Dec	LTS - B
Clifton Court Forebay	27*	-430	-930	-350	-780	-70%	-85%	-57%	-72%	Dec	B
Delta-Mendota Canal Intake from Old River	26*	-250	-520	-150	-370	-37%	-51%	-22%	-36%	Dec	B
WEST DELTA, SUISUN BAY, AND MARSH SUB-REGION											
Sacramento River at Emmaton	3	-160	-1260	100	-750	-13%	-46%	8%	-27%	Sep	LTS - B
Sacramento River at Collinsville	4	-750	-2880	170	-1680	-19%	-40%	4%	-23%	Sep	LTS - B
San Joaquin River at Jersey Point	14	-770	-1880	-260	-780	-58%	-69%	-19%	-29%	Dec	B
San Joaquin River at Antioch	15	-1140	-1510	-100	240	-35%	-28%	-3%	4%	Oct	LTS - B
Suisun Bay at Port Chicago	5	-1110	-2590	510	-1450	-7%	-13%	3%	-7%	Sep	LTS - B
Carquinez Strait at Martinez	6	-970	-2040	630	-1130	-5%	-8%	3%	-4%	Sep	LTS

Notes:

* Indicates diversion points for municipal and industrial use.

† LTS - All impacts within ±10%
LTS-B - Some impacts within ±10, some impacts <-10%
LTS-PS - Some impacts within ±10, some impacts >10%

B = Beneficial.
CCWD = Contra Costa Water District.
EC = Electrical conductivity.
LTS = Less than significant.
µmhos/cm = Micromhos per centimeter.
PS = Potentially significant.
SR = State Route.

Alternative 3 compared to existing conditions. The impacts associated with Alternative 3, when compared to existing conditions, generally would be similar to those compared to the No Action Alternative, except in some cases in the central Delta where the impacts compared to existing conditions would be significant. During dry and critical years, impacts in the central Delta include a rise in annual EC at Turner Cut by 26 to 29% for Criterion A and Criterion B, respectively. Annual EC is projected to increase at Turner Cut by 27 to 25% for Criterion A and Criterion B, respectively, under the model results for all water-year types. The Mokelumne River at Terminous is projected to increase in EC by 16 to 21% during dry and critical years for Criterion A and Criterion B, respectively; and by an average of 17% during all water-year types. Middle River at Tracy Road is expected to increase by 16% to 19% under Criterion A (without storage) on the average for all water years and for dry and critical years, respectively. In general, potentially significant impacts would be of greater magnitude where they occur, especially under Criterion A. South Delta diversion facilities would experience significantly lower EC under this alternative. It is projected that CCFB would experience water up to 86% lower in EC under this alternative.

The overall geographic variations in the improvements, and Delta locations where the changes were significant and less than significant may be observed by comparing Table 5.3-11a with Table 5.3-7a. The differences between (1) the comparisons of average annual ECs for Alternative 3 with average annual existing conditions, and (2) annual ECs for Alternative 3 during dry and critical years with existing conditions during dry and critical years, generally showed the differences to be more pronounced during the dry and critical years.

As stated earlier, bromide modeling conducted by DWR for Alternatives 1 and 2 predict that bromide concentrations would be significantly reduced, depending on the extent to which the alternative limits recirculation of San Joaquin River water and preferentially conveys Sacramento River water to the export facilities.

5.3.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's incremental contribution could be avoided or mitigated to a less-than-significant level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For water quality, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.3.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts. At the programmatic level of analysis, the impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level are noted on the list in **bold type**. Sections 5.3.7 and 5.3.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on water quality in the Delta, Bay, Sacramento River, and San Joaquin River Regions, and the Other SWP and CVP Service Areas: American River Water Resources Investigation, American River Watershed Project, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento Water Forum Process, EBMUD Supplemental Water Supply Project, Sacramento County municipal and industrial water supply contracts, and urbanization. The Trinity River Restoration Project and ISDP would cause water quality effects in the Program study area that were considered in the environmental impact analysis presented in Sections 5.3.7 and 5.3.8. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.3.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level—with the exception of localized increases in EC (a measure of salinity) in water in the central Delta. This potentially unavoidable impact could affect the Delta Region and is discussed in Section 5.3.12. At the programmatic level of analysis, it is unknown whether the CALFED Program's contribution to this cumulative impact, can be avoided, reduced, or mitigated to a less than cumulatively considerable level. Therefore, the analysis concludes that the impact is a significant unavoidable cumulative impact. This conclusion is based on currently available information and the high level of uncertainty as to whether this impact can be avoided, mitigated, or reduced to a level that is less than cumulatively considerable.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. The Preferred Program Alternative generally would maintain and enhance long-term productivity of water quality but may cause adverse impacts on water quality resulting from short-term uses of the environment.

The Preferred Program Alternative would result in short-term adverse effects on water quality during the construction of facilities that are included in each alternative. The contaminant of concern most affected would be TSS. TSS concentrations are likely to be increased in the immediate vicinity of construction activities. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on these resources. The short-term impacts of the Preferred Program Alternative on water quality would be greater than, but similar to, those of Alternative 1, and less than those of Alternatives 2 and 3.

The short-term impacts on water quality of the Preferred Program Alternative would be offset by long-term improvements. The Ecosystem Restoration, Water Quality, and Watershed Program elements would result in long-term positive impacts on water quality for aquatic life and municipal and agricultural supply. The Levee System Integrity Program and the Storage and Conveyance elements of all Program alternatives would result in little effect on water quality for aquatic life but would improve the quality of water diverted from the Delta for municipal and agricultural use at some locations, with one exception. The reduction in total Delta outflow to San Francisco Bay could adversely affect water quality in the Bay.

Irreversible and Irretrievable Commitments. The irreversible and irretrievable commitments of resources associated with the Preferred Program Alternative would not affect water quality.

5.3.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during project planning and development. Specific mitigation measures will be adopted consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location and timing.

Ecosystem Restoration Program. The Ecosystem Restoration Program element could increase the TOC content of Delta waters. TOC concentrations could increase as a result of having more aquatic vegetation. TOC contributes to the formation of DBPs, some of which have been shown to cause significant health problems. Therefore, the release of TOC is not as critical as TOC being increased at municipal water supply intakes. The following mitigation strategies could be employed: TOC increases may be mitigated by locating created wetlands away from drinking water intakes, by treating wetland discharges, or by treating water to remove TOC before it is disinfected and supplied to water system customers.

The Water Use Efficiency and Water Transfer Program elements of the alternatives, would result in some localized adverse impacts on water quality which could be mitigated, in most cases, by release of greater volumes of fresh water from upstream reservoirs.

The Ecosystem Restoration Program could promote the conversion of elemental mercury into the bioavailable form, methyl mercury. Increasing methyl mercury production would happen only if mercury-laden sediment or water were allowed into constructed shallow-water habitat. Therefore, shallow-water habitat would need to be located away from mercury sources until such time as methods for eliminating mercury from water and sediment are implemented.

Ecosystem Restoration Program actions are proposed for portions of the Delta and Bay Region that may result in coincidental beneficial water quality impacts, according to model results on concepts of several projects. Detailed studies of these projects have not been conducted, and further studies are being pursued (as part of Stage 1 implementation). If these projects meet the CALFED solution objectives, project-specific environmental evaluation and documentation will address the environmental impacts of individual projects. Should a project be considered for construction with beneficial water quality impacts as part of the project, these beneficial impacts may be considered as mitigation for other Program actions. Considering the preliminary nature of information about these projects, it is uncertain whether the projects will be able to reduce adverse salinity impacts to a less-than-significant level.

Levee System Integrity Program. Construction activities for the Levee System Integrity Program would be similar to and integrated with those described for the Ecosystem Restoration Program. Existing levees would be demolished, and new levees would be constructed—either at or close to the site of the original levees or set back some distance from the original levees if a channel is to be widened or a wetland created. Short-term effects on water quality would be similar to those described for the Ecosystem Restoration Program but would occur only in the Delta Region. Local increases in the TSS content of waters in Delta channels are expected. Some increase in nutrient and TOC concentrations also may occur. Toxic substances contained in old levees or in channel sediments could be released during demolition or dredging. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern.

It is expected that short-term construction impacts can be reduced to a less-than-significant level by employing construction methods that minimize in-water construction and by applying appropriate mitigation strategies. Soils in the levees and channel sediments would be tested prior to commencement of construction so that the need for special mitigation measures can be determined. (See "Sediment Dredging and In-Channel Earth Movement" below.)

Water Use Efficiency Program. Increased water use efficiency would adversely affect water quality when the volume of municipal wastewater or agricultural tailwater discharged to a stream is reduced but the mass load of salts and other contaminants in the discharge remains the same. The adverse effect would be most pronounced in streams where municipal or agricultural discharges represent a substantial proportion of streamflow. Adverse effects would occur most acutely in small streams in the Sacramento River and San Joaquin River Regions, downstream of municipal and agricultural wastewater discharges.

It is expected that the localized adverse water quality impacts of the program can be mitigated to a less-than-significant level by increasing treatment of wastewater before it is discharged to waterways or increasing fresh-water releases from reservoirs to provide more dilution water.

Water Transfer Program. Water transfers could affect water quality primarily through changes to river flow and water temperatures. The source of water for a transfer; and the timing, magnitude, and pathway of each transfer would affect the potential for significant impacts. Because specific transfers can invoke both beneficial and adverse impacts, at times on the same resource, net effects must be considered on a case-by-case basis. Water transfers could result in a potentially significant adverse (although localized) impact on water quality if diversions are transferred in a pipeline or canal to the area of use. For direct groundwater transfers, water quality could be adversely affected if the groundwater source is of poorer quality than the conveying channel. Possible methods to mitigate these adverse impacts could include:

- Requiring transferred water to be conveyed through natural channels to the area of use where feasible.
- Developing water transfer rules that protect downstream users (see Section 7.2.7.3).

Storage. All of the long-term adverse effects of surface and groundwater storage on water quality could be reduced to a less-than-significant level by various mitigation measures. Surface water reservoirs could be sited to avoid areas where rocks contain mercury or other potentially hazardous substances. If avoidance is impossible, rock outcrops could be covered with inert materials and vegetation cleared from the site to minimize the development of anaerobic conditions at the bottom of reservoirs. Outlet works at the reservoirs could be designed with multiple outlet portals to minimize depression of dissolved oxygen concentrations, to minimize the elevation of dissolved nitrogen concentrations, and to better control the temperature of released water. Water could be released from surface storage reservoirs to simulate natural flows in the small stream on which they are built.

Sediment Dredging and In-Channel Earth Movement. Sediment that is dredged from the Bay and Delta has the potential to cause water quality impacts due to the chemical quality of the sediment and its final disposition. Suitability of reuse of the sediment depends on its soil properties and the final disposition of the sediment.

The Program proposes to dredge sediment in Delta channels for a variety of reasons, including to widen or deepen channels and to deepen intake structures. Other sediment dredging and earth moving (or channel modification) may be conducted to modify levees, provide habitat, or build up areas for the protection of habitat. Each of these activities could benefit from soils dredged from Delta channels.

Sediment with toxic materials (such as mercury) must be prevented from degrading water quality. The potential to degrade water quality is related to the concentrations of toxic material, its contact with surface water, and the mechanisms by which the material becomes toxic to aquatic organisms.

Much of the mercury in dredged sediment is not an immediate threat to aquatic organisms. Mercury must be transformed to a toxic form to affect the ecosystem. In nature, this transformation is accomplished through bacteria that exist in the greatest numbers in shallow-water habitat. Therefore, mercury that remains buried under sediment or in a levee may not pose a substantial threat to the environment. The transformation of other toxic materials is less complicated. Preventing release to the environment of toxic materials often requires simply segregating the material from contact with surface water.

Each application of dredged sediment would be assessed for sediment quality through core sampling (both of the removed sediment and the sediment that is exposed on the channel bottom). The proposed placement of the material would be based on the quality of the sediment. The sediment would be assessed for suitability both from a soil property and a chemical quality standpoint. Criteria set by regulatory authorities would need to be met for placement of the dredged sediment. Other permit requirements should include the following mitigation strategies as principal methods of preventing the release of sediment and toxic material into surface water. These mitigation strategies will be applied in various ways to achieve the best protection of the environment.

Sediment curtains or cofferdams (a method of separating disturbed sediment from surrounding stream water) will be used in all cases of dredging and in-stream earth moving. Performing specific sediment core sampling prior to project implementation will provide the information necessary to determine the suitability of the soils for placement. Quality information (both soil properties and chemical qualities) from the cores will be compared to criteria set by regulatory authorities, and the appropriate mitigation measures will be identified and implemented. In some cases, simple separation of mercury-laden soils and surrounding water is necessary to prevent releases of additional mercury into the environment. Separation may be provided by a few centimeters of fine soils (capping) that are protected from erosion by various means (such as vegetation or gravel). Not all sediment is expected to be suitable for placement near water or human exposure. Regulatory agencies will set criteria for those soils not suitable for reuse.

The following mitigation strategies can be implemented to reduce water quality impacts:

- Improving treatment levels provided at municipal wastewater treatment plants to upgrade the quality of the constituents (other than dissolved inorganic solids) discharged to receiving waters in order to compensate for the reduction in dilution caused by improved water use efficiency or water transfers. Salt concentrations in discharges could be reduced by improved salt management of wastewater inputs to treatment plants.

- Releasing additional water from enlarged or additional off-stream surface storage, or from additional groundwater storage.

- Releasing additional water from storage in existing reservoirs or groundwater basins.

- Treating water at the source (such as Delta drains), upgrading water treatment processes at drinking water treatment plants, and/or providing treatment at the point of use (consumer's tap). Using a mix of alternative source waters to reduce the influent bromide concentration.

- Using innovative, cost-effective disinfection processes (for example, UV irradiation and ozonation—in combination with other agents) that form fewer or less harmful DBPs.

- Using existing river channels for water transfers and timing the transfers to avoid adverse water quality impacts.

- Using best construction and drainage management practices to avoid transport of soils and sediments into waterways.

- Using cofferdams to construct levees and channel modifications in isolation from existing waterways.

- Using sediment curtains to contain turbidity plumes during dredging.

- Separating water supply intakes from discharges of agricultural and urban runoff.

- Applying agricultural and urban BMPs, and treating drainage from lands to reduce contaminants. Treating drainage from agricultural lands underlain by peat soils to remove TOC.

- Relocating diversion intakes to locations with better source water quality.

- Restoring additional riparian vegetation to increase shading of channels.

- Conducting core sampling and analysis of proposed dredge areas and engineering solutions to avoid or prevent environmental exposure of toxic substances after dredging.

- Capping exposed toxic sediments with clean clay/silt and protective gravel.

- Locating constructed shallow-water habitat away from sources of mercury until methods for reducing mercury in water and sediment are implemented.

- Engineering surface storage release times and magnitude to mimic natural regimes.

- Avoiding inundation or engineering solutions to inundation of toxic materials, such as covering with an engineered cap.

- Scheduling ground-disturbing construction during the dry season.

5.3.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

One potentially significant adverse impact on water quality that is associated with the Preferred Program Alternative may not be reduced to a less-than-significant level by mitigation. This impact is an unavoidable consequence of implementing the Preferred Program Alternative.

Although the Preferred Program Alternative would improve water quality at many locations in the Delta, it would cause water quality to deteriorate in others. Without a diversion facility on the Sacramento River, impacts on water quality associated with the Preferred Program Alternative would be similar to those for Alternative 1. The increased EC (a measure of salinity) of water in localized areas of the central Delta would result in a potentially significant and unavoidable impact on the suitability of the water as a source for agricultural irrigation.

5.4 Groundwater Resources

Groundwater is a vital water supply resource in California that is greatly influenced by human actions. In some areas, groundwater is in overdraft conditions, which can result in land subsidence and poor groundwater quality. In other areas, groundwater basin management has helped to ensure the continued beneficial use of this valuable resource.

5.4 Groundwater Resources

5.4.1 SUMMARY

Groundwater provides about 30% of California's water supply during average years; that percentage increases during drought conditions. Although the amount of water in California's aquifers is greater than that stored in the state's surface water reservoirs, only a small percentage of the groundwater resources can be economically and practically extracted. Overall, the CALFED Bay-Delta Program (Program) would benefit this crucial resource, but there is some potential for significant adverse impacts, depending on water supply conditions and options exercised. Mitigation strategies are available to reduce the potentially significant adverse impacts to a less-than-significant level.

Preferred Program Alternative. The Preferred Program Alternative would benefit groundwater resources by providing opportunities for groundwater recharge. In areas with groundwater overdraft, more recharge can lead to better groundwater quality, reduced land subsidence, more dependable long-term water supply reliability, and reduced groundwater pumping. Under the Ecosystem Restoration and Levee System Integrity Programs, land conversion could benefit groundwater resources by reducing the amount of groundwater used on that land and reducing subsidence, additional groundwater recharge, and a reduction of salt-water intrusion in some areas. Potentially significant adverse impacts on groundwater resources from these programs could include reduced groundwater recharge as less agricultural drainage or irrigation water is used and returned to the system. The Water Use Efficiency Program could result in a reduced demand for groundwater supplies, which in turn could result in better quality groundwater. However, this program also could reduce the amount of water available in some areas for groundwater recharge. The Water Transfer Program could result in such potentially significant adverse impacts as increased groundwater pumping in areas where it previously had not occurred, reduced amount of water available for groundwater recharge, lower groundwater levels and higher pumping costs, degraded groundwater quality, and an increased dependence on groundwater supplies in areas receiving the transferred water. Mitigation strategies are available to reduce the potentially significant adverse impacts to a less-than-significant level.

The Storage element could benefit groundwater resources by increasing water supply reliability, increasing groundwater levels and thereby decreasing pumping costs, and reducing or reversing the effects of groundwater overdraft—primarily land subsidence and water quality degradation. However, potentially significant adverse impacts from the Storage element could include increased pumping and higher pumping costs, land subsidence, and poor-quality water, as well as reduced well yields and streamflow depletions. The Conveyance element could result in a potentially significant adverse impact related to the unlined canal that is associated with the diversion facility on the Sacramento River. An unlined canal could leak, depending on the soil permeability, and cause soils along the canal to waterlog.

Changes in project operations may result in a potentially significant adverse impact on groundwater resources in the Other SWP and CVP Service Areas. The potential range of changes in supply for this area could result in increased groundwater pumping; however, these same changes could lead to beneficial results in this area, depending on how the resources were managed. Mitigation strategies are available to reduce the potentially significant adverse impacts to a less-than-significant level.

Alternatives 1, 2, and 3. Alternatives 1, 2, and 3 would result in similar benefits and adverse impacts as those described for the Preferred Program Alternative. Alternatives 2 and 3 have greater potential for beneficial and adverse impacts than the Preferred Program Alternative or Alternative 1 because of their additional conveyance features.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Changes in groundwater levels (1,2,3,4,5,6,12,15,19,20, 21,22)

Increased demand for groundwater supplies (1,2,3,5,7,9, 15).

Increased groundwater overdraft (4,8,10,11,14,15,16,19, 20).

Increased land subsidence (4,8,10,11,12,13,14,15,16,19, 20).

Increased degradation of groundwater quality from contaminant movement, salt-water intrusion, or naturally poor-quality water drawn into the aquifer (2,8,10,11,12, 14,15,16,17,18,19,20).

Impacts from groundwater recharge and storage system operations (4,7,8,10,11,12,15,16,18,19).

Mitigation Strategies

1. Creating additional groundwater or surface water storage facilities to meet demand without resorting to overdraft.
2. Importing water from other basins.
3. Purchasing water rights from willing sellers (including transferring water rights between sectors—for example, from agriculture to municipal uses).
4. Regulating groundwater withdrawals to avoid overdraft and third-party impacts.
5. Implementing water conservation measures to reduce demand.
6. Integrating Ecosystem Restoration Program floodplain restoration efforts with setback levees.
7. Increasing water supplies from recycling.
8. Increasing regulations regarding new and existing domestic wells and septic systems.
9. Developing alternative water supplies.
10. Monitoring and testing groundwater wells and aquifers.
11. Limiting new septic tank systems in vulnerable areas.
12. Allowing water levels to increase periodically.
13. Importing new soil (including dredged spoil) to raise land surface.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative (continued)

14. Reducing or discontinuing groundwater pumping.

15. Recharging aquifers through injection wells (confined aquifers) or percolation ponds (unconfined aquifers).

16. Distributing groundwater pumping over a wide region rather than to a concentrated area to minimize drawdown of the aquifer.

17. Treating extracted groundwater at the well head.

18. Diluting poor-quality groundwater with higher quality water.

19. Developing new groundwater basin management plans or expanding existing groundwater basin plans, including defining objectives, project boundaries, responsibilities, operation and maintenance specifications and procedures, and conditions under which corrective actions are taken.

20. Temporarily removing the recharge system from service to avoid impacts associated with high water tables.

21. Monitoring water-level conditions on islands adjacent to in-Delta storage.

22. Installing interception wells at in-Delta storage facilities to control seepage.

23. Lining conveyance canals to prevent seepage.

No potentially significant unavoidable impacts on groundwater are associated with the Preferred Program Alternative.

5.4.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. According to this definition, no areas of controversy relate to groundwater resources.

There are a number of concerns over groundwater resources. The Program has initiated a groundwater outreach component to help identify and address stakeholder concerns about groundwater use and management with special emphasis on conjunctive use projects. The Program has contacted and met with dozens of individuals, including private citizens, water managers, water district board members, and elected officials to learn about local concerns regarding conjunctive use programs, and to determine which areas would be interested in participating in a locally-controlled conjunctive use program. Additionally, the Program has participated in workshops in both the Sacramento and San Joaquin Valleys to present the status of the groundwater program and to solicit additional comments and concerns regarding conjunctive use.

The CALFED Groundwater Outreach Program has resulted in a greater awareness of stakeholder concerns regarding potential negative impacts resulting from conjunctive use programs. While these impacts are specific to each area, they essentially fall into the following categories:

- Reduced well yields
- Subsidence
- Water quality degradation

- Costs for lowering pumps or deepening wells
- Changes in stream flow
- Overdrafted basins
- Loss of water rights
- Wetlands impacts

In addition to these potential impacts, many stakeholders have questions regarding the implementation of conjunctive use projects, such as:

- Who authorizes a conjunctive use project?
- Who controls the amount of water extracted?
- Who monitors and protects water quality?
- How are area of origin rights protected?
- Who allows water to be transferred and under what authority?
- How is conjunctive use integrated with existing management?
- How are the cumulative effects of all the projects monitored and evaluated?
- How are mitigation of impacts carried out?

The Program recognizes that these are real concerns, many of which are based on direct experiences with conjunctive use programs that in the past were not structured to identify or mitigate for negative impacts. As a result, the Program is developing guiding principles for conjunctive use programs to ensure that local concerns and potential impacts are fully addressed prior to implementing a conjunctive use operation.

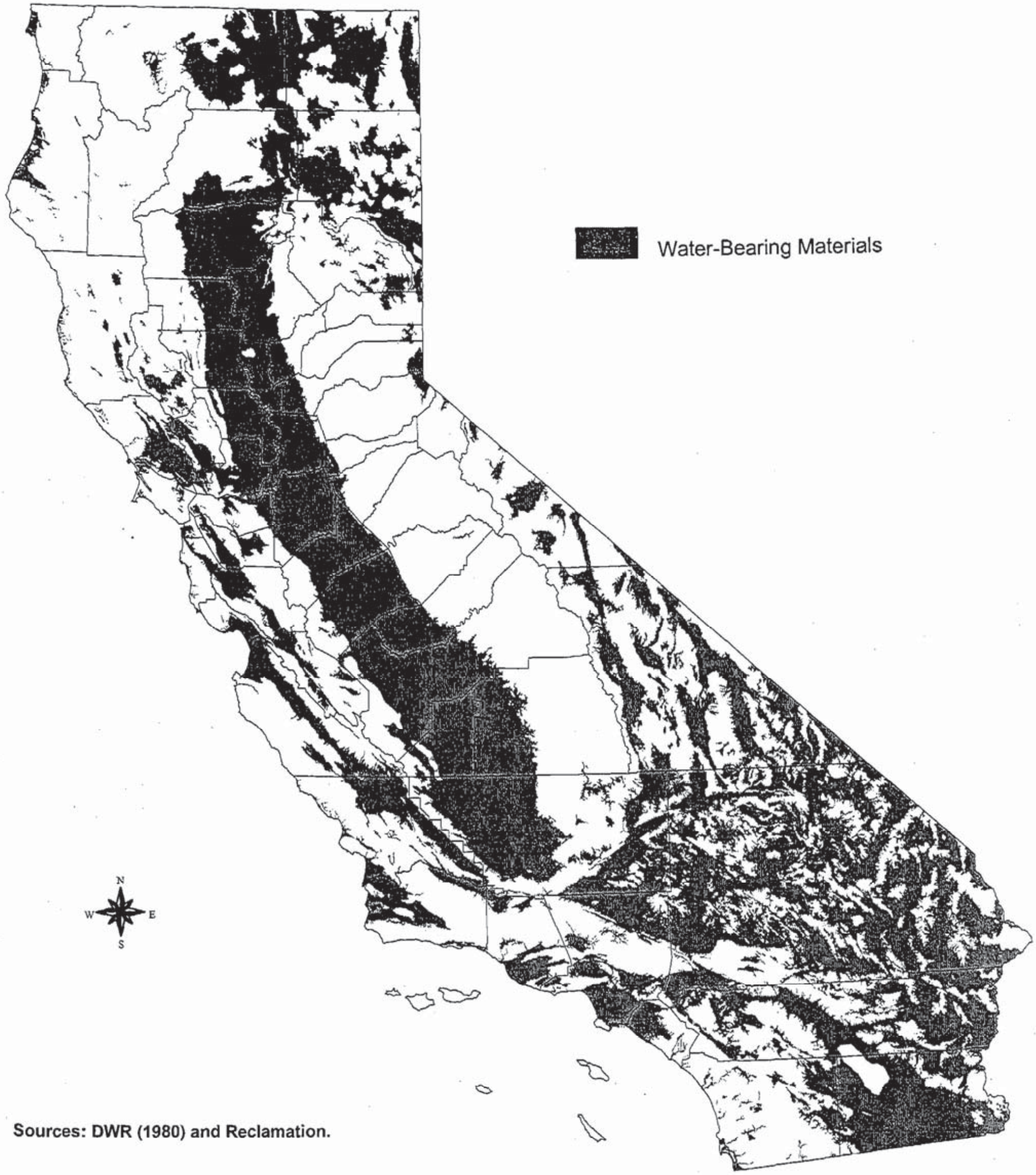
5.4.3 AFFECTED ENVIRONMENT/ EXISTING CONDITIONS

Groundwater Hydrology. About 30% of runoff from rainfall and snowmelt moves quickly over the ground surface and flows into stream channels. Some of the runoff from the upper watershed is transferred out of the watershed in canals or pipelines, but some of the runoff and streamflow is able to percolate below the ground surface and recharge subsurface aquifers. Aquifers may be limited in their lateral extent, thickness, and ability to discharge water due to geologic and structural constraints.

Water that percolates deeply enough can reach the groundwater table. At this point, the slope of the groundwater table determines in which direction groundwater will flow. Often the slope of the water table mimics the slope of the land surface, but this is not always the case. After travel through the aquifer, some of the groundwater may discharge at the surface further downslope in springs, lakes, or streams.

Groundwater from wells drilled into aquifers are used by private and municipal users for consumption as drinking water, for irrigation water, and for industrial uses. Thin soils and steep slopes in upper watershed areas often limit the groundwater storage capacity of aquifers in these areas.

Groundwater also is present in significant quantities in fractured rock aquifers that lie outside identified groundwater basins. This water is extensively used within upper watershed areas, particularly in the Sierra foothills, where adequate surface water supply may not be available for municipal and industrial purposes and some agricultural development. Well yields are typically low, and water quality may be affected by local pollutant sources and can contain high concentrations of metals and other contaminants, such as lime and arsenic.



Sources: DWR (1980) and Reclamation.

Figure 5.4-1 Distribution of Groundwater Basins in California

Identification and characterization of groundwater basins is the responsibility of DWR. The first comprehensive inventory of the groundwater basins in the state was completed in 1975 and published as Bulletin 118. Bulletin 118 was revised in 1980 in response to legislation requiring that DWR "identify the State's groundwater basins on the basis of geological and hydrological conditions and consideration of political boundary lines whenever practical." DWR also was asked to identify basins subject to "critical conditions of overdraft." Bulletin 118-80 identified 450 groundwater basins, 11 of which were found to be subject to critical conditions of overdraft. One of these, the Eastern San Joaquin County Basin, is located in the Delta Region, and extends into the San Joaquin River Region. Figure 5.4-1 shows the distribution of geologic materials that have been defined as groundwater basins.

DWR recently has revised the descriptions of some groundwater basins, which will be published in a future edition of Bulletin 118. The description of groundwater basins presented in this report is based, to the extent possible, on the working definitions currently used by DWR staff.

Groundwater Rights. California has developed a system of groundwater rights that recognizes overlying rights, appropriative rights, and prescriptive rights. Overlying rights attach to percolating groundwater and are the prior and paramount rights to groundwater, usually held by property owners with property overlying a groundwater basin. Appropriative rights to percolating groundwater are based on the concept that an entity uses water for reasonable and beneficial purposes on non-overlying land. The appropriator is limited, however, to the use of "surplus" water, which is the water in excess of the cumulative water requirements of all overlying owners.

Public use of groundwater, such as sales to retail customers, is characterized as an appropriative use, not as an overlying use. Municipalities and water districts typically hold appropriative rights to groundwater because they generally do not possess an ownership interest in land overlying a groundwater basin. Under Article X, Section 5 of the California Constitution, water pumped and distributed by a public agency is immediately characterized as a public use. As a result, public entities that dedicate their supplies to a public use are held to be lawful appropriators even though they may provide water to customers overlying the very same groundwater basin from which the public entities draw their supply. A municipality, including private water companies that supply municipal water, can exercise an overlying right only to the extent that it uses groundwater on city-owned land overlying the groundwater basin.

An overlying owner has the right to protect his/her prospective use against an established appropriation by obtaining a declaratory judgment before a basin becomes adjudicated. However, until the overlying owner uses the full available supply of water, appropriators have the right to use any surplus that exists. The constitutional amendment of 1928 prohibits the waste or unreasonable use, method of use, or method of diversion of water by groundwater users. The overlying right, however, does not depend on continuous use or the date that the use of groundwater was first initiated—in contrast to the appropriative right.

Overlying rights also are considered correlative with all other similarly situated property owners who overlie the common groundwater supply. A correlative right simply means that all overlying owners have equal rights to pump groundwater from the basin. Where the overlying owners do not fully utilize the available safe yield of the basin, a surplus exists that is available for appropriation by others.

Between appropriators, priority is determined based on first in time, first in right. Consequently, if the first appropriator utilizes all available surplus from a particular groundwater basin, no additional appropriators will be allowed. As between appropriators of surplus, the prior appropriator may extract up to the amount of water used in the past before the next senior appropriator may take any water.

All groundwater rights, whether overlying or appropriative, are limited by the concept known as safe yield. The term "safe yield" is a technical definition of basin yield that has been adopted by the courts to delineate the legal rights to extract groundwater in a basin. The terms "safe yield" and "perennial yield" have been used interchangeably in the past.

Safe yield generally is characterized as being equivalent to the annual replenishment the groundwater basin receives from all hydrologic sources. Safe yield is reached when the amount of water being pumped equals the replenishment coming to the basin by rainfall, return waters, runoff, and underflow. Overdraft of the groundwater basin begins whenever extractions increase to the point where the surplus ends and the safe yield is exceeded. The generally accepted legal definition for safe yield is "the maximum quantity of water which can be withdrawn annually from a groundwater supply under a given set of conditions without causing an undesirable result."

The concept of safe yield has become the focal point of groundwater basin adjudications and is used to establish the existence and extent of water rights in the groundwater supply, although typically after the safe yield has been exceeded. Eighteen basins in California have been adjudicated, and the court has appointed a watermaster to oversee the court judgement. Two adjudicated basins (the Cummings Basin and the Tehachapi Basin) are located in the upper watershed of the southern San Joaquin Valley. One of the adjudicated basins is outside the Program study area, in the North Coast Region. The remaining 15 adjudicated basins are within the Other SWP and CVP Service Areas.

Groundwater Management. California does not have a statewide program for the management of groundwater. Groundwater management in California is a local responsibility accomplished under the authority of the California Water Code. In addition to groundwater basin adjudication as discussed above, the most common forms of groundwater management include the following.

Local Agencies. Many local agencies, districts, and other entities identified in the California Water Code have the authority to develop some forms of groundwater management. Some of these agencies have actively managed their groundwater resources. Examples of the types of agencies that may have statutory authority to manage groundwater include California water districts, community services districts, flood control and water conservation districts, irrigation districts, municipal utility districts, reclamation districts, water conservation districts, water replenishment districts, and water storage districts.

Special Legislation Districts. Special legislation has been enacted in some parts of California to form groundwater management districts or water management agencies. The legislation allows these districts or agencies to enact ordinances in order to limit or regulate groundwater extraction. Currently, there are nine of these groundwater management districts or agencies in California and three agencies that acquired similar authority through amendments to the Water Code.

Assembly Bill 3030. Sections 10750-10756 of the California Water Code (AB 3030, Chapter 947, Statutes of 1992 and amendments) provide a systematic procedure for an existing local agency to develop a groundwater management plan. These sections of the Water Code provide such an agency with the powers of a water replenishment district to raise revenue in order to pay for facilities to manage the basin (extraction, recharge, conveyance, and quality). To date, 149 agencies have adopted groundwater management plans in accordance with AB 3030. Many other agencies have begun the process.

City and County Ordinances. California courts have ruled that State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater. To date, 12 counties have adopted groundwater management ordinances. Many of these ordinances require a permit to extract and transfer groundwater beyond county boundaries. The nature and extent of the police power of cities and counties to regulate groundwater is presently uncertain.

Groundwater Regulation. Groundwater regulation in California primarily is related to water quality issues, which have been addressed through a number of different legislative acts. These acts deal with water quality planning, control of waste discharges, quality of public drinking water supplies, hazardous materials management, pesticide management, solid waste disposal, water reclamation, mining waste reclamation, environmental assessment, and local land use planning.

Several state agencies regulate groundwater, each with different responsibilities. The SWRCB and the nine regional water quality control boards are responsible for protecting the quality of the waters of the state for present and future beneficial uses. The regional boards formulate, adopt, and implement basinwide water quality control plans and policies.

The Department of Toxic Substances Control (DTSC) has statutory responsibility to protect public health and the environment from the improper handling, storage, transport, and disposal of hazardous wastes. EPA authorized DTSC to implement the Resource Conservation and Recovery Act (RCRA) program in California, while the Department of Pesticide Regulation (DPR) has statutory responsibility to prevent pesticide pollution of groundwater that may be used for drinking water supplies.

The California Integrated Waste Management Board (CIWMB) oversees the disposal of non-hazardous solid waste by local agencies. The Office of Drinking Water and Environmental Management, within the Department of Health Services (DHS), protects public health by regulating drinking water supplies and establishing drinking water standards. Finally, the Department of Conservation (DOC) is responsible for preventing contamination of groundwater resulting from the drilling, maintenance, and destruction of oil, gas, and geothermal wells.

5.4.3.1 DELTA REGION

The Delta Region is underlain by organic-rich, fine-grained alluvial soils. Peat deposits more than 20 feet thick are found in the central Delta. These deposits have been mined in some areas for use as a soil amendment. Beneath the young surficial deposits are up to 3,000 feet of unconsolidated non-marine sediments. These deposits contain the principal regional aquifer in the Delta.

In the central Delta, the aquifer consists of many poorly connected sand and gravel units that are locally confined by silt and clay layers. Both low yields to wells and poor water quality limit the use of groundwater in the central Delta. Groundwater from depths of less than 100 feet is too saline for most beneficial uses in an area covering over 200 square miles of the central Delta.

Information on use of groundwater in the Delta Region is limited. Historically, groundwater pumping in the central Delta has been used to drain waterlogged soils for agriculture. Groundwater use has been limited to the upland areas on the Delta periphery.

Most of the current groundwater pumping on Delta islands is for the purpose of draining crop lands. The land surface on many Delta islands lies below the elevation of water in the surrounding channels and would be flooded if groundwater levels were not lowered by pumping. The Delta aquifer is recharged primarily by streamflow and to a lesser degree by underflow from adjacent aquifers.

One type of land subsidence is associated mainly with loss of peat soils. As water levels decline, oxygen from the atmosphere enters the pore space once occupied by water. The oxygen reacts with the peat, which is composed of plant material, and slowly causes it to oxidize, which is a chemical process like burning. The byproducts of oxidation of peat are carbon dioxide and water. As a result, the peat disappears and no longer supports the overlying soil, resulting in subsidence.

Around the margins of the Delta Region both the quality and yield of groundwater are higher than in the central Delta lowlands. Groundwater is relied on in the peripheral Delta uplands for both domestic and agricultural uses. Average annual groundwater withdrawals are estimated to range from 100 to 150 thousand acre-feet (TAF) in upland areas of the Delta.

5.4.3.2 BAY REGION

Within the Bay Region, groundwater is found in both alluvial aquifers and in fractured rock. Alluvial basin deposits near the Bay range in thickness up to 1,000 feet. Well yields typically range from less than 100 to over 3,000 gallons per minute. Recharge to the alluvial basins occurs primarily from infiltration of rainfall along stream channels. Artificial recharge in Santa Clara County and the Niles Cone Basin also account for significant local groundwater recharge.

Total average groundwater use in the region is estimated at about 190 TAF per year. The estimated groundwater storage in the North Bay is estimated at 1.7 MAF. Groundwater storage in the South Bay is estimated at 6.5 MAF.

A portion of groundwater resources in basin areas of the Bay Region have been subject to overdraft conditions, leading to salt-water intrusion and subsidence, and pollutant loading from urban-industrial sources. Basin aquifers generally are protected from surface contamination to some extent by thick clay deposits.

Groundwater conditions in the Santa Clara County Basin are an exceptional example of the range of problems encountered elsewhere in the Bay Region. The basin aquifers were heavily pumped to meet agricultural and municipal demands prior to the 1960s, causing land subsidence, increased flooding potential, and salt-water intrusion in portions of the basin. A county-wide groundwater management program was implemented, including construction of artificial recharge basins to replenish groundwater, well registration to control cross-contamination of aquifers by intruding salt water, and a groundwater extraction monitoring and pumping fee program to track withdrawals and fund the replenishment program. Widespread groundwater pollution from industrial sources also occurred as the region underwent intense industrial development and urban expansion. Large-scale, long-term groundwater extraction and treatment projects have been undertaken to remediate some of the groundwater contamination sites. Outside the Santa Clara County Basin and the Niles Cone area, groundwater is not widely used and has not experienced sea-water intrusion or subsidence.

Groundwater use in the Bay Region has decreased, and surface water use has increased as the region has undergone urban expansion. Surface water is imported from the Delta through the CVP and SWP, and from other sources. However, groundwater use tends to increase during low rainfall periods. During the 1987-92 drought, for example, groundwater use increased substantially to make up for decreased surface water supplies.

Groundwater quality may be affected by a number of processes. Contaminants may reach groundwater from surface or subsurface sources, such as hazardous waste sites, underground storage tanks, or polluted streams. Groundwater pumping may induce poor quality groundwater from one area to migrate into another area. Salt-water intrusion caused by groundwater pumping in coastal areas is an example of this condition.

Groundwater quality varies throughout the Bay Region, depending on local geological and land use conditions.

In the North Bay, water quality is generally good, although some areas experience elevated iron, boron, hardness, total dissolved solids (TDS), and chloride. Elevated concentrations of nitrates occur in the Napa and Petaluma Basins, where fertilizers are used intensively. In the southern Suisun-Fairfield Basin, salt-water intrusion has occurred due to over-extraction of groundwater.

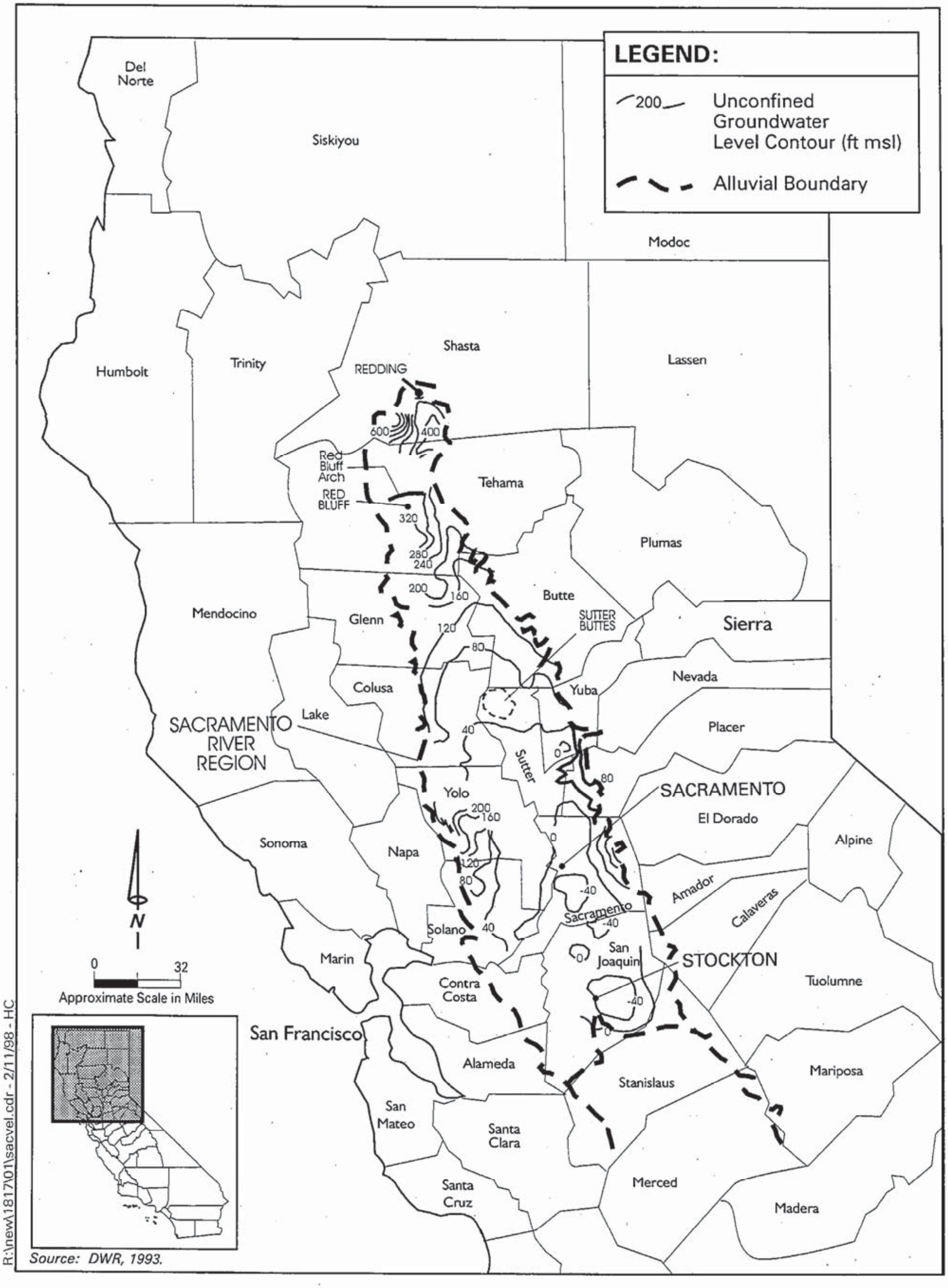
Groundwater quality is poor in many parts of the South Bay. Elevated levels of TDS, chloride, boron, and hardness occur in the Livermore Basin. In the San Mateo, Santa Clara County, Pittsburg Plain, and Niles Cone Basins, salt-water intrusion induced by over-extraction of groundwater has been a problem in the past and now is being addressed through artificial groundwater recharge and monitoring groundwater withdrawals.

5.4.3.3 SACRAMENTO RIVER REGION

For discussion purposes, groundwater sub-basins located within the floor of the Sacramento Valley, between Redding and the Delta Region, are considered together as one unit herein called the Sacramento Valley Alluvial Basin. Depth to the base of fresh water in the Sacramento Valley Alluvial Basin ranges from 1,000 feet in the Orland area to nearly 3,000 feet in the Sacramento area. Most recharge to the basin occurs along the north and east boundaries of the Sacramento Valley, where runoff is greatest. Seepage from applied irrigation and from irrigation distribution canals is an important component of groundwater recharge in some parts of the Sacramento Valley. Usable storage capacity is currently estimated at 40 MAF. The perennial yield (the amount of groundwater that can be extracted indefinitely from an aquifer without long-term adverse impacts) has been estimated at 2.4 MAF per year. Current groundwater withdrawals from the alluvial basins are estimated to total 2.6 MAF. Although total withdrawals are not much greater than the estimated perennial yield, local groundwater depressions have developed in some areas due to the uneven distribution of pumping. Figure 5.4-2 shows recent groundwater levels in the Sacramento Valley.

Prior to development, aquifer recharge to the Sacramento Valley Basin was mainly from infiltration along streambeds and from subsurface inflow along basin boundaries. With the introduction of agriculture to the region, seepage from irrigation canals and deep percolation of applied irrigation water contributed to recharge.

Historical data show that surface water and groundwater are closely linked in many parts of the basin. When the water table rises above the level of water in a stream channel, groundwater tends to flow from the aquifer to the stream (gaining stream). When groundwater levels fall, the stream loses water by seepage to the underlying aquifer (losing stream), contributing to groundwater recharge. The gaining component of a stream depends on cyclic changes in recharge and is an indicator of the unfilled storage capacity of the upper aquifer. A study of stream gains and losses from 1961 to 1977, an average recharge period, indicated that streams in the central and eastern Sacramento Valley were generally gaining streams, while west side streams and the American River were losing streams.



Source: DWR, 1993.

Figure 5.4-2. Groundwater Elevations in the Sacramento Valley

In some areas, near the Sacramento River, the stream channel is higher in elevation than the surrounding land surface. This condition can result in waterlogging of lands adjacent to the river and consequent crop losses due to seepage from the stream channel. DWR has identified several areas where this problem occurs.

Over the long term, if the amount of water stored in a groundwater basin is to remain constant, the outflow from a basin cannot be greater than the recharge to the basin. A long-term decline in groundwater storage, which would be observed as a general decline in regional water levels, is the result of more outflow than inflow. Recharge can include infiltration of surface water, groundwater underflow, or groundwater injection. Outflows include groundwater underflow, discharge to surface water bodies (springs, streams, and lakes), groundwater pumping, and evapotranspiration.

Groundwater levels in many areas on the west side of the Sacramento Valley were in a state of decline prior to the completion of CVP facilities in this area. Upon completion of the Tehama-Colusa and Corning Canals, groundwater levels in some wells began to recover and rose to historical maximum levels. These levels were essentially maintained through the 1970s and mid-1980s. The drought occurring between 1987 and 1992, coupled with increased costs of CVP water, forced many irrigators on the west side of the valley to use greater amounts of groundwater. However, these additional uses of groundwater have resulted in renewed declines in groundwater levels in several areas.

In fall 1960, regional groundwater levels north of the Sutter Buttes were similar to water levels observed in the early 1900s. However, south of the Sutter Buttes, groundwater levels in several areas of Yolo, Solano, and Sacramento Counties had dropped nearly 50 feet since the early 1900s. Groundwater levels in areas north of the Sutter Buttes continued to show little sign of long-term declines through the mid 1970s. By spring 1974, groundwater levels south of the Sutter Buttes had recovered somewhat, due to above normal runoff. However, continued groundwater development in Sacramento County and in the Marysville area east of Sutter Buttes resulted in additional declines between 1960 and 1974.

Groundwater levels in spring 1986 indicated little change from 1974 levels. Spring 1993 water level data indicated the presence of a pumping depression in Sacramento County. Groundwater levels in much of the western part of both Sacramento and San Joaquin Counties were more than 40 feet below sea level. In all other areas of the Sacramento Valley Alluvial Basin, above- normal runoff during the 1992-93 wet season resulted in nearly full recovery of groundwater levels to pre-drought (1987-92) conditions.

Depending on specific conditions in the basin, a long-term decline in groundwater storage can result in secondary impacts, such as land subsidence, increased cost of pumping, permanent reduction in permeability of aquifers, and reduction in water quality.

Declining water levels may cause land subsidence in at least two ways. In some aquifers, the sand and silt particles that form the matrix of the aquifer are kept slightly separated from each by the buoyancy effects of water. The water prevents the particles from compressing under the weight of the overlying soil. When the water is removed, however, the particles settle closer together. Subsidence is the combined effect of all of the settling of particles within the aquifer. The more water that is removed, the more subsidence occurs. Some of this compression is irreversible, so that even if groundwater returns to its previous level, the pore space between particles will remain smaller than before the compression occurred. Subsidence can cause damage to structures and increase flooding potential on low-lying land. Reduction in the pore space in the aquifer also may reduce the permeability of the aquifer, reducing the rate of groundwater flow under pumping pressure.

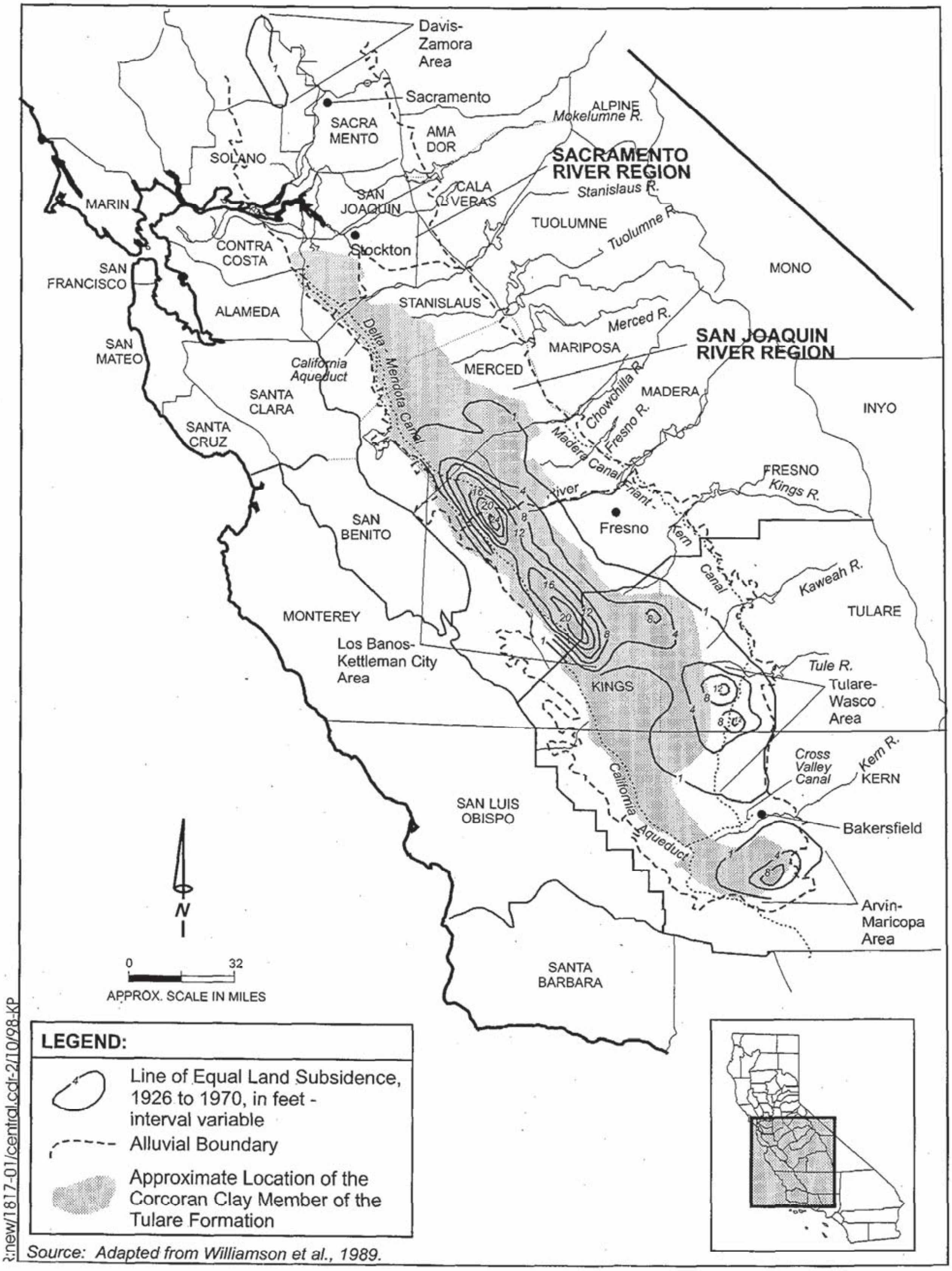
Land subsidence due to groundwater declines exceeded 2 feet by 1973 in the area east of Zamora and west of Arbuckle. Subsidence exceeded 1 foot near Davis by 1973. Localized land subsidence continued to occur in the Davis-Zamora area during the 1987-92 drought. Figure 5.4-3 shows areas of historical land subsidence.

Groundwater quality in the upper watersheds of the Sierra Nevada is good; recharge is generally high, and groundwater resources are relatively undeveloped. In some areas, however, wells drilled in fractured rock provide the water supply for permanent or recreational homesites. Due to the low yield of rock formations, the rapid flow along fractures, and the potential for fractures to intercept surface sources of pollutants, development of groundwater in fractured rock has led to problems of interference between wells and contamination from septic tank effluent. The Sierra Valley Basin has been identified as a special problem basin. Drilling of large agricultural wells and growth of housing subdivisions also has caused water levels in the formerly artesian aquifer to drop below the ground surface, complicating the problem of providing winter water for cattle.

Natural groundwater quality is generally excellent in most of the Sacramento Valley and is suitable for most uses. The concentration of TDS is a general indicator of water quality. TDS is less than 300 milligrams per liter (mg/L) in most areas of the Sacramento Valley. However, TDS has been reported above the short-term drinking water standard of 1,500 mg/L in groundwater samples from wells south of the Sutter Buttes and west of Sacramento. Iron and manganese concentrations from mineral sources have been reported in excess of drinking water standards in some wells in the Butte, Sutter, and Colusa Sub-Basins and in the southern Sacramento Valley. Levels of boron in the range of 0.75 mg/L, which is sufficiently high to affect boron-sensitive plants, have been observed in a wide region of the southern Sacramento Valley that includes Vacaville, Rio Vista, and West Sacramento, and also east of Red Bluff. Arsenic is a naturally occurring trace element that can be toxic to both plants and animals. Arsenic concentrations should generally be less than 1.0 mg/L for irrigation use, while the primary drinking water standard is 0.050 mg/L. Arsenic concentrations limit the use of groundwater as a source of drinking water in western San Joaquin County.

The eastern San Joaquin County groundwater basin (the area of San Joaquin County east of the San Joaquin River) has experienced elevated levels of chloride concentrations in the vicinity of the City of Stockton. This condition is believed to be caused either by long-term declines in groundwater levels to the east, which may have induced eastward movement of poor-quality water from the Delta sediments to the west, or possibly by groundwater pumping in the Stockton area causing upwelling of connate water from marine sediments below the fresh-water zones of the groundwater basin. DWR's Bulletin 118-80 reported that migration of these saline waters have severely affected groundwater resources in the area and has resulted in well abandonment and drilling of replacement wells to the east.

Elevated concentrations of introduced contaminants have been observed in some areas. Nitrate concentrations from dispersed sources have exceeded the primary drinking water standard of 45 mg/L in some wells in the Butte and Colusa Sub-Basins, in the Chico area, and in the southern Sacramento Valley. Pesticides have been observed sporadically in wells in the Butte Sub-Basin. The pesticides bentazon and dibromochloropropane (DBCP) have been widely reported in groundwater in Sutter County. Various pesticides are widely reported in wells in the Colusa Sub-Basin. Bentazon is reported throughout the Feather River Basin in Butte, Yuba, Placer, and Sutter Counties, and in isolated wells in the Yuba and American Sub-Basins. Elsewhere, groundwater contamination generally is limited to specific contaminant release sites.



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Source: Adapted from Williamson et al., 1989.

Figure 5.4-3. Extent of Land Subsidence in the Central Valley due to Groundwater Level Decline

5.4.3.4 SAN JOAQUIN RIVER REGION

For purposes of this report, the groundwater basins that occupy the floor of the Central Valley in the San Joaquin River Region are referred to as the San Joaquin Alluvial Basin. This is the most important basin in the region, although a number of small, isolated basins also exist in the upland margins of the valley. Although the aquifers underlying the entire San Joaquin Alluvial Basin are able to drain north to the Delta Region, the southern portion of the basin (roughly south of the Kings River) is sufficiently isolated from the northern portion of the basin that it can be thought of as a distinct groundwater basin called the Tulare Basin.

Because the Modified E clay and other clay layers prevent recharge of the confined aquifer in the central portion of the valley, most recharge to the confined aquifer occurs along the margin of the valley. Recharge to the shallow unconfined and semi-confined aquifers is contributed by seepage from stream channels, deep percolation of applied irrigation water, and seepage from irrigation distribution and drainage canals.

Prior to development, streams were typically in hydraulic connection with shallow groundwater. Agricultural development has caused groundwater levels to decline in many areas, so that most streams lose water from seepage rather than gaining water from groundwater. Prior to development, groundwater in the San Joaquin River Region flowed from the valley flanks to the axis, then north toward the Delta. Large-scale groundwater development during the 1960s and 1970s, combined with the introduction of imported surface water supplies, has modified the regional groundwater flow pattern, creating small groundwater depressions and mounds. Also, thousands of wells perforated both above and below confining layers have increased the connection between distinct aquifer units.

From the 1920s until the mid-1960s, the use of groundwater for irrigation of crops in the San Joaquin Valley increased rapidly. Declines in groundwater levels due to this increased groundwater use caused land subsidence throughout the west side and southern portions of the valley. From 1920 to 1970, almost 5,200 square miles of irrigated land in the San Joaquin River Region registered at least 1 foot of land subsidence. Land subsidence has been concentrated in areas underlain by Corcoran clay, where pumping from the confined aquifer resulted in dramatic reductions in the confining pressure that supported the overlying deposits. The effect is less pronounced in areas underlain only by an unconfined or semi-confined aquifer. Figure 5.4-3 shows areas of subsidence in the San Joaquin River Region from 1926 to 1970. The largest area is the Los Banos-Kettleman Hills area, which covers 2,600 square miles from Merced County to Kings County. Subsidence of up to 30 feet has been measured in parts of northwest Fresno County.

From 1984 to 1996, land subsidence has been reported along the Delta-Mendota Canal. About 1.3 feet of land subsidence occurred near the Mendota Pool, and about 2.0 feet of subsidence occurred about 25 miles northeast of the Mendota Pool. From 1990 to 1995, up to 2.0 feet of subsidence was reported in the Westlands Irrigation District along the California Aqueduct.

Currently, heavy groundwater pumping in some parts of the San Joaquin Valley, combined with reductions in recharge, has created local cones of depression that draw groundwater from surrounding areas into the regions of concentrated pumping. Regional groundwater level contours from wells completed in the unconfined or semi-confined aquifer zone are shown in Figure 5.4-4 to illustrate the compartmentalized flow pattern in the shallow aquifer. Similar conditions occur in the confined aquifer.

Cones of depression can be seen in Figure 5.4-4 in the vicinity of Fresno and near Merced, while a groundwater high mound, shown as a closed 200-foot contour, can be seen near the boundary between Fresno and Kings County. This groundwater high, due to inflow from the alluvial fan of the Kings River, acts as a hydraulic barrier and prevents groundwater from the Tulare Lake basin from flowing north into the Kings River basin.

Northwest of the groundwater high mound and southwest of Fresno, a groundwater depression is shown by the open 50-foot elevation contour. The depression prevents groundwater in the vicinity of the Kings River from flowing north into the Chowchilla area. Further to the north, another groundwater depression is shown by a closed 50-foot contour. This depression captures water in the Chowchilla area and prevents it from moving north into the Merced area.

Usable groundwater storage capacity for the northern portion of the San Joaquin Valley is estimated at approximately 24 MAF. The perennial yield is estimated at approximately 3.3 MAF per year. Average annual groundwater withdrawals are estimated at 3.2 MAF, of which about 70% is used for agriculture.

Total groundwater overdrafts in the northern San Joaquin Valley recently were estimated at about 0.2 MAF per year for 1990 normalized conditions. Conditions are normalized to a 1990 level of development and adjusted to remove unusual conditions affecting water supply and demand to facilitate identification of long-term trends.

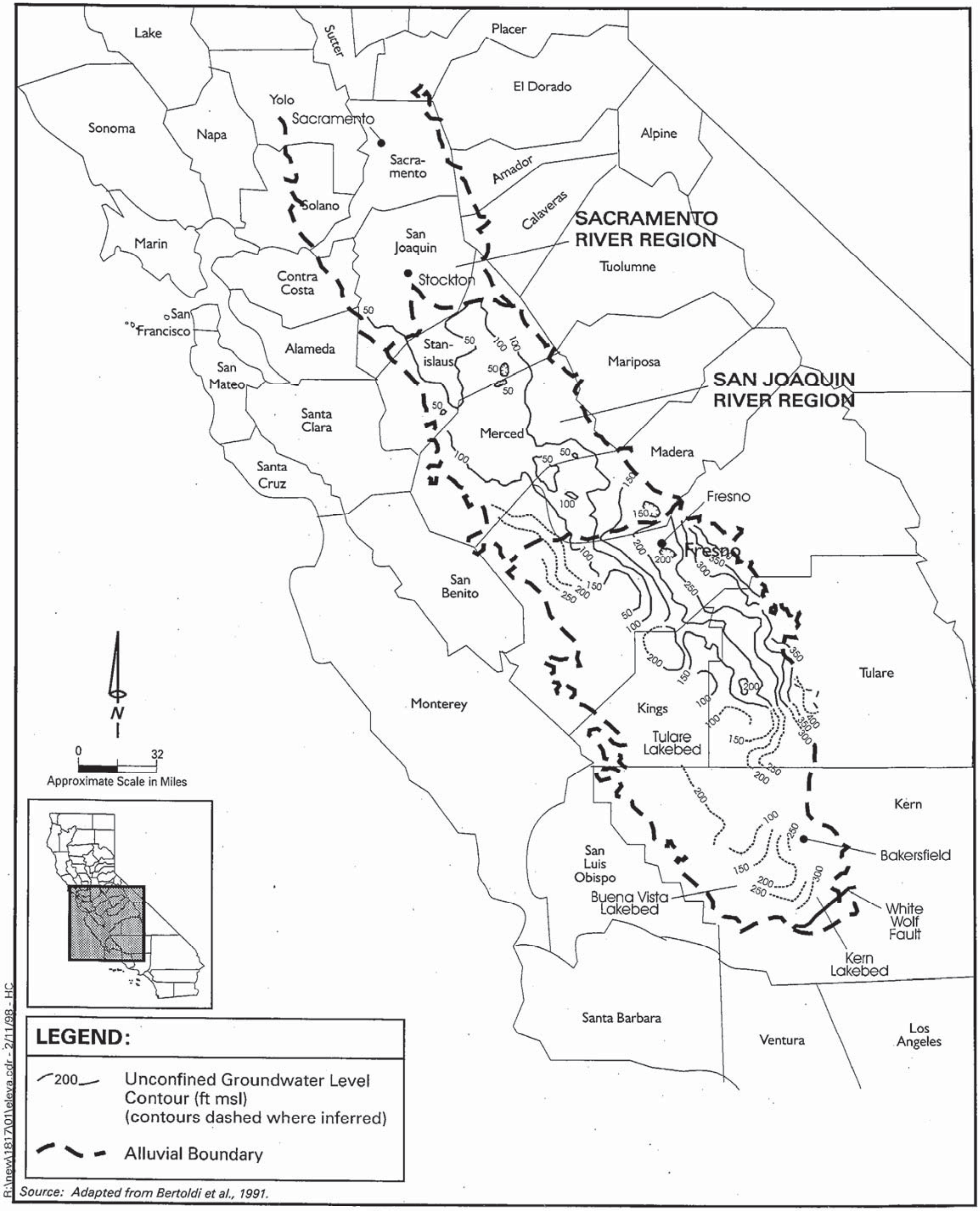
Groundwater level declines in the lower confined aquifer of more than 400 feet have been observed along the west side of the region. The declines were partially reversed after the introduction of imported water supplies.

In some areas, high groundwater levels rather than declining water levels are the principal concern. In the lower reaches of the San Joaquin River, the confluences of major tributaries and in certain other areas, a high water table reduces use of land for agriculture. In the western portion of the Stanislaus River watershed, groundwater pumping historically has been used to control high groundwater levels. Along the San Joaquin River from the confluence with the Tuolumne River through the south Delta, flood control operations in conjunction with spring pulse flow requirements recently have contributed to seepage-induced waterlogging damage of low-lying farmland. However, spring pulse flows most likely are a minor cause of high groundwater levels.

TDS concentrations in groundwater along the east side of the San Joaquin Valley are generally lower than along the west side. The difference is mainly due to differences in quality of aquifer recharge. On the west side of the valley, concentrations range from 500 to 2,000 mg/L. The concentrations in excess of 2,000 mg/L typically occur above the Modified E clay layer, in the semi-confined zone. In the center and east side of the valley, concentrations are generally less than 500 mg/L.

Use of groundwater from above the Modified E clay by agriculture is limited in the western portion of Fresno and Kings Counties due to high TDS concentrations. Municipal use of groundwater is limited by TDS concentrations in scattered locations throughout the San Joaquin Valley.

High boron concentrations occur in the northwestern part of the San Joaquin River Region. Agricultural use of groundwater is limited by boron in eastern Stanislaus and Merced Counties, and in western Fresno and Kings Counties. In the southern portion of the Tulare Lake Basin, high concentrations of boron are generally found in areas southwest of Bakersfield (greater than 3 mg/L) and southeast of Bakersfield



Source: *Adapted from Bertoldi et al., 1991.*

Figure 5.4-4. Groundwater Elevations in the San Joaquin Valley, Spring 1993

(1-4 mg/L). Concentrations as high as 4.2 mg/L have been measured near Buttonwillow Ridge and Buena Vista Slough.

Arsenic is a naturally occurring trace element that can be toxic to both plants and animals. Arsenic concentrations should generally be less than 1.0 mg/L for irrigation use, while the primary drinking water standard is 0.050 mg/L. Arsenic concentrations limit the use of groundwater as a source of drinking water in eastern Contra Costa, Stanislaus, and Merced Counties; and in the southwest corner of the Tulare Lake Basin. Agricultural use of groundwater is impaired due to elevated arsenic concentrations in the Tulare Lake Basin, particularly in areas of the Kern Basin near Bakersfield.

Naturally high concentrations of selenium occur in soils and groundwater on the west side of the San Joaquin River Region. Selenium and other mineral constituents are leached from soils by irrigation and may be concentrated in shallow groundwater or agricultural drain water. The primary drinking water standard for selenium is 0.050 mg/L, but the EPA has identified chronic and acute threshold concentrations for protection of wildlife and aquatic organisms of 5 and 20 micrograms per liter (μg/L), respectively, while the RWQCB has set monthly mean and daily maximum selenium objectives of 5 and 12 μg/L, respectively. Selenium concentrations in groundwater in the western part of Fresno and Kings Counties have limited its use as a drinking water supply.

In the Tulare Basin and in large areas of eastern Fresno and Tulare Counties, the pesticides DBCP and ethylene dibromide (EDB) have exceeded primary drinking water standards, resulting in limitations on groundwater use.

Groundwater in the Yosemite Valley Basin is not widely used.

5.4.3.5 OTHER SWP AND CVP SERVICE AREAS

Two distinct, noncontiguous areas are included in the Other SWP and CVP Service Areas: in the north are the San Felipe Division's CVP and the South Bay SWP service areas; in the south are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of the Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

The CVP and the SWP supply water to water agencies inside and outside the Central Valley. Contractor agency jurisdictions typically are large enough to include several groundwater basins. Some groundwater basins extend beyond the boundaries of one contractor agency into an adjacent contractor area, while portions of other groundwater basins lie outside any SWP contractor area boundary. Since CVP and SWP water potentially contributes to groundwater recharge or may be used in lieu of groundwater (and vice versa), the mismatch of jurisdictional boundaries presents a potential problem for the conjunctive management of surface water and groundwater.

Of the CVP service area, only the San Felipe Division lies outside the Central Valley. The San Felipe Division overlaps several distinct groundwater basins.

In the northern central coast, groundwater is the primary source of water for both urban and agricultural use. The Carmel, Pajaro, and Salinas Rivers provide most of the groundwater recharge for the area. Extraction of groundwater in excess of recharge has resulted in groundwater level declines and sea-water intrusion in coastal areas. Within the Pajaro Valley, groundwater withdrawals are estimated at about 64 TAF per year. About 550 TAF per year are extracted from the Salinas Valley.

The SWP service area overlaps the CVP's San Felipe Division service area in Santa Clara County and includes more than 15 million additional acres outside the Central Valley. Units of the SWP service area outside the Central Valley include parts of the North Bay and South Bay service areas, and the entire central coastal and southern California service areas. These service areas are briefly described below.

The North Bay service area, which includes the Napa County and Solano County Water Agency, overlaps groundwater basins in Napa and Solano Counties. The South Bay service area includes the Santa Clara Valley Water District (SCVWD), the Alameda County Flood Control and Water Conservation District, Zone 7, and the Alameda County Water District. These districts overlap several distinct groundwater basins in Santa Clara and Alameda Counties.

The Central Coastal service area of the SWP includes the San Luis Obispo and Santa Barbara County Flood Control and Water Conservation Districts, and overlaps a number of distinct groundwater basins.

In the inland desert areas, groundwater is the principal source of water. Relatively low recharge rates in comparison to their large storage capacities has led to groundwater extraction in excess of recharge in many desert basins.

A large number of distinct groundwater basins lie within the southern California service area of the SWP. Much of this area (over 3 million acres), is in the service area of MWD, the San Bernardino Valley Municipal Water District (over 200,000 acres), or the San Gorgonio Pass Water Agency (140,000 acres). This heavily urbanized area relies less on groundwater and more on surface water imports. However, past uncontrolled groundwater use has led to declining groundwater levels and sea-water intrusion in some basins. Most of the major groundwater basins have been adjudicated, or groundwater use is restricted through a basin-wide planning process.

Contamination is another factor limiting the use of groundwater in some parts of the region, including the San Fernando, San Gabriel, Upper Santa Ana Valley, and San Jacinto areas, and scattered portions of San Diego County.

Two of the principal water contracting agencies in the Lahontan Region are the Mojave Water Agency, which serves an area of over 3 million acres, and the Antelope Valley-East Kern Water Agency, which serves an area of over 1.5 million acres. Approximately the northern half of the Colorado Desert Region is in the service area of the Mojave Water Agency, while the southern half represents the service areas of the Coachella Valley County Water Agency (about 600,000 acres) and the Desert Water Agency (about 200,000 acres).

5.4.4 ASSESSMENT METHODS

Both qualitative and quantitative methods were used to assess the potential impacts of the Program alternatives on groundwater resources. In general, qualitative methods were used to assess impacts from implementation of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer and Watershed Programs. Qualitative methods were also used to assess impacts from implementation of the Storage element and Conveyance element in all Program regions except the

San Joaquin River Region. In the San Joaquin River Region, potential changes in SWP and CVP Delta deliveries warranted the use of quantitative methods. Furthermore, Alternative 1 (with storage conditions) is used as a surrogate for the assessment of impacts associated with the Preferred Program Alternative and Alternatives 2 and 3. Impacts on groundwater resources associated with Alternative 1 (with storage conditions) represents the likely range that could occur in the San Joaquin River Region under all Program alternatives.

5.4.4.1 TOOLS

Potential impacts on groundwater resources in the San Joaquin River Region were analyzed with the Central Valley Groundwater and Surface Water model (CVGSM). CVGSM covers the entire Central Valley area, as shown in Figure 5.4-5. CVGSM is a monthly planning model that simulates groundwater flow in the Central Valley regional aquifer system. Groundwater conditions were simulated using a 69-year hydrologic sequence (water years 1922-1990). The 69-year sequence spans dry, wet, and normal hydrologic conditions. Imposing these conditions on the regional aquifer system provides a range of possible impacts. These quantitative groundwater impacts are summarized as changes in groundwater pumping and groundwater levels, as compared to the No Action Alternative. These conditions represent the general response of the groundwater basins to changes in surface water and groundwater use.

Declining groundwater levels also can be indicative of potential land subsidence in areas where clay and silt lenses susceptible to compaction are prevalent. The occurrence of land subsidence can damage water conveyance facilities, flood control and drainage levee systems, groundwater well casings, and other infrastructure. The potential for land subsidence is prevalent in the San Joaquin River Region, primarily along the west side of the region. For the purposes of this programmatic analysis, the potential differences in possible land subsidence will be inferred from the changes in groundwater levels observed.

5.4.4.2 ADDRESSING UNCERTAINTY

Many of the issues regarding uncertainty that are discussed in Section 5.1.4.2 of Section 5.1, "Water Supply and Water Management," also apply to the assessment of groundwater resources. As mentioned under this previous discussion, efforts are under way to address these issues. This is being accomplished in part by increasing the level of groundwater analysis as part of further assessments of alternative water management strategies.

For this programmatic analysis of groundwater resources, and specifically for the quantitative assessment of the San Joaquin River Region, the range of uncertainty has been addressed by considering two distinct sets of water management assumptions. These assumptions were discussed previously in Section 5.1.4.2, and are referred to as Criterion A and Criterion B. Concerning the assessment of groundwater resources, the significant difference between the two criteria is the assumption of approximately 10% greater demands under Criterion B.

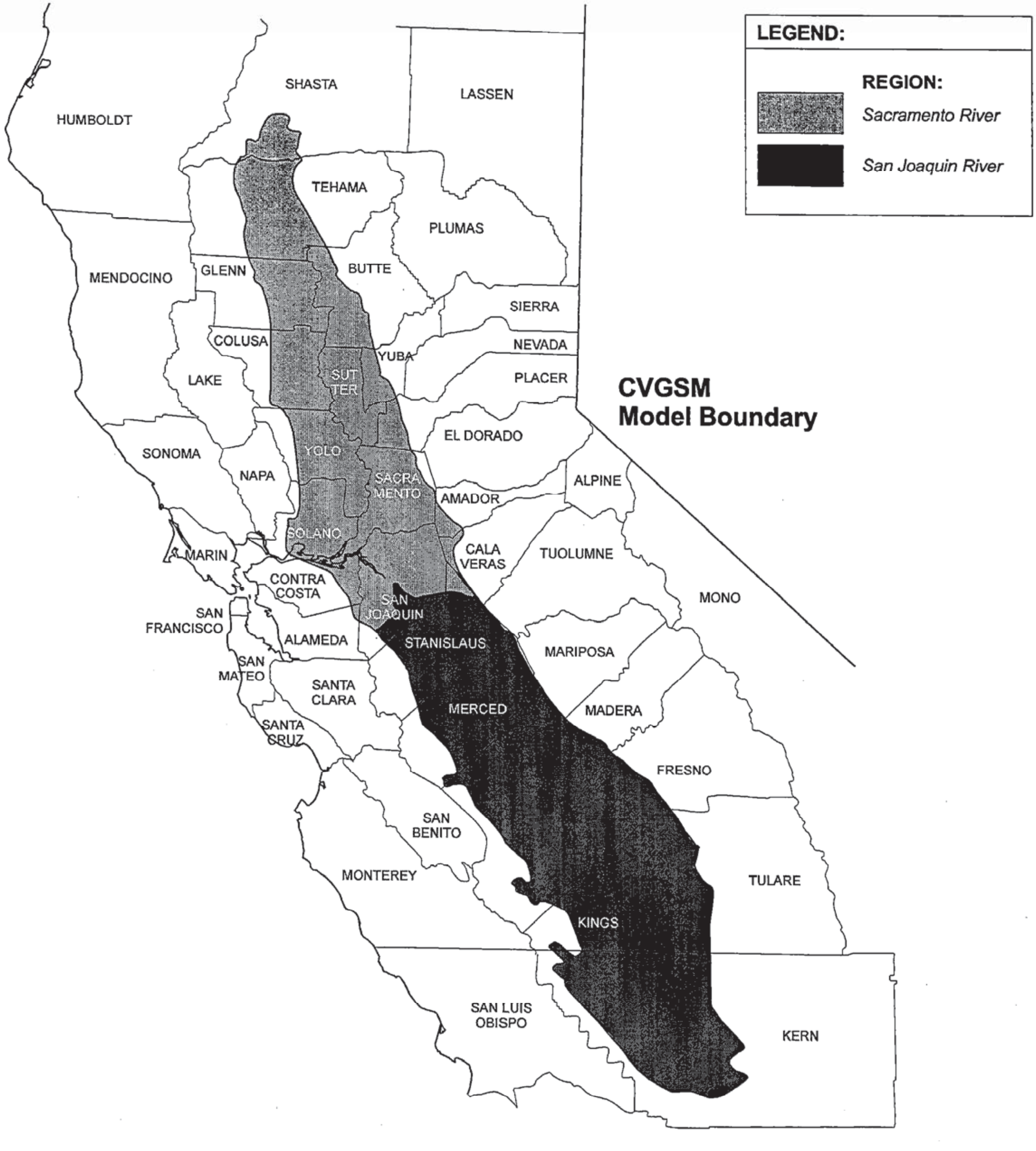


Figure 5.4-5. Groundwater Model Area

5.4.4.3 MODELING ASSUMPTIONS

A summary description of the Program alternative assumptions was provided previously in Table 5.1-2. In some instances, specific assumptions are required for modeling purposes. For the assessment of groundwater resources using CVGSM, specific assumptions include:

- Land and water use conditions in CVGSM are based on projected conditions consistent with those assumed for the DWRSIM analysis (see Attachment A).

- Consistent with current California law governing groundwater usage in the Central Valley, no restrictions are placed on groundwater pumping in CVGSM.

- All water demands not met by surface water supplies are assumed to be met by groundwater pumping. This groundwater pumping is estimated by CVGSM during the simulation process.

- CVP and SWP Delta exports to the San Joaquin River Region were obtained from DWRSIM and used in the CVGSM analysis. All other input parameters required by CVGSM for a water management analysis are assumed to be unchanged between the No Action Alternative and Alternative 1. This includes surface water supplies in the Sacramento River Region of the model, surface water supplies along the east side of the San Joaquin River Region (Friant service area deliveries and local surface water supplies), and modeled stream flow throughout the CVGSM model area.

- CVGSM requires the Sacramento River Region groundwater system to be simulated dynamically with the San Joaquin River Region. However, groundwater conditions in the Sacramento River Region are not assessed using CVGSM. The use of results from CVGSM is limited to output covering only the San Joaquin River Region.

5.4.4.4 CVGSM MODELING RESULTS

The qualitative analysis of groundwater conditions in the San Joaquin River Region was performed using Alternative 1 (with storage conditions) in comparison to the No Action Alternative. Furthermore, both bookend water management criteria assumption sets (Criteria A and B) were used to define the range of uncertainty associated with this assessment.

Programmatic comparisons of deliveries to the South-of-Delta SWP and CVP Service Areas were made for the No Action Alternative given the possible range of demands represented under Criteria A and B. As a result of this range of deliveries, average annual groundwater pumping in the San Joaquin River Region could vary under the No Action Alternative by approximately 350 TAF/year, Criterion A having the greater amount of groundwater pumping. This would result in greater declines in groundwater levels under Criterion A relative to conditions under Criterion B.

Using CVGSM to simulate this range of possible conditions, it was determined that average declines in regional groundwater levels could be approximately 10-20 feet lower under Criterion A. In considering simulated groundwater conditions observed at the end of the 69-year hydrologic sequence, declines at a local level could be as much as 90 feet lower under Criterion A. This is depicted regionally in Figure 5.4-6, which shows contours of differences in groundwater levels at the end of the simulation (a positive difference contour indicates that groundwater levels are higher under Criterion B relative to Criterion A).

Figure 5.4-6. Differences in End-of-Simulation Groundwater Elevations for Criteria A and B under the No Action Alternative

The range of groundwater pumping and groundwater levels under the No Action Alternative were compared with the range expected under Alternative 1. Groundwater pumping was reduced approximately 60-100 TAF/year under Alternative 1 in response to increased SWP and CVP deliveries to the region, with the greatest reduction occurring under Criterion B water management assumptions. Regional long-term average groundwater levels would be approximately 5-10 feet higher under Alternative 1 with storage conditions, as compared to the No Action Alternative. The upper range would occur under Criterion B water management assumptions.

Simulated groundwater levels observed at the end of the 69-year hydrologic simulation sequence indicate local increases as high as 15-30 feet under Alternative 1 with storage conditions, as compared to the No Action Alternative, the upper range occurring under Criterion B water management assumptions. These conditions are depicted regionally in Figures 5.4-7 and 5.4-8 for Criterion A and Criterion B, respectively. These two figures show contours the of differences in groundwater levels between Alternative 1 and the No Action Alternative at the end of the simulation (a positive difference contour indicates that groundwater levels are higher under Alternative 1). With an increase in groundwater levels in portions of the San Joaquin River Region, the possible reduction or reversal of the adverse effects of past overdrafting of groundwater, such as land subsidence and water quality degradation could be reduced.

5.4.5 SIGNIFICANCE CRITERIA

Groundwater impacts include changes in groundwater quantity or quality. The following conditions would be considered significant impacts if they occurred as a result of implementing Program actions:

- Any measurable degradation in groundwater quality relative to regulatory standards or potential beneficial uses of groundwater.
- A substantial long-term decline in groundwater levels or a net reduction in groundwater storage, resulting in third-party effects.
- Detectable land subsidence caused by water level declines.

At the programmatic level, these impacts generally are identified at the scale of a groundwater basin or sub-basin. Impacts may be either adverse or beneficial. Although increases in groundwater levels are typically considered to be beneficial, increases that cause waterlogging of agricultural crop lands would be considered an adverse impact under some conditions.

The significance of declining (or increasing) water levels depends on the duration and permanence of the impact. In the short term, groundwater levels fluctuate naturally because of changes in rainfall that affect recharge rates. Short-term changes in water levels that are within the normal range of groundwater fluctuations would not be considered significant.

In general, any long-term degradation in groundwater quality is considered significant. Under some conditions, however, a reduction in groundwater quality may be considered less than significant if it does not result in a reduction in the beneficial uses of the water resource and if it does not conflict with a promulgated regulatory standard.

Figure 5.4-7. Differences in End-of-Simulation Groundwater Elevations for Criterion A under Alternative 1 and the No Action Alternative

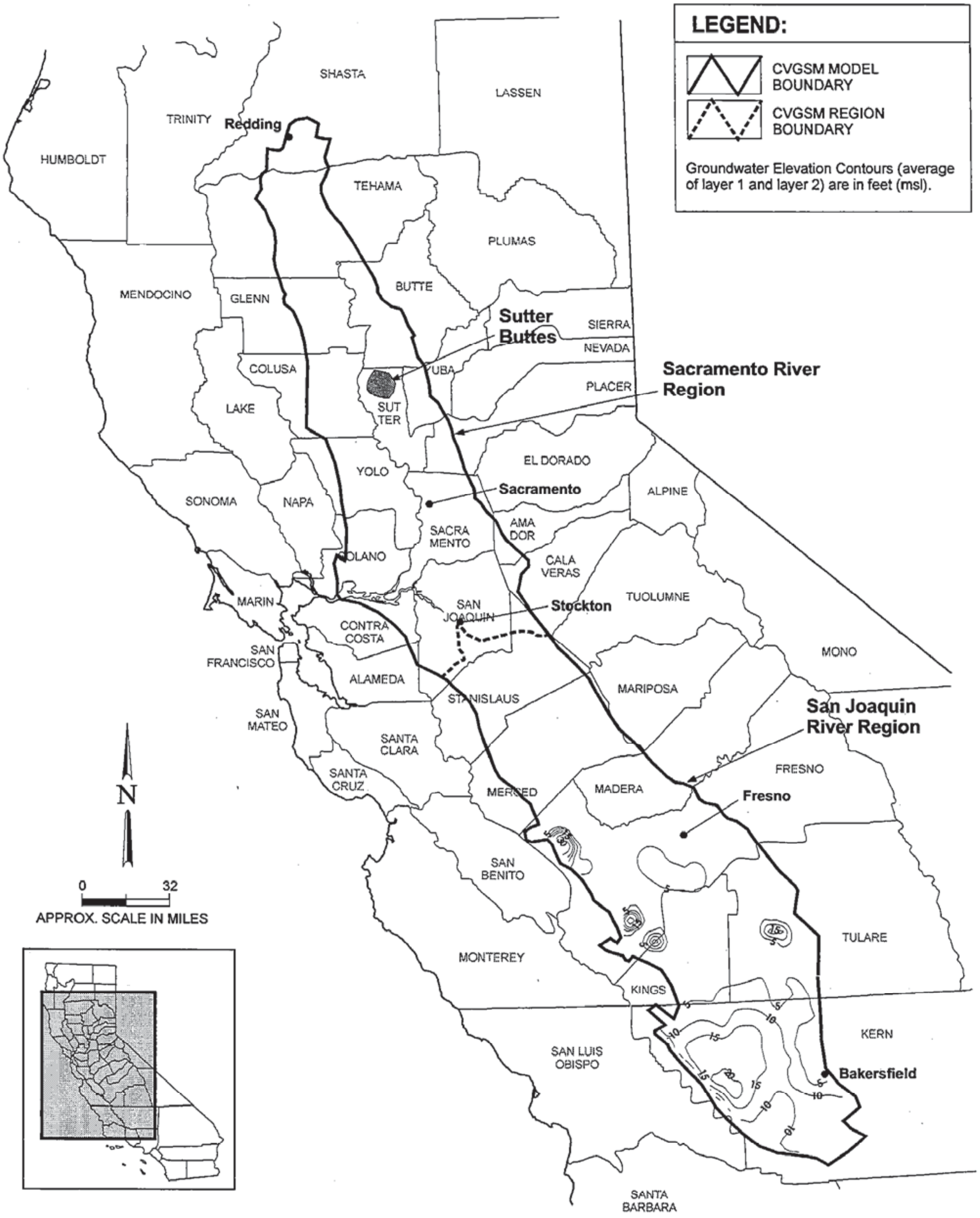


Figure 5.4-8. Differences in End-of-Simulation Groundwater Elevations for Criterion B under Alternative 1 and the No Action Alternative

5.4.6 NO ACTION ALTERNATIVE

5.4.6.1 DELTA REGION

No net change in groundwater use in the Delta is expected under the No Action Alternative. However, subsidence of Delta islands will continue as groundwater pumping for drainage of crop lands continues. No other groundwater impacts are expected in the Delta Region.

5.4.6.2 BAY REGION

Under the No Action Alternative, groundwater quality is likely to continue to improve in areas with point source pollution problems, as identified groundwater pollution sites are cleaned up and point and nonpoint sources continue to be eliminated. Water levels in areas subject to subsidence will continue to be monitored, and groundwater recharge basins will continue to be operated to prevent subsidence from groundwater withdrawals. Similarly, groundwater basins adjacent to the Bay that have been subject to salt-water intrusion will continue to improve with maintenance of hydraulic barriers.

With increasing populations and the resulting increased water demand, water agencies in the Bay Region are evaluating a number of options to increase supplies as well as to ensure reliability of their existing water sources. As part of these efforts, groundwater and surface water will continue to be used conjunctively. To what degree future supply shortages will be met by increased groundwater overdraft is unknown. However, in some areas of California, the historical response to increasing water demands has been to overdraft groundwater basins to meet those shortages.

Overdraft could lead to substantial declines in groundwater levels in areas with good- quality groundwater supplies. Increased groundwater use probably would occur mainly in rural areas, including those with expanding urban populations, where local sources of groundwater may be an economical alternative to imported surface water.

Groundwater quality degradation due to salt-water intrusion may occur in shoreline areas around the Bay Region, and land subsidence may occur locally in areas where groundwater basin management plans have not been developed. However, these impacts are not likely to be significant because these problems are widely recognized, and monitoring will be conducted to identify problems before they become severe.

5.4.6.3 SACRAMENTO RIVER REGION

Changes in groundwater conditions are expected to occur in response to increased local demand for groundwater. Based on current trends, groundwater declines could continue in the Yolo County area of the Sacramento Valley Basin and in the Sacramento County Basin. In the Yolo County area, groundwater declines could result in additional land subsidence.

Groundwater quality could be adversely affected by expected increases in groundwater extraction in the Sutter Buttes area and in southern Yolo County. Groundwater containing relatively high concentrations of TDS (Sutter Buttes area) and boron (southern Yolo County) is expected to continue to be drawn toward groundwater pumping centers in these two areas.

A reduction in groundwater recharge may result from reduced infiltration and storage in the upper watersheds as retention capacity in the watersheds continue to decrease. This is not expected to affect groundwater levels in the Sacramento River Region but could result in significant local impacts in the upper watershed. For example, a reduction in the groundwater underflow component of streamflow could cause a decline in streamflows.

Similarly, increased demands on groundwater resources that would occur under the No Action Alternative would continue to result in deterioration of groundwater quality, with the potential for poor-quality water to be drawn into basin pumping centers.

Potentially significant local impacts may occur in the upper watershed due to increased use of groundwater from fractured rock aquifers, where groundwater resources are depleted and contaminants may be drawn into domestic wells.

Declining groundwater levels associated with increased demands on local aquifers in the upper watershed will reduce the economic feasibility of agriculture in some areas, such as in the Sierra Valley Basin. This decline may accelerate the shift from agriculture to more intensive land uses (homesite development), resulting in increased demands on water resources.

5.4.6.4 SAN JOAQUIN RIVER REGION

The population of the San Joaquin River Region is expected to more than double by 2020. This growth is expected to lead to conversion of some agricultural land to urban uses. The impacts on groundwater resources will depend on where this growth occurs. In general, it is likely that population growth will result in increased dependence on groundwater during dry years, when surface water storage decreases. If managed carefully, municipal wells could be strategically placed to achieve maximum regional yields while minimizing local declines in water levels that typically are caused by concentrating production wells in a small area. Increased dependence on groundwater in areas where groundwater extraction is already at or above sustainable levels would result in a significant long-term decline in water levels.

Increased population probably would result in a reduction in the amount of surface water available to agriculture during dry periods, since municipal use is generally given higher priority than agriculture when water supplies must be rationed. This could force a shift to increased use of groundwater by agriculture. The impacts could be significant locally but probably would not be widespread, since most M&I water use in the San Joaquin Region is supplied by groundwater sources.

Increased groundwater extraction could result in increased potential for land subsidence in susceptible areas, such as along the west side of the San Joaquin River Region and in the southwestern portion of Tulare County.

In Section 5.1, programmatic comparisons of deliveries to the South-of-Delta SWP and CVP Services Areas were made for the No Action Alternative, given the possible range of demands represented under Criteria A and B. As a result of this range of deliveries, average annual groundwater pumping in the San Joaquin River Region could vary under the No Action Alternative by approximately 350 TAF/yr, Criteria A having the greater amount of groundwater pumping. This amount would result in greater declines in groundwater levels under Criterion A, relative to conditions under Criterion B.

As noted in Section 5.4.4.4, using CVGSM to simulate this range of possible conditions, it was determined that average declines in regional groundwater levels could be approximately 10 to 20 feet lower under Criterion A. In considering simulated groundwater conditions observed at the end of the 69-year hydrologic sequence, declines at a local level could be as much as 90 feet lower under Criterion A. This is depicted regionally in Figure 5.4.6-1, which shows contours of differences in groundwater levels at the end of the simulation (a positive difference contour indicates groundwater levels are higher under Criterion B relative to Criterion A).

In addition to the increased 2020 demands due to population growth, under the No Action Alternative, the CVPIA would require allocation of up to 800 TAF of water per year for environmental purposes, resulting in reduced exports to water contractors inside and outside the Central Valley. The reduction in water available for existing beneficial uses will require water contracting agencies to look elsewhere for supplemental water supplies. Although difficult to quantify, the increased demand for water and decreased availability of water is likely to result in a potentially significant adverse impacts on groundwater resources in some areas, including declines in water levels, increased potential for subsidence in severely depleted areas, and degradation of water quality through migration of poor quality water toward pumping centers.

Shallow, unconfined aquifers are more susceptible to surface contamination than deep, confined aquifers. Increased withdrawals of high-quality water from deep aquifers will increase the potential for shallow groundwater, which may be contaminated by pesticides, fertilizers, or mineral salts, to migrate to deeper aquifers. Confining layers are seldom completely effective in preventing downward migration of groundwater because of natural discontinuities in deposition or because of man-made conduits, such as improperly sealed wells. Although it may take time, declining water levels in confined aquifers could result in gradual declines in water quality from shallow groundwater sources.

Impacts on groundwater in the upper watershed areas would be similar to those described for the Sacramento River Region.

5.4.6.5 OTHER SWP AND CVP SERVICE AREAS

As described for the San Joaquin River Region, reallocation of 800 TAF of water per year for environmental purposes to meet CVPIA requirements could result in a reduction in exports to water contractors outside the Central Valley through the SWP and CVP. This is likely to result in potentially significant adverse impacts on groundwater resources in some areas, including declines in water levels, salt-water intrusion in coastal areas, increased potential for subsidence in severely depleted areas, and degradation of water quality through migration of poor quality water toward pumping centers.

5.4.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For groundwater resources, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs, and the Storage element are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 5.4.8.

5.4.7.1 Delta Region

Ecosystem Restoration Program

Conversion of agricultural lands to wetland or aquatic habitat is a component of the Ecosystem Restoration Program. Groundwater currently pumped to drain croplands or to grow crops would be reduced and would provide a benefit by reducing pumping-induced subsidence. The converted lands also would provide a benefit by increased infiltration area, thereby improving groundwater recharge.

Water Quality Program

Contaminant concentrations in water and sediment can be expected to decline in the streams immediately downstream of pollutant sources. Because the behavior of these contaminants in natural aquatic systems is complex, it is difficult to predict the consequence downstream. However, it seems probable that these actions could result in minor improvements to the groundwater quality in the Delta Region.

Levee System Integrity Program

Reductions in agricultural acreage would occur in some areas where levee strengthening required setback levees or flooding portions of the interiors of certain Delta islands. Some of this acreage would overlap areas included in Ecosystem Restoration Program actions. Reductions in groundwater pumping to drain agricultural lands could result in similar impacts as those described for the Ecosystem Restoration Program. The amount of land, and therefore the potential impacts, would be less for the Levee System Integrity Program than for the Ecosystem Restoration Program.

The Levee System Integrity Program would not affect groundwater in any Program region other than the Delta; therefore, the program is not discussed under the specific regions below.

Water Use Efficiency Program

Policies designed to increase efficiency of water use would mainly cause reductions in demand, increases in reuse of wastewater, and more effective distribution of water through water transfers. Some opportunities may exist for more efficient use of water in Delta upland areas, which could lead to reduced dependence on groundwater extraction. Since groundwater extraction from deep aquifer zones in excess of recharge can lead to salt-water intrusion, water use efficiency could reduce the potential for future salt-water intrusion. Water use efficiency policies would result in little or no impact on groundwater use in the Delta lowlands, where groundwater pumping primarily is used for draining waterlogged soils.

Water Transfer Program

Groundwater is not expected to be transferred from the Delta. Therefore, no impacts on Delta groundwater resources would result from water transfers.

Watershed Program

Elements of the Watershed Program are expected to improve groundwater quality and increase groundwater storage in watershed areas (including the Central Valley floor) tributary to the Delta. These efforts are not expected to measurably affect Delta groundwater resources. Therefore, no impacts on Delta groundwater resources would result from Watershed Program actions.

Storage

Any in-Delta storage that is implemented could increase hydraulic head at the storage site. Currently, groundwater flows from Delta channels toward the interiors of islands that are drained for agricultural production. The difference in hydraulic head across the levees toward the interior of the example storage facility is about 15 feet. After filling, the difference in head across the levees would be about 4 feet, and the hydraulic potential would be directed toward the surrounding channels and adjacent land tracts. The increase in the hydraulic head, greater wetted surface area, and larger volume of water in a new reservoir relative to the rivers could cause substantial groundwater underflow toward the tracts opposite the banks of the island storage. This potentially significant impact on groundwater levels in the adjacent tracts can be mitigated to a less-than-significant level.

In-Delta storage variations might include direct conveyance to the Bay Region or to South-of-Delta CVP and SWP diversion facilities. Any unlined canals used for this conveyance would not significantly increase hydraulic head in surrounding areas and are not expected to significantly affect groundwater conditions. Pipelines or lined canals used for conveyance would be hydraulically isolated and not affect groundwater conditions.

5.4.7.2 BAY REGION

Ecosystem Restoration Program

The Ecosystem Restoration Program would convert agricultural lands to wetland or other habitat uses. This could result in a reduction in groundwater pumping in shoreline areas. Most pumping in these areas is currently done to depress the water table; therefore, reduced pumping could result in a reduction in pumping-induced subsidence. A reduction in groundwater pumping in submerged lands could locally reduce the potential for salt-water intrusion. These are considered beneficial impacts.

Water Quality Program

Impacts of the Water Quality Program on groundwater quality in the Bay Region are difficult to predict. The impacts are expected to be beneficial but are likely to be negligible because most of the point and nonpoint sources of groundwater contamination in the Bay Region are already subject to regulation.

Water Use Efficiency Program

Opportunities exist for more efficient use of water in the Bay Region, which could lead to reduced dependence on groundwater extraction. Benefits of reduced groundwater use could include reduced potential for salt-water intrusion in shoreline areas, reduced potential for subsidence, reduced potential for pumping-induced migration of existing contaminants, and a more dependable long-term supply of groundwater.

Water Transfer Program

Transfers of water to the Bay Region could reduce dependence on groundwater in the Bay Region during low runoff years. This would provide a beneficial impact on groundwater resources relative to the No Action Alternative.

Watershed Program

Elements of the Watershed Program are expected to improve groundwater quality and increase groundwater storage in watershed areas (including the Central Valley floor) tributary to the Delta. These efforts are not expected to measurably affect groundwater resources in the Bay Region. Therefore, no impacts on groundwater resources in the Bay Region would result from Watershed Program actions.

Storage

Impacts on groundwater resources in the Bay Region are not anticipated.

5.4.7.3 SACRAMENTO RIVER REGION

Ecosystem Restoration Program

The Ecosystem Restoration Program could convert agricultural lands to riparian habitat. Conversion of agricultural land could result in a reduction in groundwater pumping for drainage or for irrigation. This effect on groundwater resources is expected to be negligible. Groundwater extracted from agricultural lands to depress a high water table may contain farm chemicals, which are pumped with the drain water into the adjacent stream channel. A decrease in pumping for farm drainage could result in a small decrease in loading of these chemicals in the stream waters. This reduction in chemical loading would benefit surface water quality.

Water Quality Program

The Water Quality Program is expected to focus on reducing contaminant loading to surface waters from point and nonpoint sources. To the extent that Water Quality Program actions improve surface water quality, the dynamic stream-aquifer link that exists between surface water and underlying groundwater resources could result in long-term secondary improvements to groundwater quality conditions in the Sacramento River Region.

Water Use Efficiency Program

Increased water use efficiency could result in beneficial and potentially significant adverse impacts. Reduced demand for water would place less stress on both groundwater and surface water resources. However, inequalities in the distribution and use of groundwater and surface water could lead to local potentially significant adverse impacts on ground-water. Mitigation strategies are available to reduce these impacts to a less-than-significant level.

Agricultural water conservation, including a reduction in deep percolation of applied irrigation or reduction in seepage from irrigation conveyance facilities, can result in local reductions in groundwater recharge. In most areas, applied irrigation is managed to minimize the amount of deep percolation and reduce irrigation costs. But in some areas, this seepage is a significant source of recharge and could result in loss of beneficial use to other local groundwater users or reductions in flows of gaining streams dependent on a high water table. The loss of recharge would not necessarily be accompanied by a decrease in loading of salts and agricultural chemicals since irrigation systems generally are operated to ensure that these chemicals are leached through the root zone of plants. However, one of the efficient water management practices (EWMP) in the agricultural water management (AB 3616) process is to optimize conjunctive use of surface water and groundwater resources. If implemented, this process could offset any potentially significant adverse impacts related to improved on-farm water use efficiency. Other mitigation strategies also are available to reduce these impacts to a less-than-significant level.

As irrigators turn toward some of the more efficient methods, such as drip and micro-irrigation systems, some growers may switch to groundwater as a more reliable source of high-quality water. This could result in groundwater declines and possibly land subsidence. The significance of this impact is not known but is considered potentially significant at the programmatic level. The actual impact would depend on many variables, including the location, groundwater quality, relative cost of pumping groundwater compared to the cost of surface water, and the applicability to crops. Also, the reduction in surface water use could result in indirect groundwater savings elsewhere. Mitigation strategies are available to reduce the impact to a less-than-significant level.

For some communities, treated wastewater is intentionally applied to spreading basins for recharge of local groundwater resources. To the extent that conservation or recycling reduces the amount of artificial recharge, associated adverse impacts may result to the local aquifer. The significance of the impact is unknown and depends on whether reductions in water use are larger or smaller than reductions in recharge.

Water Transfer Program

Water transfers provide an opportunity to move water from a watershed or basin with surplus water supplies for use in a watershed or basin with inadequate supplies. (The terms "surplus" and "inadequate" are used here in a relative sense. Criteria could include market forces, hydrologic factors, or any criteria that support moving water from one location to another.) The transferred water usually would be surface water with subsequent local groundwater use. In some cases, direct transfers of groundwater would occur.

The Water Transfer Program proposes a framework of actions, policies, and processes that, collectively, would facilitate water transfers and further development of a statewide water transfers market. This could result in the transfer of water from areas of abundance to areas of scarcity, which could in turn result in indirect physical changes to groundwater resources—either quantity or quality. These indirect physical changes to groundwater may cause adverse impacts on groundwater resources and other resource areas. In addition, indirect physical changes to groundwater may cause indirect adverse impacts on third-party groundwater users.

Promoting development of a statewide water transfers market may cause groundwater use to increase first in basins where groundwater is not yet being withdrawn at rates greater than the perennial yield, where groundwater management programs do not restrict groundwater use, and in basins that have not been adjudicated.

Potentially significant adverse groundwater impacts could occur if transfers from a basin exceed inflows. The reasons that this might occur include inadequate planning, low inflow compared to forecast inflow, or intentional overdrafting of a groundwater basin to achieve regional objectives or economic benefits. Mitigation strategies are available to reduce these impacts to a less-than-significant level.

Potentially significant adverse impacts also could result if water transfers are based on the conservation of water applied to agricultural lands, some of which percolates below the crop's root zone (deep percolation) and recharges the local aquifer. To the extent that this portion of water is saved or conserved and transferred, less water would recharge the aquifer ,which could result in an adverse effect—depending on the characteristics of the affected aquifer. Water transfers based on land fallowing also could adversely affect deep percolation, thus creating a potentially significant adverse effect on local groundwater conditions. Mitigation strategies are available to reduce these impacts to a less-than-significant level.

In general, the Sacramento River Region is expected to be a net exporter to other regions. Cross-Delta transfers from the Sacramento River Region to other regions would be limited by the capability to safely convey water across the Delta under the No Action Alternative. The alternatives would increase this capability.

Increased transfers within the region also could occur. The Program would provide assistance in coordinating these transfers, but the Program does not propose new infrastructure to accommodate intra-regional transfers.

Unless properly regulated, groundwater transfers—or surface water transfers based on groundwater substitution—could result in potentially significant adverse impacts on third-party groundwater users, with potential adverse effects in the source water area. Such impacts might include land subsidence, lower groundwater levels and higher pumping costs, degradation of groundwater quality, impacts on vegetation dependent on groundwater or, in extreme cases, losses of existing wells.

Mitigation strategies outlined in Section 5.4.11 are available to reduce these adverse impacts to a less-than-significant level. In addition, actions described in the Water Transfer Program will protect against adverse impacts in other related resource areas and impacts on groundwater users. (See Chapter 4 in the Water Transfer Program Plan.) Prior to implementation of any groundwater transfers, safeguards would need to be implemented to protect third-party users. For example, local groundwater management programs could be used to study the groundwater resources of a particular area and to provide technical review, advice, and guidance regarding transfers involving groundwater.

Watershed Program

Impacts on groundwater resources from the Watershed Program would be beneficial. Watershed actions could increase net surface water storage, reducing demand for groundwater withdrawals and increasing the amount of water available for recharging groundwater storage facilities. Direct impacts on groundwater recharge in basin areas due to watershed improvements also are important, since the principal basin recharge areas are in the lower watershed.

Storage

The storage components include both surface water and groundwater storage. Both components could affect groundwater resources. The types of impacts on groundwater resources that might occur because of the construction, operation, and maintenance of surface water storage facilities are described below. More detailed impact analysis would be conducted at the project level for specific sites.

Two example sites were evaluated to study potential groundwater impacts; in both examples, the impacts were similar. Local streamflows could be insufficient to maintain a reservoir, and water would be conveyed to the reservoir via a canal. One example site is underlain by upper Cretaceous marine rocks that typically yield poor-quality water. Groundwater is present in the shallow alluvial aquifer and in alluvium-filled intermittent stream channels. The site contains several farm wells that draw water from the shallow aquifer. The alluvial aquifer beneath the site is hydraulically isolated from other areas, and withdrawal of water from this aquifer is not expected to affect wells outside the project area. Therefore, construction-related impacts on local groundwater resources are expected to be less than significant.

Surficial deposits beneath the site include Quaternary alluvium underlain by upper Cretaceous marine rocks of low permeability. The reservoir would be contained in the natural basin formed in the Upper Cretaceous rocks. Groundwater flow in the Cretaceous rocks is expected to occur primarily within joints and fractures. Some leakage may be possible along joints and fractures that extend through a ridge that forms one of the sides of the reservoir. Stream channels typically form along pre-existing permeable geological structures, and the intermittent stream channels probably represent preferential groundwater flow pathways. Significant fractures would be investigated and sealed for construction of the dams, but some leakage may still occur, resulting in discharge to springs downslope of the reservoir site; however, subsurface leakage is not expected to result in a potentially significant adverse impact on groundwater.

Inundation of the reservoir would fully saturate the alluvial materials beneath the site to the depth of the underlying bedrock. Therefore, recharge to the shallow aquifer through existing wells in the reservoir inundation area would result in no additional impact on groundwater conditions.

A canal would be constructed to convey reservoir releases to various points in the Sacramento River Region. No potentially significant adverse impacts on local groundwater resources are expected from operation of the canal if the canal is lined and hydraulically isolated from the surrounding environment.

The groundwater storage component could consist of various conjunctive use and/or water-banking techniques with the basic objective of improving the reliability of the overall water supply and preserving existing surface water and groundwater resources. Techniques for storing and accounting for the water differ, but they are all designed to manage groundwater storage as a renewable supplement to surface water supplies. Efforts by the Program, DWR, and others are under way to identify and evaluate specific groundwater storage programs in the region. Currently, groundwater storage programs are being explored by the Program through outreach to local communities in order to determine which areas would be interested in participating in a locally controlled program. As part of this effort, information has been gathered from stakeholders. Many communities and individuals with direct experience with past conjunctive use and groundwater banking programs provided historical information concerning local impacts and other concerns. As a result of these efforts, the Program has summarized stakeholder concerns, developed draft guidelines for evaluating groundwater storage development, and identified preliminary mitigation strategies.

Both beneficial and potentially significant adverse impacts on groundwater resources could occur. The potential benefits of an artificial recharge program include increased water supply reliability; reduced long-term lift costs to extract groundwater; and possible reduction or reversal of the adverse effects of past overdrafting of groundwater, such as land subsidence and water quality degradation.

If improperly managed, groundwater storage programs could result in potentially significant adverse impacts associated with overdrafting the aquifer, including land subsidence, water quality degradation, increased pumping costs, reduced well yields, and streamflow depletions.

The nature and magnitude of these impacts would depend on site-specific conditions and the groundwater management program governing groundwater extraction and recharge.

Land subsidence results from compaction of unconsolidated aquifer materials and, more importantly, from compaction of compressible clay layers in multilayered aquifer systems. Sands and gravels are far less compressible than clays and also yield water more easily to wells. But many aquifers consist of a sequence of sands or gravels separated by layers of silts and clays. As groundwater levels decline, the sands compact slightly due to reduction in pore water pressure. But compaction of the clays can be much more significant. Although sandy aquifers tend to rebound when water levels rise again, clay compaction is relatively inelastic. That is, once the clay layers are compacted, they do not recover completely. As a result, most of the subsidence caused by groundwater pumping is not reversible.

These potentially significant adverse impacts could affect the parties directly involved in the groundwater storage project and also could affect neighboring third parties only if the project was mismanaged. During extended drought periods, unforeseen groundwater level declines could occur as a result of over pumping in the storage facility area, and adverse impacts on third-party users could be potentially significant. In extreme cases, third-party users could lose the use of some wells as a result of groundwater quality degradation or lower groundwater levels. Third-party impacts also are discussed in Section 7.2, "Agricultural Economics," and Section 7.14, "Environmental Justice."

Groundwater storage programs typically would be operated to store water before it was extracted. This type of operation would result in a net long-term increase in storage relative to the No Action Alternative. Consequently, adverse impacts associated with the groundwater storage program could be minimized. In fact, groundwater levels are expected to increase over the long term as a result of increased storage. Some long-term beneficial impacts could result to third-party users, including reduced pumping costs and possibly a reversal of the adverse impacts of past groundwater declines.

If mismanaged, groundwater programs could result in groundwater level declines in comparison to the No Action Alternative during dry year periods due to increased groundwater pumping. Most of the remaining potential adverse impacts of operating a groundwater storage project would result from groundwater recharge. The magnitude, extent, and type of impacts would depend on the size, location, and operation of the specific project and would be identified for a particular project in a project-level EIS/EIR. The following impacts refer to artificial recharge systems but also apply to in-lieu recharge, which refers to supplying surface water to an area relying on groundwater so that natural recharge of the aquifer can occur.

Artificial recharge systems are designed to speed up natural recharge rates, either by enhancing the rate of percolation to the water table or bypassing natural barriers to recharge. Percolation ponds speed up groundwater percolation by providing constant downward water pressure. Percolation ponds usually are used to recharge shallow, unconfined water table aquifers. Injection wells are designed to conduct recharge water past fine-grained soil layers that otherwise would impede the downward flow of water. Injection wells can be used to place surface water into a targeted aquifer unit at a selected depth.

Differences in the chemical or biological properties of the recharge water relative to the water in the targeted aquifer (such as the dissolved oxygen concentration, pH, mineral content, temperature, microbial population, and other parameters) could result in potentially significant adverse impacts. For example, introduction of nutrients can cause existing dormant microbial populations to bloom. New, undesirable microbial populations may be introduced. Changes in water chemistry can cause precipitation or solution of minerals. In addition, in some locations, recovery of water levels could remobilize residual chemical contaminants that have been left behind by falling water levels.

Other potentially significant adverse impacts include:

- Increased movement of contaminants due to changes in groundwater levels.
- Impacts on groundwater quality due to poor-quality recharge waters.

In most locations, the adverse impacts would be less than significant; however, potentially significant adverse impacts can be mitigated to a less-than-significant level.

5.4.7.4 San Joaquin River Region

Ecosystem Restoration Program

The Ecosystem Restoration Program would convert agricultural lands to riparian or aquatic habitat. The impacts would be the same as those described for the Sacramento River Region, except that a smaller amount of acreage would be affected. Increased streamflows during low runoff periods and restoration of natural stream meanders could increase groundwater recharge along the San Joaquin River. This increase is considered a beneficial impact on groundwater resources.

Additional in-streamflow requirements may result in reduced frequency of meeting agricultural (and to some extent) municipal and industrial demands in the San Joaquin River Region relative to the No Action Alternative. This would put increased pressure on groundwater resources to supply the unmet demand and could result in potentially significant adverse impacts on groundwater resources in some basins during low runoff years. These impacts can be mitigated to a less-than-significant level.

Water Quality Program

The impacts on groundwater quality in the San Joaquin River Region would be the same as those described for the Sacramento River Region.

Water Use Efficiency Program

Opportunities exist for more efficient use of water in the San Joaquin River Region. If implemented, water use efficiency measures could lead to reduced dependence on groundwater. This would result in beneficial impacts in areas currently subject to groundwater overdraft. Agricultural and landscape water use efficiency also could cause reductions in recharge to the water table aquifer. In areas where groundwater basins are recharged mainly from percolation of applied water, reductions in applied water could reduce recharge and result in declines in the shallow water table, a potentially significant impact. Mitigation strategies are available to reduce this impact to a less-than-significant level.

Many water districts use delivery canals as recharge basins. During wet years, these canals are purposely filled with water during winter to recharge the underlying aquifer. Recharge also occurs during normal periods of operation. Canal lining would reduce this source of groundwater recharge. This is not considered a potentially significant adverse impact, however.

The most important recharge zone for the deep, confined aquifer is along the margin of the valley, on alluvial fans of large streams at the base of the Sierra Nevada foothills. The Water Use Efficiency Program is unlikely to significantly affect recharge of the confined aquifer, unless water savings from water use efficiency programs are transferred to a program to artificially recharge the deep aquifer, which would result in a net benefit. The Program provides a possible institutional format in which to transfer water savings from one sector to another sector in order to achieve desired regional objectives.

Water Transfer Program

The Water Transfer Program could result in similar beneficial and adverse impacts to those described for the Sacramento River Region. As recipients of cross-Delta transfers, basins in the San Joaquin River Region would receive immediate benefits from water transfers that alleviate pressure on the groundwater resources in the region. In the long term, however, increased reliance on inter-basin transfers could result in potentially significant adverse impacts if the reliability of transferred water is reduced.

Storage

Operation of the groundwater storage component could result in groundwater impacts similar to those described for the Sacramento River Region. The potential for subsidence is of considerable concern in the San Joaquin River Region, given the large regional occurrence of land subsidence in the western and southern portions of the San Joaquin Valley.

5.4.7.5 OTHER SWP AND CVP SERVICE AREAS

Ecosystem Restoration Program

The Ecosystem Restoration Program would not directly affect groundwater resources in the Other SWP and CVP Service Areas. However, to the extent that the amount of water available for export to the service areas was reduced the program at certain times, water supply contractors could increase their dependence on groundwater at these times. The impacts would be less than significant.

Water Quality Program

In some areas, groundwater contamination has reduced the beneficial uses of large amounts of groundwater. It is possible that additional efforts to reduce point and nonpoint sources of contamination could lead to an increase in the amount of high-quality groundwater resources available to supplement surface water sources. Without these efforts, additional groundwater resources may be rendered unusable in the future.

Water Use Efficiency Program

More efficient use of water in the Other SWP and CVP Service Areas would result in the same impacts on groundwater resources as described for the Sacramento River Region. Reducing demand or increasing supply through recycling waste water would decrease dependence on groundwater.

Water Transfer Program

The Other SWP and CVP Service Areas could receive additional water from transfers from the Central Valley or from other basins outside the Central Valley. This water could partially offset groundwater overdrafts in the service areas, thereby resulting in a beneficial impact on groundwater resources outside the Central Valley. As described in the previous sections, increased reliance on imported water could result in potentially significant adverse impacts if the reliability of the transferred water is reduced.

Watershed Program and Storage

Impacts on groundwater resources in the Other SWP and CVP Service Areas are not expected from Watershed Program or Storage element actions.

5.4.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For groundwater resources, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

5.4.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

With the diversion facility on the Sacramento River, leakage could occur through the unlined canal transferring water from the diversion facility to the Mokelumne River. The amount of leakage would depend on the permeability of the bottom of the canal, the permeability of the soils underlying the canal, and the difference between the elevation of water in the canal and the elevation of the water table beneath the canal. Leakage could cause waterlogging of soils along the alignment of the canal. The rate of leakage also would depend on the width of the canal. Leakage could result in a potentially significant adverse impact on water levels in soils adjacent to the canal. Mitigation is available to reduce the impact to a less-than-significant level.

Changes in project operations would not significantly affect water quantities potentially available for beneficial use in the channels and open waterbodies of the Delta Region. Proposed flow changes would not be sufficiently large or prolonged to cause significant changes in groundwater resources. Since no change in groundwater pumping or recharge is expected, no impacts on groundwater are anticipated in the Delta Region from the changes in operations.

Changes in project operations could affect groundwater resources in the Bay Region. Potential short- and long-term changes in the amounts of water available for export could cause increases or decreases in water supply and water management in the Bay Region. This could lead to small losses or benefits in opportunities to use and recharge groundwater resources and to implement conjunctive use programs.

In the Sacramento River Region, changes in project operations would not significantly affect groundwater resources. Water supply and water management in the region could be affected by changes in reservoir operation and river flows to meet new Delta operational requirements. These changes would not be sufficiently large or prolonged to cause significant changes in groundwater resources.

Changes in project operations could result in potentially significant impacts on groundwater resources in the San Joaquin River Region and in the Other SWP and CVP Service Areas. The impact would depend on the magnitude of change in recharge rates and pumping that could result due to the reduction or increase in export water resulting from operation changes. The potential range of changes in supply for SWP and CVP service areas south of the Delta could vary from increases of up to about 800 TAF to losses of as much as 500 TAF. Changes in project operations also could adversely affect water supply and water management in the San Joaquin River Region; changes in groundwater use could be adverse or beneficial, depending on the magnitude of the change.

CVGSM modeling indicated that with increased SWP and CVP deliveries, groundwater levels could remain higher than under the No Action Alternative. Changes in groundwater use could change subsidence rates, which could affect land use and water demands. Groundwater effects could extend outside service areas if water resources are managed to make up or redirect the effects of changing the amount of export water deliveries. Changes in beneficial uses of the groundwater resource would depend on the magnitude of the variations in supply and usage.

5.4.8.2 ALTERNATIVE 1

Under Alternative 1, the Conveyance element is not expected to affect groundwater resources in any Program region. Changes in project operations would cause effects similar to those described for the Preferred Program Alternative.

5.4.8.3 ALTERNATIVE 2

Under Alternative 2, the impacts associated with conveyance facilities would be similar to those described for the Preferred Program Alternative but with greater water diversion capacity. Changes in project operations also would cause effects similar to those described for the Preferred Program Alternative.

5.4.8.4 ALTERNATIVE 3

With the isolated facility water conveyance in Alternative 3, leakage could occur through the unlined canal of the isolated facility. The amount of leakage would depend on the permeability of the bottom of the canal, the permeability of the soils underlying the canal, and the difference between the elevation of water in the canal and the elevation of the water table beneath the canal. Leakage could cause waterlogging of soils along the alignment of the canal. The rate of leakage also would depend on the width of the canal. Leakage could result in a potentially significant adverse impact on water levels in soils adjacent to the canal.

Changes in project operations would cause effects similar to those described for the Preferred Program Alternative.

5.4.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of existing conditions to the Preferred Program Alternative and Alternatives 1, 2, and 3. This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions were the same impacts as those identified in Sections 5.4.7 and 5.4.8, which compare the Program Alternatives to the No Action Alternative.

Some actions that are beneficial when compared to the No Action Alternative could result in a potentially significant adverse impact when compared to existing conditions. While the Program is expecting an overall improvement in groundwater resources relative to the No Action Alternative, the potential remains that groundwater conditions could be worse than those currently existing. This potential primarily is possible because of changes in population levels and demand that would occur under the No Action Alternative but are not considered under existing conditions. Implementation of the Program likely would result in groundwater resources being better than without the Program but degraded relative to existing conditions.

For some actions, the beneficial impacts of Program actions would be greater when compared to existing conditions. Under existing conditions, clean-up of existing point and nonpoint pollution sources would not occur. The beneficial impacts of Program actions on groundwater resources therefore would be incrementally higher compared to existing conditions than under the No Action Alternative scenario. Subsequent environmental documentation for specific projects will better identify the type and extent of the improvements in relation to existing conditions.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any additional significant environmental consequences than were identified in the comparison of Program alternatives to the No Action Alternative. All potentially significant adverse impacts identified when compared to the No Action Alternative are still significant when compared to existing conditions. However, the extent of the potentially significant adverse impacts could be greater under some actions when compared to existing conditions.

The following potentially significant impacts are associated with the Preferred Program Alternative:

- Changes in groundwater levels.
- Increased demand for groundwater supplies.
- Increased groundwater overdraft.
- Increased land subsidence.
- Increased degradation of groundwater quality from contaminant movement, salt-water intrusion, or naturally poor-quality water drawn into the aquifer.
- Impacts from groundwater recharge and storage system operations.

No potentially significant unavoidable impacts on groundwater resources are associated with the Preferred Program Alternative.

5.4.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For groundwater resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This similarity is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.4.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts.

At the programmatic level, the analysis did not identify any impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level. Sections 5.4.7 and 5.4.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on groundwater resources in the Delta, Bay, Sacramento River, and San Joaquin River Regions and in the Other SWP and CVP Service Areas: American River Water Resource Investigation, American River Watershed Project, other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento Water Forum process, Supplemental Water Supply Project, Sacramento County municipal and industrial water supply contracts, and urbanization. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.4.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level.

Growth-Inducing Impacts. The Program is proposing to manage groundwater resources in order to improve water supply reliability. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. This section assesses the balance between short-term uses of groundwater resources throughout the study areas and the maintenance and enhancement of the long-term productivity of those resources in those areas.

Development and associated activities would cause some unavoidable short-term adverse impacts on groundwater in local areas. However, these impacts can be mitigated as described previously, to the maximum extent possible. Mitigation would be accomplished through minimization of adverse effects, containment of impacts, and application of sound groundwater management practices. The overall benefits to long-term productivity of any facilities, changes in land forms, and resultant or independent changes in ground-water resource management that are selected for implementation generally would outweigh any short-term adverse impacts. If the reverse were true, the proposed actions would be eliminated from consideration during screening.

Changes in the following specific resource categories also could affect groundwater resources: surface water, geomorphologic forms, soils, regional economics, agricultural production, land use, urbanization, flooding and flood control actions, power production and energy, and environmental hazards and their control or remediation. Where possible, avoidance of adverse impacts and implementation of mitigation measures would be used as standard procedures to lessen impacts on these resources that would cause long-term adverse impacts on groundwater resources.

Irreversible and Irretrievable Commitments. Implementation of the Program could result in some irreversible and irretrievable commitments of existing groundwater resources. In addition to short-term direct groundwater deficiencies due to water supply demands, land subsidence due to adverse groundwater conditions and diminished groundwater quality would be difficult, if not impossible, to fully reverse once these conditions occurred. Adaptive management would be used during the course of the Program to identify situations that could lead to undesirable or less-than-optimum results. In this way, potential mistakes could be identified early, and plans could be altered to minimize any unintentional adverse results.

Land subsidence results from compaction of unconsolidated aquifer materials and, more importantly, from compaction of compressible clay layers in multi-layered aquifer system. Compaction of clays can be significant and irreversible. Once the clay layers are compacted, they do not recover completely. As a result, in certain areas of the study region, most of the subsidence caused by groundwater pumping is not reversible.

In some areas, groundwater contamination has reduced the beneficial uses of large amounts of groundwater. Once the quality of groundwater is diminished, this condition is nearly irreversible. In addition, differences in the chemical and biological properties of recharge water relative to the water in a targeted aquifer (such as the dissolved oxygen concentration, pH, mineral content, temperature, microbial population, and other parameters) could result in potentially significant adverse and irreversible impacts.

5.4.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during project planning and development to complement existing mitigation projects. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, hydrogeological conditions, and timing.

Mitigations are proposed as strategies in this programmatic document and are conceptual in nature. Final mitigations would need to be approved by responsible agencies as specific projects are approved by subsequent environmental review.

The following mitigation strategies could reduce impacts on groundwater resources from Program actions:

- Creating additional groundwater or surface water storage facilities to meet demand without resorting to overdraft.
- Importing water from other basins.
- Purchasing water rights from willing sellers (including transferring water rights between sectors—for example, from agriculture to municipal uses).
- Regulating groundwater withdrawals to avoid overdraft and third-party impacts.
- Implementing conservation measures to reduce demand.
- Integrating Ecosystem Restoration Program floodplain restoration efforts with setback levees.
- Increasing water supplies from recycling.
- Increasing regulations regarding new and existing domestic wells and septic systems.
- Developing alternative water supplies.
- Monitoring and testing groundwater wells and aquifers.

- Limiting new septic tank systems in vulnerable areas.
- Allowing water levels to increase periodically.
- Importing new soil (including dredged spoil) to raise land surface.
- Reducing or discontinuing groundwater pumping.
- Recharging aquifers through injection wells (confined aquifers) or percolation ponds (unconfined aquifers).
- Distributing groundwater pumping over a wide region rather than to a concentrated area to minimize local drawdown of the aquifer.
- Treating extracted groundwater at the well head.
- Diluting poor-quality groundwater with higher quality water.
- Developing new groundwater basin management plans or expanding existing groundwater basin plans, including defining objectives, project boundaries, responsibilities, operation and maintenance specifications and procedures, and conditions under which corrective actions are taken.
- Temporarily removing the recharge system from service to avoid impacts associated with high water tables.
- Monitoring water-level conditions on islands adjacent to in-Delta storage.
- Installing interception wells at in-Delta storage facilities to control seepage.
- Lining conveyance canals to prevent seepage.

5.4.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

None of the potentially significant adverse impacts on groundwater resources that are associated with the Preferred Program Alternative are unavoidable.

5.5 Geology and Soils

The CALFED Bay-Delta Program would result in overall benefits to geomorphological characteristics and soils throughout the Program study area. Construction would result in some short-term impacts that would cease when construction was complete.

5.5 Geology and Soils

5.5.1 SUMMARY

Over the eons, water and wind have helped carry sediment and debris downstream. During floods, much of that sediment was redistributed over the Central Valley floor, providing excellent conditions for agriculture. Urbanization, agricultural practices, and flood control facilities have affected some historical trends. However, the rich soils and unique geological resources in the CALFED Bay-Delta Program (Program) study area continue to influence human activities and contribute to the quality of life.

Preferred Program Alternative. Geology and soils would benefit from many of the Program elements. The Ecosystem Restoration Program, in restoring wetland and wildlife habitat, could lessen soil depletion and wind erosion on Delta islands. By improving water quality, the Water Quality Program could reduce soil salinity, selenium concentrations, and sediment contamination. The Levee System Integrity Program could decrease subsidence on Delta islands. The overall long-term benefits from the Program generally outweigh the short-term potentially significant impacts, all of which can be mitigated to a less-than-significant level.

Although significant, short-term construction-related impacts associated with the Preferred Program Alternative would be limited to the duration of construction and can be reduced to a less-than-significant level with mitigation strategies. Increased conversion of agricultural land soils for levee system construction and increased potential for erosion on outboard slopes of levees is considered a potentially significant impact. Increased wind and soil erosion and increased soil salinity due to fallowed agricultural land is considered a potentially significant impact. Ground disturbance and innundation caused by the construction of new storage facilities also is considered a potentially significant impact. In addition, changes in downstream geomorphology that would result from expanding existing storage facilities is considered a potentially significant impact. Mitigation strategies are available to reduce these impacts to a less-than-significant level.

Alternatives 1, 2, and 3. Alternatives 1, 2, and 3 would result in similar benefits and adverse impacts as those described for the Preferred Program Alternative. The Preferred Program Alternative and Alternatives 2 and 3 have greater potential for short-term construction-related impacts than Alternative 1 because of their additional Conveyance elements. However, these alternatives also could result in greater long-term benefits, such as reduced erosion, restored wildlife habitat, and improved water quality. Conversely, Alternative 1 could result in the least amount of short-term impacts but also would provide the least amount of overall long-term benefits.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Increased conversion of agricultural land soils for levee system construction and increased potential for erosion on outboard slope of levees (3,4,5,6,8,9,14, 15,16).

Potential for increases in local subsidence from potential increased reliance on groundwater use (1,2).

Potential for increases in wind and soil erosion and in soil salinity due to fallowed agricultural lands (4,9, 10,11).

Increased construction-related short-term soil erosion, and increased sediment deposition or soil compaction (4,5,6,8,13,14,15,16).

Potential changes to downstream geomorphology from enlarging existing storage facilities (6,7,8,12, 17,18).

Ground disturbance, inundation, seepage, and shoreline wind- and wave-generated erosion from new storage facilities (4,5,6,14,16,19).

Mitigation Strategies

1. Monitoring groundwater levels and subsidence in areas of increased reliance on groundwater resources and regulating withdrawal rates at levels below those that cause subsidence.
2. Minimizing or avoiding direct groundwater transfers or groundwater substitution transfers from regions: (1) experiencing long-term overdraft, (2) where subsidence historically has occurred, or (3) where local extensometers indicate that subsidence rates are increasing.
3. Protecting flooded Delta island inboard levee slopes against wind and wave erosion with vegetation, soil matting, or rock.
4. Protecting exposed soils with mulches, geotextiles, and vegetative ground covers to the extent possible during and after project construction activities in order to minimize soil loss.
5. Implementing erosion control measures and bank stabilization projects where needed.
6. Increasing sediment deposition and providing substrate for new habitat by planting terrestrial and aquatic vegetation.
7. Measuring channel morphology over time to monitor changes and implementing erosion control measures where needed.
8. Re-using dredged materials to reduce or replace soil loss.
9. Leaving crop stubble from previous growing season in place while fallowing and employing cultivation methods that will cause the least amount of disturbance in order to minimize erosion of surface soils.
10. Limiting the salinity of replacement water, relative to local conditions, in water transfers.
11. Ensuring that the volume of irrigation water used is sufficient to flush accumulated salts from the root zone.
12. Operating new storage facilities to minimize sediment trapping and transport in rivers and tributaries.
13. Retrofitting soil-comprised structures to seismic events with shock-absorbing devices and materials in areas of seismic vulnerability, wherever possible.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative (continued)

14. Preparing and implementing best construction management plans.
15. Preparing and implementing a water quality and soils monitoring program.
16. Preparing and implementing construction mitigation plans.
17. Preparing and implementing contingency plans for wetland and marshland restoration.
18. Modifying storage facility operations to maintain the frequency, magnitude, and duration of flows necessary to maintain and restore downstream riparian habitat.
19. Controlling boat traffic in order to reduce boat wakes to levels that will not cause levee or bank erosion.
20. Monitoring water-level conditions on islands adjacent to in-Delta storage.
21. Installing interception wells around in-Delta storage facility and operating to remove excess seepage.
22. Lining conveyance for in-Delta storage to prevent seepage.

No potentially significant unavoidable impacts on geology and soils are associated with the Preferred Program Alternative.

5.5.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. According to this definition, no areas of controversy relate to geology and soils.

Some controversy exists, however, about the Water Use Efficiency Program reducing applied water to agricultural lands in the Sacramento River basin, which in turn could increase the amount of residual salts in the soil and degrade agricultural productivity. Retiring drainage-impaired agricultural land to reduce selenium and salt loadings in the San Joaquin River could result in increased soil erosion due to wind and runoff. Other concerns have been generated by the Storage Program. A concern exists that off-stream storage facilities could alter sediment transport by potentially trapping sediments, reducing sediment transport, increasing stream erosion, and altering geomorphologic characteristics downstream of the storage facility.

At the programmatic level of analysis, these areas of concern are addressed qualitatively in the following analysis. The Program would result in an overall beneficial effect on soil salinization and erosion. Additionally, the Program would result in a beneficial effect on channel erosion, sedimentation, and geomorphologic characteristics due to changes on land surfaces. These issues will be addressed and analyzed further as specific projects are proposed to carry out the Preferred Program Alternative.

5.5.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

Key resource categories and assessment variables described in this section include geology and physical processes; fluvial geomorphology, especially erosion and sedimentation; oxidation, wind erosion, and land subsidence; soil salinity and drainage problems; and seismicity.

Overview. Different geologic processes acting on various rock formations over millions of years have created many geologically different areas in California. The areas have been grouped into 11 geologic provinces. From north to south, they are the Coast Ranges, Klamath Mountains, Cascade Range, Modoc Plateau, Central Valley, Sierra Nevada, Basin and Range, Mojave Desert, Transverse Ranges, Peninsular Ranges, and the Salton Trough. The study area for this investigation includes all of the provinces mentioned, except the Basin and Range, and Salton Trough. Figure 5.5-1 shows all the geologic provinces in the state. The Central Valley Geological Province is a valley trough that extends over 400 miles from north to south and consists of the Sacramento Valley and the San Joaquin Valley. The San Joaquin Valley is comprised of the San Joaquin River basin, drained by the San Joaquin River from the south, and the Tulare basin, a hydrologically closed basin that is drained only during extremely wet periods. The Sacramento Valley is drained by the Sacramento River from the north. The confluence of these two major river systems and lesser streams and systems forms the inland Delta, which is drained through Suisun Bay and the narrow Carquinez Strait into San Pablo and San Francisco Bays—and into the Pacific Ocean.

The upper and lower watersheds of the area contain four primary physiographic land types, each with characteristic soil conditions: valley land, valley basin land, terrace land, and upland (Figure 5.5-2). Valley land and valley basin land soils occupy most of the Central Valley floor. Valley land soils consist of deep alluvial and aeolian soils that make up some of the best agricultural land in the state. Valley basin lands consist of organic soils of the Sacramento-San Joaquin Delta, poorly drained soils, and saline and alkali soils in the valley trough.

Areas above the Central Valley floor consist of terrace and upland soils, which are primarily used for grazing and timberland.

Existing soils and the geomorphology of streams in the upper watersheds of the Bay Region mainly show the effects of urbanization, whereas these same resources in the upper watersheds of the Sacramento River and San Joaquin River Regions primarily are influenced by grazing and logging.

5.5.3.1 DELTA REGION

The Delta, a triangular-shaped network of channels and islands, is the meeting point for the Sacramento, San Joaquin, and Mokelumne Rivers. The Delta islands have been reclaimed for agricultural use because of their fertile soils. Conversion of the Delta wetlands to farmlands began in 1850 when the federal government transferred ownership of "swamp and overflow" lands to the states. Substantial reclamation was accomplished between 1880 and 1920. By 1930, the Delta essentially was developed to its current configuration.

Source: California Division of Mines and Geology 1966

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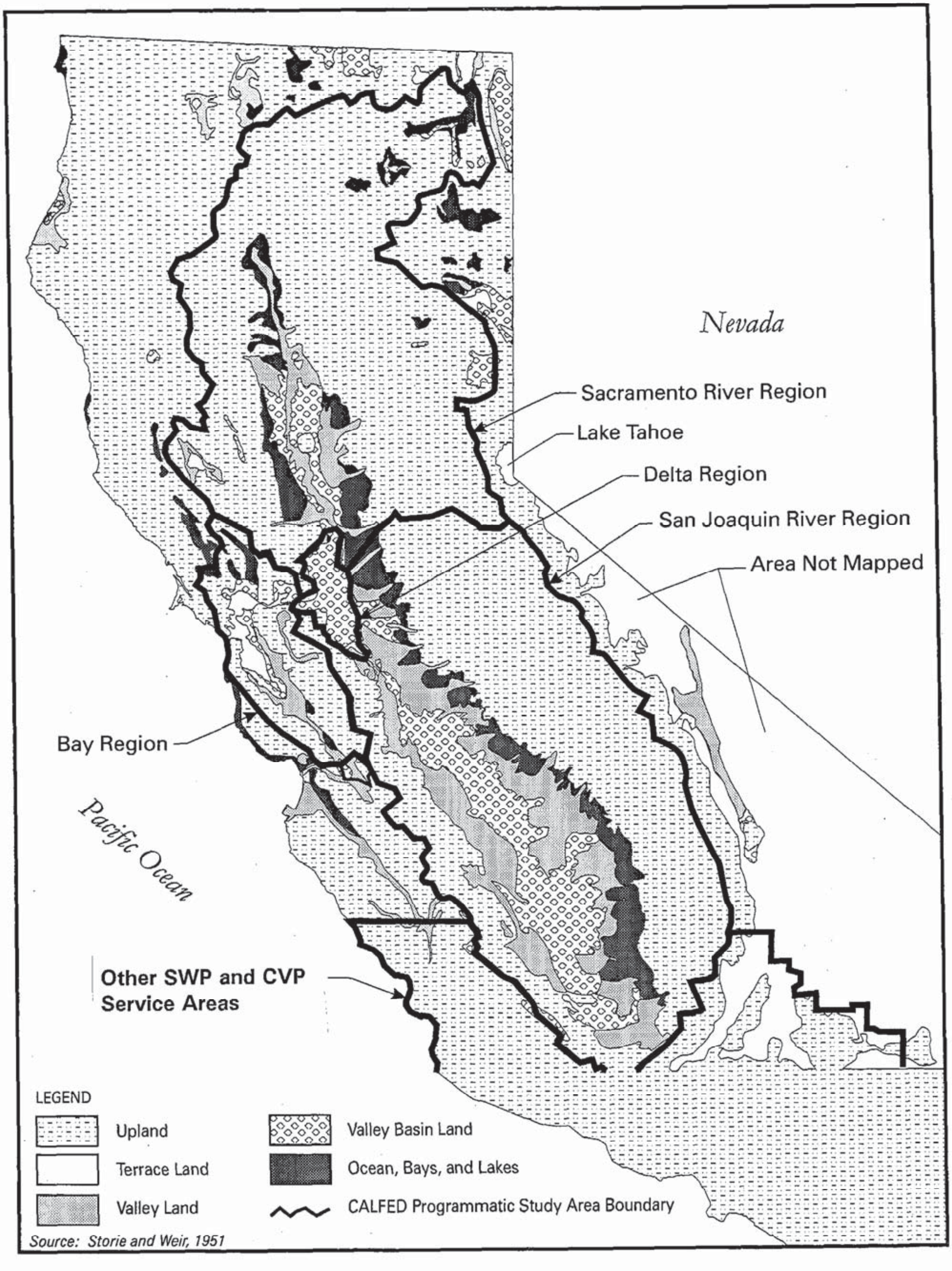
Figure 5.5-1. Geologic Provinces of California



Source: Storie and Weir, 1951

Figure 5.5-2. Generalized Soils of California

By 1920, it was recognized that the drained Delta lands were subsiding. Elevation measurements made from 1922 to 1981 indicate that land use practices on peat soils (organic or highly organic mineral soils) tended to cause from 1 to 3 inches of subsidence per year.

Soils. The soils of the Delta Region vary primarily as a result of differences in geomorphological processes, climate, parent material, biologic activity, topography, and time. For this discussion, the soils are divided into four general soil types:

- Delta organic soils and highly organic mineral soils.
- Sacramento River and San Joaquin River deltaic soils.
- Basin and basin rim soils.
- Moderately well- to well-drained valley, terrace, and upland soils.

The Delta Region contains primarily soils with the required physical and chemical soil characteristics, growing season, drainage, and moisture supply necessary to qualify as prime farmland. This includes 80-90% of the area of organic and highly organic mineral soils, Sacramento River and San Joaquin River deltaic soils, and basin and basin rim soils. Most of the remaining soils of the Delta Region qualify as farmland of statewide importance.

The Delta soils that have been most affected by agricultural development are the organic soils and highly organic mineral soils. These effects are caused by the flood protection of levees and the lowering of water tables by pumps and drainage ditches in order to make production possible.

Soil Subsidence. Subsidence of the Delta's organic soils and highly organic mineral soils (Figure 5.5-3) continues to be a concern and could present a threat to the present land use of the Delta islands.

Interior island subsidence is attributable primarily to biochemical oxidation of organic soil material as a result of long-term drainage and flood protection. The highest rates of subsidence occur in the central Delta islands, where organic matter content in the soils is highest.

Development of the islands resulted in subsidence of the island interiors and greater susceptibility of the topsoil to wind erosion. Subsidence, as it relates to Delta islands, refers generally to the falling level of the land surface that results primarily from the process of peat soil oxidation. Levee settlement may be partially caused by peat oxidation if land adjacent to levees is not protected from subsidence.

Delta Seismicity. The primary seismic threat to the Delta is levee failure resulting from lateral displacement and deformation, with resultant breaching or mass settlement due to ground shaking and liquefaction of levee materials. Many levees include sandy sections with low relative density and high susceptibility to liquefaction. Therefore, the seismic risk to Delta levees varies significantly across the Delta, depending on the proximity to the source of the earthquake and the conditions of the levee and levee foundation.

A review of available historical information indicates that little damage to Delta levees has been caused by historical earthquakes. No report could be found to indicate that an island or tract had been flooded due to an earthquake-induced levee failure. Further, no report could be found to indicate that significant damage had ever been induced by earthquake shaking. The minor damage that has been reported has not significantly jeopardized the stability of the Delta levee system.

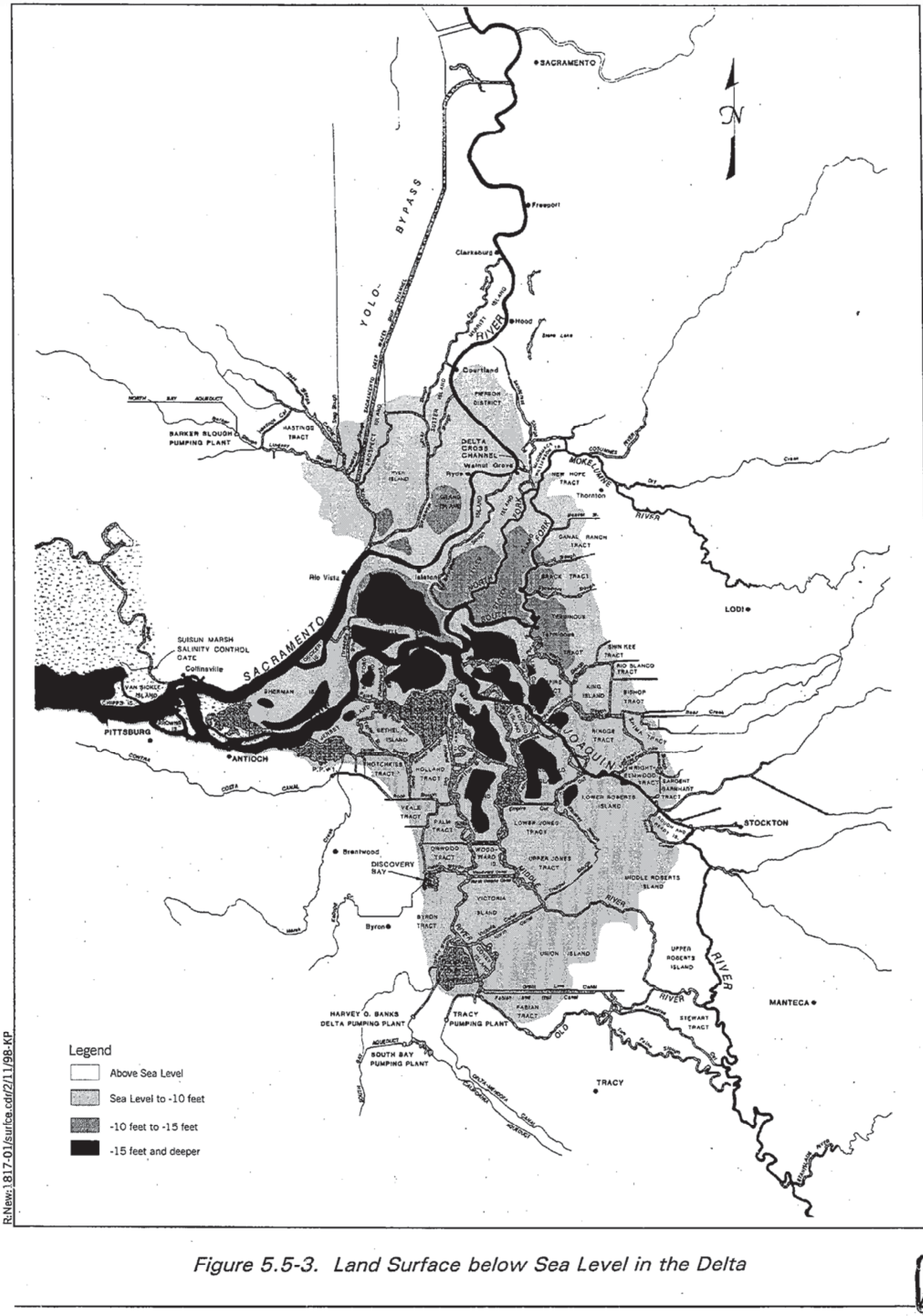


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Figure 5.5-3. Land Surface below Sea Level in the Delta

This lack of severe earthquake-induced levee damage corresponds to the fact that no significant earthquake motion has apparently ever been sustained in the Delta area since the construction of the levee system approximately a century ago. The 1906 San Francisco earthquake occurred 50 miles to the west, on the San Andreas Fault, and produced only minor levels of shaking in the Delta. As the levees were not yet very tall in 1906, these shaking levels posed little threat. Continued settlement and subsidence over the past 90 years and the increasing height of levees needed for flood protection have, however, substantially changed this situation. Consequently, the lack of historical damage to date should not lead, necessarily, to a conclusion that the levee system is not vulnerable to moderate-to-strong earthquake shaking. The current levee system simply has never been significantly tested.

The Delta levees are located in a region of relatively low seismic activity compared to the San Francisco Bay Area. The major strike-slip faults in the Bay Area (San Andreas, Hayward, and Calaveras Faults) are located over 16 miles from the Delta Region. The less active Green Valley and Marsh Creek-Clayton Faults are over 9 miles from the Delta Region. Small but significant local faults are situated in the Delta Region, and there is a possibility that blind thrust faults occur along the west Delta (Figure 5.5-4.).

Soil Salinity. Increasing soil salinity has been recognized as a problem in the San Joaquin Valley since the late 1800s, when a rapid increase in irrigated acreage coincided with increasingly poor drainage (due to elevated shallow groundwater table levels) and elevated soil salinity levels in the western and southern portions of the San Joaquin Valley.

Dissolved salts in irrigation water can lead to high soil salinity, an unfavorable condition for agricultural crop production. High soil salinity is an issue in several portions of the Delta, including the south Delta area, the west Delta area (primarily Sherman and Twitchell Islands), and Suisun Marsh. North and east Delta areas receive relatively low-salinity water from the Sacramento River and east side tributaries, and do not experience salinity problems.

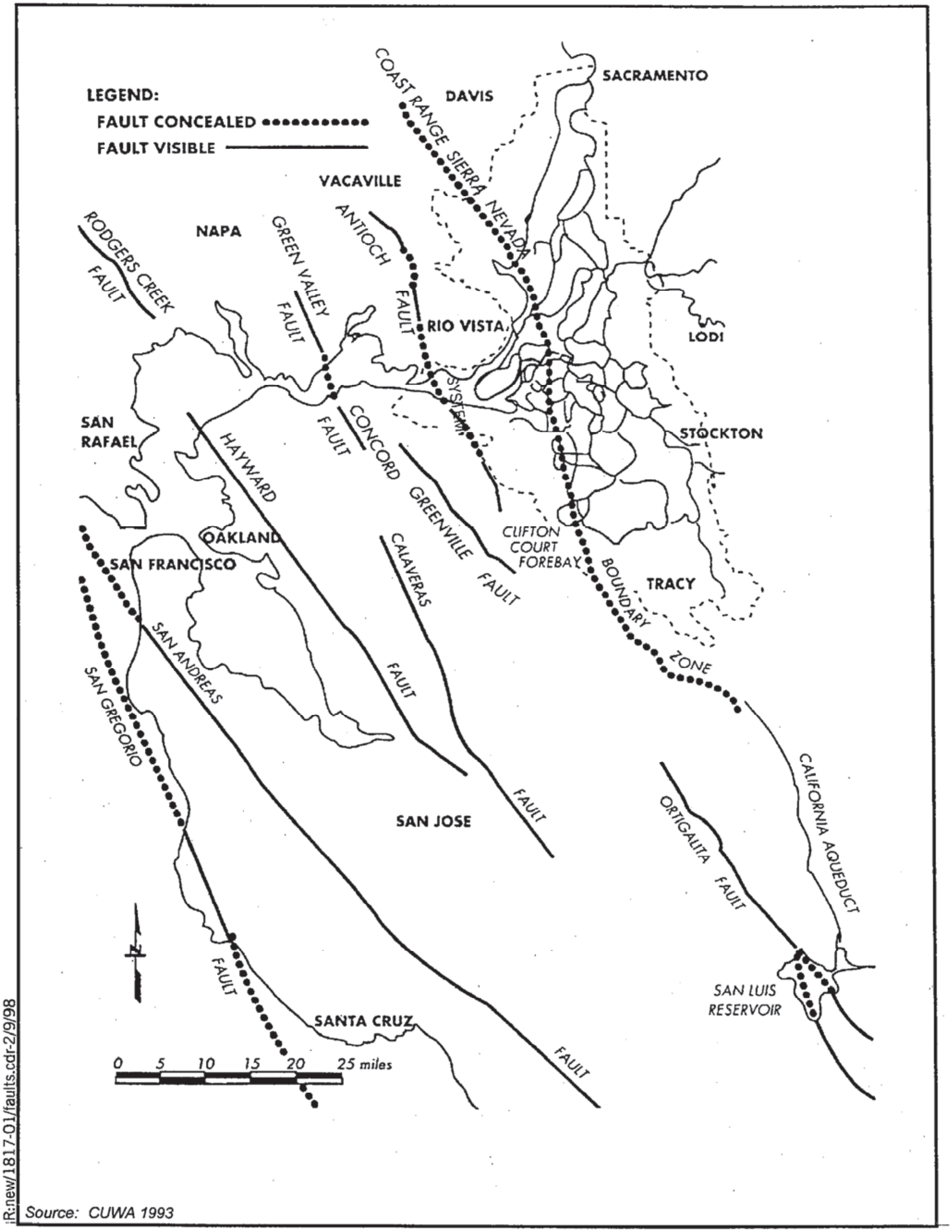
The concentration of salinity in shallow groundwater and the salt mass contained in Delta soils are direct consequences of the quality of the irrigation water drawn from Delta channels.

Wind Erosion. The Delta organic soils and highly organic mineral soils have wind erodibility ratings of 2-4 on a scale where 1 is most erodible and 8 is least erodible. The high wind erodibility of Delta soils is due to their organic matter content. The rate of wind erosion is estimated at 0.1 inch per year.

Sedimentation and Fluvial Erosion in the Delta. The great quantities of sediment transported by the rivers into the Delta move primarily as suspended load. Of the estimated 5 million tons per year of sediment inflow into the Delta, about 80% originates from the Sacramento River and San Joaquin River drainages; the remainder is contributed by local streams. Approximately 15-30% of the sediment is deposited in the Delta; the balance moves into the San Francisco Bay system or out through the water project facilities.

Sediment circulation within the Bay-Delta system is complex due to the numerous interconnected channels, tidal flats, and bays, within which the interaction of fresh-water flows, tides, and winds produce an ever-changing pattern of sediment suspension and deposition. Pumping at the CVP and SWP Delta facilities alters this circulation of sediments within the system and may cause erosion of the bed and banks by inducing higher water velocities in the channels.

The mechanics of sediment transport in either saline or tidally affected streams, such as the lower Sacramento River and the Delta, are even more complex than in fresh-water streams. This complexity



Source: CUWA 1993

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Figure 5.5-4. Faults within and near the Delta results from changes in flow velocity, flow direction, and water depth caused by the tides. The Delta is primarily a depositional environment, but variations in water and sediment inflow result in either erosion or deposition.

Erosion may occur when (1) the velocity of flow in a channel is increased, (2) the sediment inflow to a channel in equilibrium is reduced, or (3) predominance of flow in one direction is altered in a channel that experiences reverse flows. The actual rate of erosion depends on the composition of the material on the bed and banks, and on the amount of change in the factors listed previously.

Deposition is induced when conditions are the opposite of those favorable for erosion. The rate of deposition depends on the type and amount of sediment in suspension, the salinity, and the extent to which the transport capacity of the channel has been changed by reduction in flow velocity and channel size. Increasing salinity causes the suspended load of clay and silt particles to form aggregates that settle and deposit more rapidly than individual sediment particles. Deposition near Rio Vista may be caused by the convergence of the Sacramento River with the Deep Water Channel, forming a wider channel with resultant lower water velocities.

Flows induced by use of the DCC have affected the North Fork of the Mokelumne River by eroding a rather deep channel near New Hope, thereby accelerating the need for riprap on the Mokelumne River levees. DCC flows that go down the South Fork pass through Dead Horse Cut and impinge on the Staten Island levee at a right angle, resulting in erosion of the bank in this area.

The discharges and velocities in the channels south of the San Joaquin River are influenced significantly by exports at the CVP and SWP pumping plants. Sediment deposition and gain from local drainage alter the amount and composition of the sediment transported in the channels. In addition, degradation or aggradation, and widening or narrowing of certain channels may be occurring due to the higher velocities caused by pumping.

5.5.3.2 BAY REGION

The Bay occupies a structural trough that formed during the late Cenozoic when it was part of a great drainage basin of the ancestral San Joaquin, Sacramento, and Coyote Rivers. The Bay was formed between 10,000 and 25,000 years ago, when the polar ice caps melted at the end of the fourth glacial period. Sea level rose in response to the melting of the ice caps. As the ocean rose, it flooded river valleys inland of the Golden Gate, forming San Francisco Bay, San Pablo Bay, and Suisun Bay.

Geographically, the Suisun Marsh is located in the Bay Region. For most resources, the only Program actions that would directly affect the marsh are levee improvements under the Levee System Integrity Program and restoration actions under the Ecosystem Restoration Program.

Soils and Sediment Conditions. The sediments of the shallows comprise silty clay, clayey silt, and sand-silt-clay, while sand and silty sand cover the deeper areas of the Central Bay and San Pablo Bay. Gravelly sands are found at Golden Gate and grade seaward to a well-sorted sand that covers most of the intercontinental shelf region of the Gulf of Farallons.

The Bay Region can be divided into four major landform types (each with characteristic soils): (1) basin floor/basin rim, (2) floodplain/valley land, (3) terraces, and (4) foothills and mountains. Basin lands consists of organic-rich saline soils adjacent to the Bay and poorly drained soils somewhat farther from the Bay. Valley land soils generally are found on gently sloping alluvial fans that surround the floodplain and basin lands. These soils, along with floodplain alluvial soils, represent the most important agricultural group of soils in California. In the Bay Area, most of the floodplain and valley land soils have been urbanized.

Terrace land soils are found along the southeastern edge of the San Francisco Bay Area at elevation 5-100 feet above the valley land. Most of these soils are moderately dense soils of neutral reaction.

Soils of the foothills and mountains that surround the Bay are formed in through the decomposition and disintegration of the underlying parent material. The most prevalent foothills soil group is that with a moderate depth to bedrock (20-40 inches), with lesser amounts of the deep depth (>40 inches) and shallow depth (<12 inches) to bedrock soil groups being present. Moderate-depth soils generally are dark colored and fairly high in organic matter, and constitute some of the best natural grazing lands of the state. Deep soils occur in the high rainfall zones at the higher elevations in the Coast Ranges. They generally support the forested lands in the Bay Region and are characterized by acid reaction and depths to bedrock of 3-6 feet. Shallow soils occur in the medium- to low-rainfall zone. They are loamy in character and are used principally for grazing.

San Francisco Bay Seismicity. Major earthquake activity has centered along the San Andreas Fault zone, including the great San Francisco earthquake of 1906. Since that earthquake, four events of magnitude 5.0 on the Richter scale or greater have occurred in the Bay Region. The San Andreas and Hayward Faults remain active, with evidence of recent slippage along both faults.

Sedimentation and Erosion in San Francisco Bay. The major source of suspended sediment in the Bay is outflow from the Delta. Approximately three-quarters of the suspended sediment enters the Bay with the high winter and early spring flood flows. The highest suspended sediment and turbidity levels occur during these periods. Although much of the suspended sediment begins to aggregate at the salinity gradient and deposit in the shallow areas of Suisun and San Pablo Bays, high seasonal flows can transport incoming sediment as far as the Central and South Bays.

Sediments deposited in the shallower regions are resuspended by wave and wind action. Approximately 15 times as much material is resuspended each year as actually enters the Bay. Resuspension of sediment is the most important process in maintaining turbidities in the Bay from late spring through fall.

5.5.3.3 SACRAMENTO RIVER REGION

The Sacramento River drains over 21,000 square miles (above the Feather River confluence), producing an annual average flow of 19,000 cubic feet per second (cfs). The upper watersheds of the Sacramento River Region include the drainages above Shasta Reservoir (including that portion of the Trinity River watershed, from which flows are diverted into the Bay-Delta system), the Clear Creek drainage basin west of Redding, the upper Colusa and Cache Creek watersheds west of the valley, and the Feather River and American River watersheds east of the valley. These watersheds are described in detail in Section 5.1, "Water Supply and Water Management."

Hydraulic mining on the western slopes of Sierra Nevada between 1853 and 1884 dramatically increased the sediment budgets of central Sierran streams and rivers. The addition of abundant coarse material overwhelmed the capacity of the rivers, resulting in temporary storage of the sediment in channels and floodplains, and in widespread flooding of Central Valley towns and farms. Since the end of hydraulic mining more than 100 years ago, most rivers have reestablished their original gradients, aided by trapping of the mining sediment behind dams and scouring of the channels promoted by levees built along the rivers.

The Sacramento River's hydrology has been profoundly altered by reservoir construction. At Red Bluff, the average annual flood flow was 121,000 cfs before construction of Shasta Dam (1879-1944), and 79,000 cfs after (1945-93). The 10-year flood has been reduced from 218,000 to 134,000 cfs, reducing the energy available to transport sediment in the Sacramento River. Moreover, the sediment supply to the river has been reduced by sediment trapping in reservoirs; by mining of sand and gravel from channel beds; and from artificial protection of river banks. The erosion of the river banks had supplied sediment to the channel.

Rates of bank erosion and channel migration have declined since 1946, presumably due to change in flow and blockage of upstream sediment supply as a result of Shasta Dam, and due to the construction of downstream bank protection projects. The channel sinuosity (ratio of channel length to valley length) also has decreased.

Soils. The Sacramento River Region contains four major landform types (each with its own characteristic soils): (1) floodplain, (2) basin rim/basin floor, (3) terraces, and (4) foothills and mountains. Floodplain alluvial soils make up some of the best agricultural land in the state. Basin landforms consist of poorly drained soils, and saline and alkali soils in the valley trough and on the basin rims. These soils are used mainly for pasture, rice, and cotton. Areas above the valley floor have terrace and foothill soils, which are primarily used for grazing and timberland.

The upper watersheds of the Sacramento Valley area mainly drain foothill soils. These soils are found on the hilly to mountainous terrain surrounding the Sacramento Valley and are formed in place through the decomposition and disintegration of the underlying parent material. The most prevalent foothill soil groups are those with a deep depth (>40 inches), shallow depth (<20 inches), and very shallow depth (<12 inches) to bedrock.

Deep soils occur in the high rainfall zones at the higher elevations in the mountains surrounding the Sacramento Valley. These areas are important timberlands that are characterized by acid reaction and depths to bedrock of 3-6 feet.

Shallow soils occur in the medium-to-low rainfall zones at lower elevations. The soils range from calcareous brown stony clay (for example, Lassen soils) to noncalcareous brown loam (for example, Vallecitos soils) and are used principally for grazing.

Very shallow soils are found on steep slopes, often at high elevations. They consist of stony clay loam or stony loam and are not useful for agriculture or timber because of their very shallow depth, steep slopes, and stony texture. As such, they also are rated very low for grazing purposes.

Geologic Conditions. The geologic provinces composing the Sacramento River Region include the Klamath Mountains, the Coast Ranges, the Cascade Range/Modoc Plateau, the Sierra Nevada, and the Central Valley.

Geomorphologic Conditions. Downstream of Red Bluff, the Sacramento River flows within a meander belt of recent alluvium. The river is characterized by an active channel, with point bars on the inside of meander bends, and is flanked by active floodplain and older terraces. While most of these features consist of easily erodible, unconsolidated alluvium, there are also outcrops of resistant, cemented alluvial units such as the Modesto and Riverbank formations.

In the channel itself, the bed is composed of gravel and sand (less gravel with distance downstream), and point bars are composed of sand. The bottomlands flanking the channel consist of silts and sands (deposited from suspended load in flood waters), commonly overlying channel gravels and sands. Higher, older surfaces consisting of (often cemented) Pleistocene deposits also are encountered.

The river channel migrates (maintaining roughly constant dimensions) across the floodplain to the limits of the meander belt, constrained only by outcrops of resistant units or artificial bank protection. As meander bends grow, they may become unstable and form cutoffs.

Since construction of Shasta Dam in the early 1940s, flood volumes on the river have been reduced, which has reduced the energy available for sediment transport. Straightening and reduced meander migration rate of the river may be associated with flow regulation due to Shasta Dam. The reduction in active channel dynamics is compounded by the physical effects of riprap bank protection structures, which typically eliminate shaded bank habitat and associated deep pools, as well as halting the natural processes of channel migration.

Sediment loads in the streams draining the upper watersheds have been artificially increased due to past and current logging and grazing practices. Both practices remove soil-stabilizing vegetation, create preferential drainageways, and promote localized soil compaction. Erosive overland flow is enhanced by the loss of vegetation and compacted soils. Larger amounts of sediment are delivered to the streams from increased rates of soil erosion and from enhanced rates of mass movement, such as landslides. During high runoff events, the sharp increases in sediment yields can lead to widespread channel aggradation, which in turn can lead to lateral migration of the channels and increased rates of landsliding.

Where reservoirs have been created by dams, most of the sediment is trapped behind the dam and, during the life of the reservoir, will not be transported downstream of the dam. Where such sediment traps are not in place, the sediment load will be transferred downstream.

Soil Subsidence. Land subsidence in the Sacramento Valley is localized and concentrated in areas of groundwater-pumping-induced overdraft. Land subsidence had exceeded 1 foot by 1973 in two main areas in the southwestern part of the valley near Davis and Zamora; however, additional subsidence since then has not been reported.

Seismicity. The Great Valley thrust fault system forms the boundary between the Coast Ranges and the Sacramento and San Joaquin Valleys. This fault system is capable of earthquakes up to magnitude 6.8 along the west side of Sacramento Valley. The Mendocino Range west of the valley is mainly subject to seismicity from northwest-trending faults associated with the right-lateral strike-slip San Andreas Fault system.

The mapped active faults of this system that are most likely to affect the upper watersheds west of the Sacramento Valley are the Green Valley, Hunting Creek, Bartlett Springs, Round Valley, and Lake Mountain Faults. These faults lie along a 150-mile-long northwest-trending zone of seismicity that is 10-45 miles west of the Sacramento Valley and extends from Suisun Bay past Lake Berryessa and Lake Pillsbury to near the latitude of Red Bluff. These faults are capable of earthquakes up to magnitude 7.1.

Active faults likely to affect the upper watersheds northeast of the Sacramento Valley, in the drainages upstream of the Shasta Reservoir, include the Mayfield-MacArthur-Hat Creek Faults, 25-85 miles north of Lake Almanor; the Gillem-Big Crack Faults near the California-Oregon border southeast of Lower Klamath Lake; and the Cedar Mountain Fault southwest of Lower Klamath Lake. These faults are part of the Sierra Nevada-Great Basin dextral shear zone and are capable of earthquakes up to magnitude 7.0. Farther northeast, the Likely Fault is judged capable of a magnitude 6.9 earthquake; in the northeast corner of the state, the Surprise Fault is capable of a magnitude 7.0 earthquake.

Active faults likely to affect the upper watersheds east of the Sacramento Valley include the Indian Valley Fault southeast of Lake Almanor and the Honey Lake Fault zone east of Lake Almanor, which is capable of a magnitude 6.9 earthquake. Surface rupture occurred in 1975 along the Cleaveland Hill Fault south of Lake Oroville. The Foothills Fault system, which borders the east side of the Sacramento and San Joaquin Valleys, is judged to be capable of a magnitude 6.5 earthquake.

In-Stream Gravel Mining. Aggregate mining occurs within many streams in the western foothills of California and in the lower foothills of the Sierra Nevada. Because of their convenient proximity to the ground surface and their location on flat land, these deposits have been mined for many years. In-stream gravel mining causes significant water quality and habitat problems due to the increased release of sediments in the river as well as the removal of soils in the areas of mining activities.

Wind Erosion. Soil erodibility, climatic factors, soil surface roughness, width of field, and quantity of vegetative coverage affect the susceptibility of soils to wind erosion. Wind erosion renders the soil more shallow, and can remove organic matter and needed plant nutrients. In addition, blowing soil particles can damage plants, particularly young plants. Blowing soils also can cause off-site problems such as reduced visibility and increased allergic reaction to dust.

5.5.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River drains 13,500 square miles along the western flank of the Sierra Nevada and eastern flank of the Coast Ranges, producing an average flow of 4,600 cfs near Vernalis. The San Joaquin River has three major tributaries that drain the Sierra Nevada. In downstream order, they are the Merced (drainage area 1,270 square miles, average flow 1,350 cfs), Tuolumne (1,884 square miles, average flow 2,254 cfs), and Stanislaus (980 square miles, average flow 1,400 cfs) Rivers. Precipitation is predominantly snow above 4,000 feet in the Sierra Nevada, and rain in the middle and lower elevations of the Sierra Nevada and Coast Ranges. As a result, the natural hydrology reflects a mixed runoff regime of summer snowmelt and winter-spring rainfall runoff. Another major river, the Mokelumne, enters the east Delta along with minor tributaries (including the Cosumnes and Calaveras Rivers), joining the San Joaquin River prior to its confluence with the Sacramento River. The drainage area of the Mokelumne River is 660 square miles. The hydrology of the San Joaquin River and its tributaries has been profoundly altered by dam construction and surface water diversions. So much water is diverted from Friant Dam that the mainstem San Joaquin River now goes dry at Gravelly Ford, some 30 miles downstream, except during periods of high flow. Storage of flood waters behind Friant Dam has resulted in a decline in flood magnitudes on the mainstream San Joaquin River. Similar reductions have occurred on the major tributaries, such as the Merced River. This decline has reduced the energy available to transport sediments.

Sediment supply to the river system has been reduced by catchment and trapping in reservoirs; mining of sand and gravel from channel beds; and artificial protection of river banks, the erosion of which had supplied sediment to the channel.

The floodplains of the San Joaquin River and its tributaries have been extensively modified for agricultural development, with elimination of many acres of slough and side-channel habitat.

Gravel extraction has been both extensive and intensive from the upper mainstem and the major tributaries. The combined effects of sediment trapping by upstream reservoirs and, to a lesser extent, reduced bank erosion from riprapping, have resulted in a condition of sediment-starvation. In addition, excavation of pits for aggregate production has directly transformed many reaches of the San Joaquin River and its tributaries from flowing rivers to quiescent lakes.

Soils. The San Joaquin River Region contains four major landform types (each with its own characteristic soils): (1) floodplain, (2) basin rim/basin floor, (3) terraces, and (4) foothills and mountains. Floodplain lands contain two main soil types: alluvial soils and aeolian soils. The alluvial soils make up some of the best agricultural land in the state, whereas the aeolian soils are prone to wind erosion and are deficient in plant nutrients. Basin lands consist of poorly drained soils, and saline and alkali soils in the valley trough and on the basin rims. These soils are used mainly for pasture, rice, and cotton.

Areas above the valley floor contain terrace and foothill soils, which are primarily used for grazing and timberland.

The upper watersheds of the Sacramento and San Joaquin Valleys mainly drain foothills soils, which are found on the hilly to mountainous topography surrounding the San Joaquin Valley. Moderate depth to bedrock (20-40 inches) soils occur on both sides of the northern part of the San Joaquin Valley, where the annual rainfall is intermediate to moderately high. Deep (>40 inches) soils are the important timberlands of the area and occur in the high rainfall zones at the higher elevations in the mountains east of the valley. Shallow (<20 inches) soils, used for grazing, occur in the medium- to low-rainfall zone at lower elevations on both sides of the valley. Very shallow (<12 inches) soils are found on steep slopes, mainly at higher elevations. These soils are not useful for agriculture, grazing, or timber because of their very shallow depth, steep slopes, and stony texture.

Geologic Conditions. The geologic provinces composing the San Joaquin River Region include the Coast Ranges, Central Valley, and Sierra Nevada.

Geomorphologic Conditions. The mainstem San Joaquin River meanders within a meander belt of recent alluvium. The river is characterized by an active channel, with point bars on the inside of meander bends, flanked by an active floodplain and older terraces. While most of these features consist of easily erodible, unconsolidated alluvial deposits, there are also outcrops of resistant, cemented alluvial units such as the Modesto and Riverbank formations.

Within the channel itself, the bed is composed of gravel and sand (less gravel with distance downstream), and point bars are composed of sand. The bottomlands flanking the channel consist of silts and sands (deposited from suspended load in flood waters), commonly overlying channel gravels and sands. Higher, older surfaces consisting of (often cemented) Pleistocene deposits also are encountered.

The river channel migrates (maintaining roughly constant dimensions) across the floodplain to the limits of the meander belt, constrained only by outcroppings of resistant units or artificial bank protection. As meander bends grow, they may become unstable and form cutoffs, leaving oxbow lakes like those visible along lower reaches of the mainstem.

Sediment loads in streams draining the upper watersheds of the San Joaquin River Region are similar to those described for the Sacramento River Region.

Soil Subsidence. After nearly two decades of little or no land subsidence, significant land subsidence recently has been detected in the San Joaquin Valley along the Delta-Mendota Canal due to increased groundwater pumping during the 1987-92 drought.

It was not until the 1920s that deep well pumping lowered the water table below the root zone of plants on the east side of the valley. Dry-farming practices were replaced with irrigated agriculture on the west side in the 1940s, leading to the spreading and worsening of drainage problems on the west side of the valley and near the valley trough in the 1950s.

As a result of heavy pumping, groundwater levels declined by more than 300 feet in certain areas during the 1940s and 50s. The groundwater level declines resulted in significant land subsidence over large areas. Significant historical land subsidence caused by excessive groundwater pumping has been observed in the Los Banos-Kettleman Hills area, the Tulare-Wasco area, and the Arvin-Maricopa area.

Seismicity. In the San Joaquin River Region, the Great Valley thrust fault system forms the boundary between the Coast Ranges and the west boundary of the San Joaquin Valley. This fault system is capable of earthquakes up to magnitude 6.7 along the west side of San Joaquin Valley.

The Diablo Range west of the valley is mainly subject to seismicity from northwest-trending faults associated with the right-lateral strike-slip San Andreas Fault system.

The mapped active faults of this system that are most likely to affect the upper watersheds west of the San Joaquin Valley are the Ortigalita Fault and the Greenville-Marsh Creek Fault. These faults lie along northwest-trending zones of seismicity 5-20 miles west of the San Joaquin Valley; each fault is capable of earthquakes up to magnitude 6.9.

Active faults likely to affect the upper watersheds east of the San Joaquin Valley include the Foothills Fault system and major faults along the east margin of the Sierra Nevada. The Foothills Fault system, which borders the east side of the northern part of the San Joaquin Valley, is judged to be capable of a magnitude 6.5 earthquake. Active faults along the east margin of the Sierra Nevada include the Owens Valley Fault, which ruptured in a magnitude 7.6 earthquake in 1872 and is within the Sierra Nevada Fault zone. Seismic activity along this fault zone can significantly affect the upper watersheds that drain to the San Joaquin Valley.

Active faults likely to affect the upper watersheds at the end of the San Joaquin Valley include the White Wolf Fault, which ruptured in 1952 with a magnitude 7.2 earthquake; the Garlock Fault, capable of a magnitude 7.3 earthquake; and several smaller faults 10-30 miles north of the White Wolf Fault.

Soil Salinity. Soil salinity problems occur primarily in the western and southern portions of the San Joaquin Valley. Most soils in this region were derived from marine sediments of the Coast Ranges, which contain salts and potentially toxic trace elements such as arsenic, boron, molybdenum, and selenium. Soil salinity problems in the San Joaquin Valley have been, and continue to be, intensified by poor soil drainage, insufficient water supplies for adequate leaching, poor-quality (high-salinity) applied irrigation water, high water tables, and an arid climate. A 1984 study estimated that about 2.4 million of the 7.5 million acres of irrigated cropland in the Central Valley were adversely affected by soil salinity.

Selenium Concentrations. Soil selenium is primarily a concern on the west side of the San Joaquin Valley. When soils on the west side are irrigated, selenium (along with other salts and trace elements) dissolves and leaches into the shallow groundwater. Figure 5.5-5 shows selenium levels in the top 12 inches of soil as determined by a survey in the mid 1980s. Over the past 30-40 years of irrigation, soluble selenium has been leached from the soils into the underlying shallow groundwater aquifers.

5.5.3.5 OTHER SWP AND CVP SERVICE AREAS

The Other SWP and CVP Service Areas region includes two distinct, noncontiguous areas: in the north, are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

A description of the soils and geomorphologic conditions of the Other SWP and CVP Services Areas is not included in this report because no direct impacts on geology and soils resources in this region are expected as a result of any of the Program alternatives.

5.5.4 ASSESSMENT METHODS

This programmatic assessment encompasses analyses of soil changes that could result directly from construction of new facilities or conversion of lands from one use to another; and analyses of indirect impacts of changes in policies, resources, or economics. The assessment of the effects of changes on geology and soils addresses both the direct and indirect consequences of Program actions.

Two types of analyses have been included: (1) changes in areal extent due to direct loss or conversion of soil types and geomorphologic conditions, and (2) changes in their quality. Impacts on the areal extent or quality of agricultural soils are caused by two types of Program activities: (1) conversion to different plant communities as part of a habitat-related restoration action, and (2) direct losses from the construction of project features.

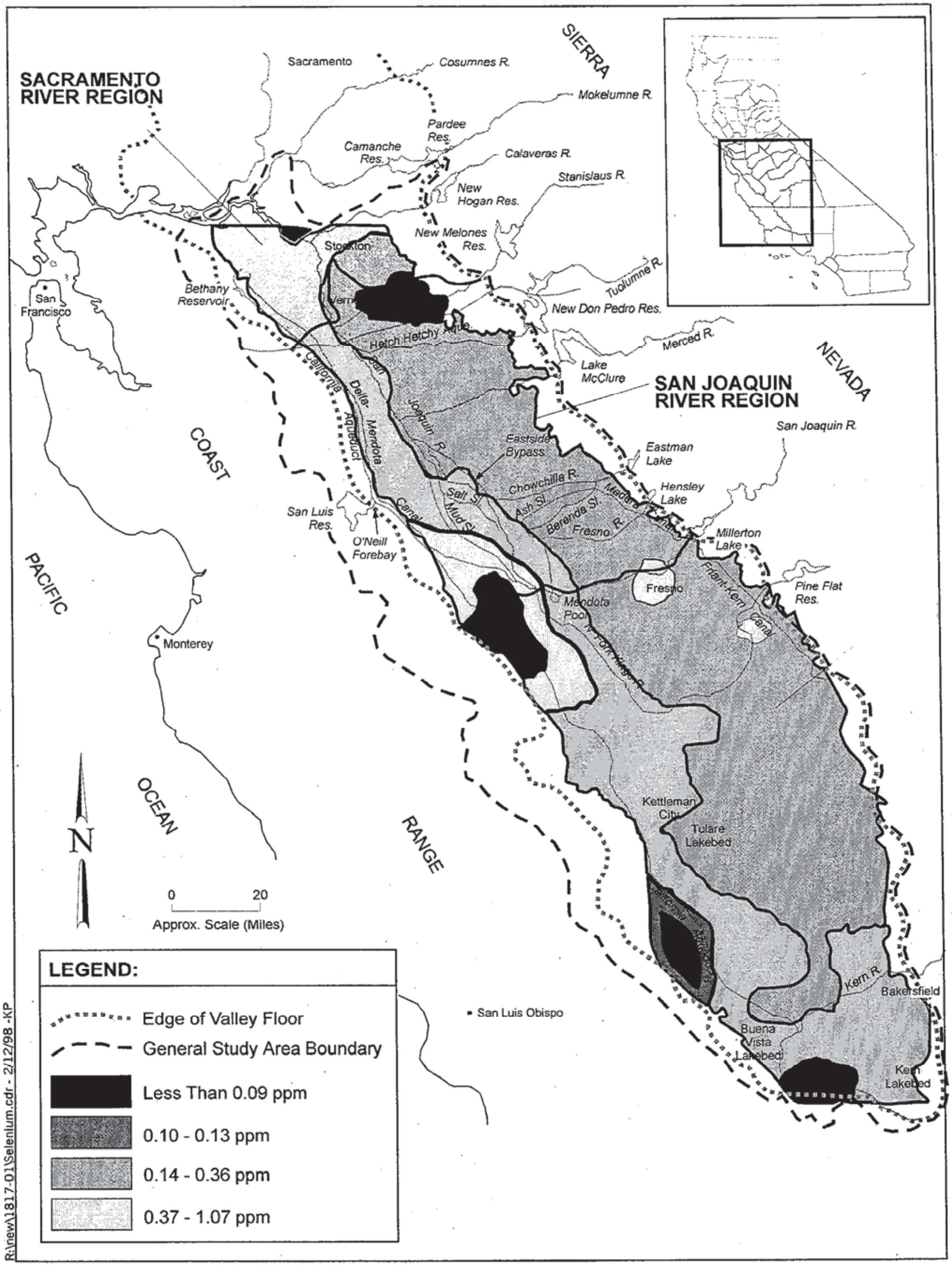

Figure 5.5-5. Selenium Concentrations

The programmatic assessment of impacts on geology and soils evaluated potential changes to the following resource categories:

- Surface soil erosion.
- Channel, basin, shore, and shallows erosion and sedimentation.
- Soil salinity.
- Soil drainage characteristics.
- Subsidence caused by the mass loading from overburden and oxidation of organic content.
- Subsidence caused by groundwater withdrawals.
- Geomorphology and soils impacts due to change on land surfaces.
- Soil acreage and characteristics due to changes in land use.

Estimated changes in soil erosion are qualitative because of variability in soil type, soil erodibility, slope, and land management practices throughout the regions. Projection of soil salinity impacts was based on estimates of the affected soils and degree to which area soils would be affected by salts. The assessment of subsidence resulting from groundwater withdrawals was based on changes in the amounts and reliability of delivered water, and the resulting changes in the rates of groundwater pumping.

5.5.5 SIGNIFICANCE CRITERIA

Impacts are considered significant if implementing a Program action would result in any of the following threshold criteria:

- Substantial removal, filling, grading, or disturbance of soils.

- Substantial degradation of the quantity or quality of native soil types or their environmental and water quality protection characteristics in significant watersheds.

- Releases of toxic materials from soils or sediments.

- Alterations to, or drainage from, soils or substrates that create conditions that increase the potential for outbreaks of wildlife diseases.

- Substantial adverse changes in rates of sedimentation and erosion.

- Substantial adverse changes in soil drainage or salinity.
- Increases in soil subsidence rates that produce adverse effects.

- Changes in soil conditions that cause undesirable seepage to adjacent lands.

- Increased potential for soil erosion by wind, waves, or currents.
- Oxidation of, or drainage from, peat soils that may cause adverse effects.

- Increased potential for erosion and mass failure-induced landslides.

- Increased potential for seismic activity or vulnerability of soil-comprised structures to seismic events.

- Disruption of natural or favorable soil profiles and horizons.
- Increased potential for damage from geologic hazards.

5.5.6 NO ACTION ALTERNATIVE

The environmental consequences to geology and soils under the No Action Alternative would be very similar to the existing conditions described in the Affected Environment section. Channel geometry in the Delta, Bay, Sacramento River, and San Joaquin River Regions would not be altered by other than current ongoing geomorphologic, irrigation, drainage, or dredging processes. Negative trends in soil erosion, subsidence, and soil contamination are expected to continue.

5.5.6.1 DELTA REGION

In the Delta Region, the No Action Alternative could result in continued problems with soil salinity, soil surface erosion and subsidence, soil selenium, and seismic susceptibility of levees to failure. Elevated levels of soil salinity in the south and west Delta could increase when compared to existing conditions for two reason: (1) the seepage and the quality of applied water caused by increasing amounts of ocean salinity intrusion, and (2) high TDS concentrations from increasing amounts of land-derived agricultural drainage. Peat oxidation of the island interior soils would continue, resulting in continued subsidence and susceptibility of the soil to wind-induced erosion. Existing high selenium concentrations could increase in the channels and applied irrigation water in the south Delta from land-derived San Joaquin Valley agricultural drainage. The susceptibility of Delta levees to seismic failure would be further increased by the continued subsidence.

5.5.6.2 BAY REGION

In the Bay Region, the No Action Alternative is not expected to result in any significant changes to geomorphologic or soils conditions relative to existing conditions.

5.5.6.3 SACRAMENTO RIVER REGION

In the Sacramento River Region, surface soil erosion can be expected to continue under the No Action Alternative.

5.5.6.4 San Joaquin River Region

In the San Joaquin River Region, soil salinity and selenium concentrations can be expected to increase as additional salt load is imported to the valley and leached from the soils by irrigation and natural discharge from contaminated soils on the west side. Subsidence caused by groundwater withdrawals can be expected to continue as groundwater pumping continues and increases. Surface soil erosion can be expected to continue under the No Action Alternative.

5.5.6.5 Other SWP and CVP Service Areas

Geology and soils in the Other SWP and CVP Service Areas are not expected to be affected by any Program alternative. Therefore, no further discussion of geology or soils is provided for this region.

5.5.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For geology and soils, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs and the Storage element are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 5.5.8.

5.5.7.1 Delta Region

Ecosystem Restoration Program

The Ecosystem Restoration Program includes habitat restoration in the Delta Region. Beneficial impacts of habitat restoration include reducing soil loss (or depletion) on Delta island interiors and levees resulting from wind erosion, wave erosion, and high-velocity flows. Habitat restoration would allow for improved vegetative growth by returning humus and nutrients to the soils, and sheltering soils from the wind. The protection and maintenance of in-channel islands also would decrease wind-fetch distances over open water, thereby reducing wind-wave erosion on nearby levees.

Agreements with willing levee reclamation districts to implement modified levee and berm management practices could promote the establishment and maturation of shoreline riparian vegetation. Riparian vegetation would reduce flow velocities adjacent to the levees, thereby potentially reducing soil erosion.

Because agricultural land could be converted to habitat for ecosystem restoration, agricultural soils may undergo a transition to soils used for native habitat types. Upland terrestrial soils may be converted to hydric soils due to temporary or permanent shallow flooding to create marshland habitat. This impact on the soil resource is considered less than significant because the soil quality is not reduced and the soil resource is not lost. Impacts on agricultural lands are addressed in Section 7.1.

Construction of ecosystem restoration projects could result in short-term significant adverse impacts on soils. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil, including decreasing permeability and increasing runoff. These impacts can be reduced to a less-than-significant level through mitigation strategies.

Water Quality Program

Activities proposed for the Water Quality Program would not adversely affect geology and soils in the Delta Region. Reductions in point source and nonpoint source pollutants would result in beneficial impacts in the Delta Region—by decreasing the loadings of toxic metals and organic compounds, and by removing potential sources of soil and sediment contamination, including salts and selenium.

Levee System Integrity Program

The Levee System Integrity Program would protect flooded Delta inboard levee slopes against wind and wave erosion with vegetation, soil, matting, or rock. Program improvements would be implemented primarily on lands used for agriculture; hence, changes in soils and geomorphologic conditions would be confined to those lands. Beneficial effects of the Levee System Integrity improvements include reducing the impact of land subsidence in the Delta, reducing the risk of levee failure, and decreasing soil salinities inboard of levees.

Construction of setback levees could significantly increase the floodplain width, which would result in lower flood stages and reduced peak flows, reduced soil erosion and sediment transport, and altered fluvial geomorphology.

Seismic retrofits to levees could reduce the risk of catastrophic failure, thereby reducing the risk of salinity intrusion from the ocean, which could increase salinity in the soils.

The use of agricultural soils for levee system construction could produce potentially significant adverse changes to soils in the affected areas. Agricultural soils would be covered where new setback levees are constructed. The loss of agricultural soils associated with levee construction is addressed in Section 7.1. Soil erosion outboard of the levees may increase but could be mitigated to a less-than-significant level by habitat restoration, sediment deposition measures, and other strategies to minimize erosion. The beneficial reuse of dredged material could replace soils that have been lost, prevent subsequent losses, and further reduce this impact. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. These mitigation strategies will reduce potentially significant impacts to a less-than-significant level.

Water Use Efficiency Program

The beneficial effects of on-farm water use efficiency improvements, such as tailwater recovery ponds or installation of pressurized irrigation systems (over gravity), include greatly reducing sediment transport from fields to streams and drains. On-farm efficiency improvements could lead to increased reliance on groundwater due to irrigation needs and secondary use issues. Highly efficient irrigation requires more frequent water deliveries, some of which may not be met from surface water sources, and impoundment of tailwater leaves less surface water available to secondary users. Such users may turn to alternative sources, such as groundwater. An increased reliance on groundwater could result in localized subsidence from depletion of groundwater resources, a potentially significant adverse impact that can be mitigated to a less-than-significant level.

Water Transfer and Watershed Programs

The Water Transfer Program is not expected to affect geology and soils in the Delta Region. The Watershed Program may indirectly cause short-term adverse impacts on soils due to construction activities, as described for the Sacramento River and San Joaquin River Regions. Mitigation strategies can reduce these impacts to a less-than-significant level.

Storage

New upstream groundwater and surface water storage could increase the amount of fresh water available during summer and fall. This increase in fresh water would dilute salinity in waters from tributaries with return flows that contain potentially high concentrations of salts. The additional flows in summer and fall also would reduce salinity intrusion from the ocean and transport more dissolved salts to the ocean, thereby reducing applied soil salt loads and soil salinity. This reduction is considered a beneficial impact.

Construction of in-Delta storage facilities and associated diversion and conveyance components would result in potentially significant adverse impacts because of local ground disturbances and inundation, the extent of which would depend on the type and size of storage, diversion and conveyance facilities constructed, construction methods, and sites selected. Reservoir construction also could require construction of access roads and temporary construction-related facilities. Increased erosion could occur on areas cleared for storage facilities or access roads. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil, including decreasing permeability and increasing runoff. Mitigation strategies are available to reduce this impact to a less-than-significant level.

Seepage to adjacent islands could be caused by groundwater underflow toward the tracts on the opposite banks of an in-Delta storage reservoir. Seepage is considered a significant adverse impact on soils. Mitigation strategies are available to reduce this impact to a less-than significant level. Related seepage impacts to groundwater, agricultural land, and flood control are addressed in Sections 5.4, 7.1, and 7.8. Wind- and wave-generated erosion along the shorelines of the reservoir could cause a potentially significant impact by increasing bank erosion and sedimentation at the site. Mitigation strategies are available to reduce erosion impacts to a less-than-significant level.

Construction of in-Delta storage would inundate agricultural soils, resulting in their permanent loss. This impact is addressed in Section 7.1.

5.5.7.2 BAY REGION

Ecosystem Restoration and Water Quality Programs

Direct, indirect, and construction-related activities associated with the Ecosystem Restoration and Water Quality Programs could alter or displace soils in the immediate vicinity of activities, causing short-term significant adverse impacts on soils. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil, including decreasing permeability and increasing runoff. Mitigation strategies can reduce these impacts to a less-than-significant level.

As in the Delta Region, reductions in point source and nonpoint source pollutants would result in beneficial impacts in the Bay Region—by decreasing the loadings of toxic metals and organic compounds, and by removing potential sources of soil and sediment contamination, including salts and selenium.

Levee System Integrity Program

The only levee system integrity activities proposed for the Bay Region involve levee rehabilitation in the Suisun Marsh.

Currently, the Suisun Marsh is a combination of managed wetlands (seasonal and permanent) and tidally influenced areas. These managed wetlands rely on the ability to manage the flow of water onto the property to control soil salinity levels. Levee failure, particularly during the leaching cycle, would result in increased soil salinities. Increased soil salinities, in turn, adversely affect the plant communities growing in the managed wetlands.

Levee rehabilitation in the Suisun Marsh would take place in areas that are primarily seasonally managed wetlands, and would diminish the possibility of catastrophic failure and unplanned conversion of those lands into tidally influenced lands. These activities would not adversely affect geology and soils in the Suisun Marsh.

Water Use Efficiency and Water Transfer Programs

Activities proposed for the Water Use Efficiency and Water Transfer Programs would not adversely affect geology and soils in the Bay Region.

Watershed Program

Water quality in the Bay Region would benefit from watershed activities that reduce hill slope and streambank erosion, which cause sediment loading and increased turbidity in streams flowing to the Bay. Potentially significant adverse impacts associated with watershed activities could include short-term increases in soil erosion and sediment discharges during the construction of various restoration projects. Soil compaction by heavy equipment during construction would temporarily affect the physical characteristics of the soil. These impacts can be reduced to a less-than-significant level. The long-term effects of these construction projects is expected to be beneficial. Benefits include reduced surface erosion and sediment discharges to streams that currently are caused by a variety of ongoing land use activities in the watersheds.

Storage

Potential geology and soils impacts associated with foreseeable changes in water availability resulting from the Storage Program are expected to be less than significant. The only potential effect would be associated with changes in sediment transport out of the Delta and into the Bay. The Preferred Program Alternative likely would cause only minor decreases in sediment transport from the Delta to the Bay.

5.5.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

The Ecosystem Restoration Program could beneficially affect geomorphologic processes in the Sacramento River and San Joaquin River Regions. Establishment of stream meander belts would widen the area available for natural channel migration to accommodate the processes of channel erosion and deposition, and allow the stream system to respond more naturally to morphologic changes without the presently imposed physical constraints.

Gravel recruitment actions would include stockpiling gravel at strategic locations for capture by high streamflows and would allow sediment-starved reaches to mimic natural stream processes. This program would be monitored to determine the effects on channel erosion, sediment deposition, and meander processes.

The removal or reduction of seasonal diversion structures on tributaries to the Sacramento and San Joaquin Rivers would reduce sediment trapping and allow for the continued transport of sediment downstream. This impact is not considered potentially significant. During removal of diversion structures, accumulated sediments behind the diversion structure could be released into the stream system, causing increased sediment deposition downstream. This potentially significant adverse impact can be mitigated to a less-than-significant level.

Construction of ecosystem restoration projects could result in short-term significant adverse impacts on soils. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil, including decreasing permeability and increasing runoff. These impacts can be reduced to a less-than-significant level through mitigation strategies.

Water Quality Program

Reductions in point source and nonpoint source pollutants would benefit the Sacramento River and San Joaquin River Regions by decreasing loadings of toxic metals and organic compounds, and by reducing the concentrations of selenium and salts in these and other minor tributaries.

Levee System Integrity Program

The Levee System Integrity Program would not affect geology and soils in the Sacramento River or San Joaquin River Region.

Water Use Efficiency Program

The Water Use Efficiency Program generally would result in the same beneficial and adverse impacts identified for the Delta Region. Potential reduction of erosion from agricultural fields through use of on-farm efficiency measures would be most pronounced in the San Joaquin and Sacramento Valleys. Efficiency measures would benefit in-stream water quality by reducing sediment transport to streams and drains.

Soil salinity of agricultural lands in the San Joaquin Valley potentially can be reduced if less high-salinity water is applied to fields. If higher-salinity water is applied, however, or if water conservation actions reduce water applications to levels that do not allow adequate soil leaching, soil salinity could be adversely affected. This impact is expected to be less than significant, however, and mitigation measures are available to reduce any potentially significant impacts to a less-than-significant level. Alternately, this action could improve the productive capacity of some fields currently high in soil salinity.

Conjunctive use practices involve using groundwater in combination with surface water to augment water supplies. When surplus Sacramento River or San Joaquin River water is available, it would be stored in groundwater basins (aquifers) for use when surface water availability is low. Conjunctive use of groundwater could benefit some areas of the San Joaquin Valley by reducing land subsidence that results from overdraft of groundwater reserves.

Water Transfer Program

Water transfers would affect geology and soils primarily through changes in land subsidence, erosion, and soil salinity. In addition to the source of water for a transfer, the timing, magnitude, and pathway of each transfer substantially affect the potential for significant impacts.

Beneficial impacts primarily include decreasing erosion and sedimentation through reduced land disturbance from fallowing; and decreasing soil salinity, relative to initial conditions, through replacement of existing irrigation water with higher quality transferred sources.

Potentially significant adverse impacts primarily include increasing wind erosion of topsoil from fallowing and the potential for land subsidence as a result of direct groundwater or groundwater-substitution-based transfers. These impacts can be mitigated to a less-than-significant level.

Watershed Program

Water quality in the Sacramento and San Joaquin Rivers would benefit from watershed activities that reduce hillslope and streambank erosion, which cause sediment loading and increased turbidity in watershed tributaries. Native vegetation could be used for bank and slope stabilization to protect ground surfaces from wind- and water-induced erosion. Road improvements and road deconstruction efforts could provide beneficial impacts by decreasing road-related erosion and reducing the potential for landslides on over-steepened slopes.

Potentially significant adverse impacts associated with upper watershed activities could include short-term soil erosion and increased sediment deposition during the construction of stream and watershed restoration projects or roadway improvements. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil. These impacts can be mitigated to a less-than-significant level. Long-term post-construction effects are expected to be beneficial. These effects include reducing human-induced sediment erosion and excess sedimentation in streams that currently are caused by timber harvesting, livestock grazing, road construction, and other land use activities. Most watershed restoration efforts would include a revegetation component to reduce erosion, stabilize hazardous slopes, and provide terrestrial or aquatic habitat.

Storage

Construction of storage facilities would result in potentially significant adverse impacts because of local ground disturbances and inundation, the extent of which would depend on the type and size of storage facilities enlarged or constructed, its water diversion and conveyance components, construction methods, and sites selected. Reservoir construction also would require construction of access roads and dams. Increased erosion could occur on areas cleared for storage facilities or access roads. Compaction of soil by heavy equipment during construction would temporarily affect the physical characteristics of the soil, including decreasing permeability and increasing runoff. Storage reservoirs could inundate agricultural soils, resulting in their permanent loss. This impact is addressed in Section 7.1.

Any expansion of existing storage facilities could potentially increase downstream stream erosion capabilities and change downstream geomorphologic characteristics. Reductions of stream bedload would be greatest during high-flow events. Off-stream storage sites would not directly affect in-stream sediment transport but may diminish flows in local stream channels due to their placement across minor drainages. Diversions of water to off-stream storage facilities potentially could adversely affect downstream geomorphology. This impact is expected to be less than significant as diversion schedules would be implemented that maintain the frequency, magnitude, and duration of flows necessary to maintain and restore downstream riparian habitat. Wind- and wave-generated erosion along the shoreline of the reservoir could cause a potentially significant impact by increasing bank erosion and sedimentation at the site. The potential for landslides in areas around a reservoir may be increased by saturation of adjacent geologic strata as the reservoir is filled. The significance of this impact cannot be determined at the programmatic level and will be addressed in future site-specific documents.

5.5.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For geology and soils resources, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

5.5.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

Under the Preferred Program Alternative, conveyance elements include constructing a screened intake on the Sacramento River, and modifying existing channels in the Delta. Significant impacts on geology and soils would include increased short-term soil erosion and soil compaction associated with construction activities. Construction-related impacts can be reduced to a less-than-significant level with mitigation strategies. Impacts caused by the land disposal of dredged material from channels in the Delta are considered potentially significant if disposal substantially disturbs or disrupts existing soils. This impact can be mitigated to a less-than-significant level.

Increased pumping of water out of the Delta could result in increased flows during some months. The magnitude of change in flow velocities would likely be negligible relative to existing flows and therefore would not adversely affect soil erosion or sediment transport processes. Consequently, the potential for increased erosion of channel and levee soils is considered less than significant.

Changes in project operations would not significantly affect geology and soils. Proposed flow changes would not be sufficiently large or prolonged to cause significant changes in fluvial geomorphologic processes in Delta channels. No resultant changes in land use practices would affect these resources from the proposed operational measures.

5.5.8.2 ALTERNATIVE 1

Effects on geology and soils under Alternative 1 would be similar to those described for the Preferred Program Alternative, except that no diversion facility would be constructed on the Sacramento River. Consequently, less construction-related geology and soils impacts are associated with Alternative 1 than with any other Program alternative.

5.5.8.3 ALTERNATIVE 2

Effects on geology and soils under Alternative 2 would be similar to those described for the Preferred Program Alternative. The primary difference between the two alternatives is the size of the diversion facility on the Sacramento River, should such a facility be deemed necessary under the Preferred Program Alternative. Because the diversion facility could be larger than that proposed under the Preferred Program Alternative, the construction-related impacts on geology and soils could be greater under Alternative 2 than under the Preferred Program Alternative or Alternative 1.

5.5.8.4 ALTERNATIVE 3

In addition to the Conveyance components listed for the Preferred Program Alternative, Alternative 3 includes the possibility of constructing an isolated facility. Because of the isolated facility, additional construction-related impacts on geology and soils would be greatest under Alternative 3.

5.5.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3 to existing conditions. This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions were the same impacts as those identified in Sections 5.5.7 and 5.5.8, which compare the Program alternatives to the No Action Alternative.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any additional potentially significant environmental con-sequences than were identified in the comparison of the Program alternatives to the No Action Alternative.

The following potentially significant environmental consequences are associated with the Preferred Program Alternative:

- Increased conversion of agricultural land soils for levee system construction and increased potential for erosion on outboard slope of levees.

- Potential for increases in local subsidence from potential increased reliance on groundwater use.

- Potential for increases in wind and soil erosion and soil salinity due to fallowed agricultural lands.

- Increased construction-related short-term soil erosion, and increased sediment deposition or soil compaction from heavy equipment.

- Potential changes to downstream geomorphology from enlarging existing storage facilities.
- Ground disturbance, inundation, and shoreline wind- and wave-generated erosion from new storage facilities.

No potentially significant unavoidable impacts on geology and soils are associated with the Preferred Program Alternative.

5.5.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For geology and soils resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's incremental contribution to cumulative impacts (and the ability to avoid, reduce, or mitigate those cumulative impacts) are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.5.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts. At the programmatic level, the analysis did not identify any impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level. Sections 5.5.7 and 5.5.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on soils and geology resources in the Delta, Bay, Sacramento River, and San Joaquin River Regions: American River Water Resource Investigation, American River Watershed Project, other CVPIA actions not yet fully implemented, Delta Wetlands Project, CCWD Multi-Purpose Pipeline Project, Delta Wetlands Project, ISDP, Montezuma Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento River Flood Control System Evaluation, Sacramento Water Forum process, EBMUD Supplemental Water Supply Project, Sacramento County municipal and industrial water supply contracts, urbanization, West Delta Water Management Program, and Sacramento River Conservation Area Program. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.5.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. The Preferred Program Alternative generally would maintain and enhance the long-term productivity of geology and soils resources but may cause adverse impacts on these resources from short-term uses of the environment.

Overall benefits to the long-term productivity of geology and soils resources would result from Program actions. Benefits resulting from reduced erosion, reduced soil salinity, and reduced soil subsidence generally would outweigh the short-term adverse impacts.

Most short-term impacts are related to construction and would cease when construction is complete. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts. The potentially significant long-term impacts on soils in the form of ground disturbance, inundation, and changes to downstream geomorphology from construction of storage facilities were identified in this impact analysis.

Irreversible and Irretrievable Commitments. The Storage and Conveyance elements in the Preferred Program Alternative can be considered to cause significant irreversible changes in geologic and soil conditions. Avoidance and mitigation measures could be implemented to lessen adverse effects, but changes would be experienced by future generations. The long-term beneficial irreversible changes include reduced soil erosion and salinity. The long-term adverse irreversible changes include ground disturbance, inundation, and changes to downstream geomorphology from construction of new storage facilities or enlargement of existing storage facilities. Storage and Conveyance elements could result in the irretrievable commitment of resources, such as construction materials, labor, energy resources, and land conversion.

5.5.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

The following mitigation strategies will be considered in future site-specific documents:

- Monitoring groundwater levels and subsidence in areas of increased reliance on groundwater resources and regulating withdrawal rates at levels below those that cause subsidence.

- Minimizing or avoiding direct groundwater transfers or groundwater substitution transfers from regions: (1) experiencing long-term overdraft, (2) where subsidence historically has occurred, or (3) where local extensometers indicate that subsidence rates are increasing.

- Protecting flooded Delta island inboard levee slopes against wind and wave erosion with vegetation, soil matting, or rock.

- Protecting exposed soils with mulches, geotextiles, and vegetative ground covers to the extent possible during and after project construction activities to minimize soil loss.

- Implementing erosion control measures and bank stabilization projects where needed. Measures can include grading the site to avoid acceleration and concentration of overland flows, using silt fences or hay bales to trap sediment, and revegetating areas with native riparian plants and wet meadow grasses.

- Increasing sediment deposition and providing substrate for new habitat by planting terrestrial and aquatic vegetation.

- Measuring channel morphology over time to monitor changes due to reoperation of SWP and CVP flows and implementing erosion control measures where needed.

- Re-using dredged materials to reduce or replace soil loss.

- Leaving crop stubble from previous growing season in place while fallowing and employing cultivation methods that will cause the least amount of disturbance to minimize erosion of surface soils.

- Limiting the salinity of replacement water, relative to local conditions, in water transfers.

- Ensuring that the volume of irrigation water used is sufficient to flush accumulated salts from the root zone.

- Operating new storage facilities to minimize sediment trapping and transport in rivers and tributaries.

- Retrofitting soil-comprised structures to seismic events with shock-absorbing devices and materials in areas of seismic vulnerability, wherever possible.

- Preparing and implementing best construction management plans.

- Preparing and implementing a water quality and soils monitoring program.

- Preparing and implementing construction mitigation plans.

- Preparing and implementing contingency plans for wetland and marshland restoration.

- Modifying storage facility operations to maintain the frequency, magnitude, and duration of flows necessary to maintain and restore downstream riparian habitat.

- Controlling boat traffic in order to reduce boat wakes to levels that will not cause levee or bank erosion.

- Monitoring water-level conditions on islands adjacent to in-Delta storage.

- Installing interception wells around in-Delta storage facility and operating to remove excess seepage.

- Lining conveyance for in-Delta storage to prevent seepage.

5.5.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

No potentially significant unavoidable impacts on geology and soils are associated with the Preferred Program Alternative.

5.6 Noise

The CALFED Bay-Delta Program is not expected to result in any long-term potentially significant adverse noise impacts. Potential long-term noise benefits could result from Program actions that increase open space by converting agricultural land to wildlife habitat.

5.6 Noise

5.6.1 SUMMARY

Sounds accentuate our everyday life, whether it's the steady hum of machinery or the buzz of bees in the garden. Our world of sound can be punctuated with bird song or the blare of a car radio passing by. Noise impacts are closely associated with land use and population density. In California, projected population growth can reasonably be expected to increase some types of noise levels, regardless of CALFED Bay-Delta Program (Program) activities. Overall, Program actions will not contribute substantially either beneficially or adversely to noise.

Preferred Program Alternative. Restoration projects, storage and conveyance projects, water quality actions, and levee system improvements could contribute to short-term construction-related potentially significant adverse noise impacts under the Preferred Program Alternative. These impacts can be mitigated to a less-than-significant level. Most noise-related impacts would occur in the Delta Region because more Program-related construction would take place in this area. Facility operation and maintenance activities could result in long-term potentially significant adverse noise impacts, but these impacts also can be mitigated to a less-than-significant level.

The Ecosystem Restoration and the Levee System Integrity Programs could result in long-term noise benefits from land conversion. For example, changes from cultivated agricultural land uses to riparian habitat could decrease the level of noise associated with farm machinery.

Alternatives 1, 2, and 3. Alternatives 1, 2, and 3 would result in similar benefits and potentially significant adverse impacts as those described for the Preferred Program Alternative. Alternatives 2 and 3 have greater potential for short-term impacts associated with construction noise because of larger-scale water conveyance projects possible under these alternatives.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Increased noise from heavy equipment operation during construction (1,4,5,6,7,8,9,10,11).

Increased noise from increases in traffic along major access and haul routes, and increased vehicle traffic associated with the construction labor force (2,3,4, 8,11).

Increased noise from diversion and storage facility operations, including spillways, pumps, generating plants, and switchyards (1,4,5,6,9,10).

Increased noise from automobile or boat traffic associated with recreational use at enlarged reservoirs (10).

Increased traffic noise from permanently relocated roadways (10, 12).

Mitigation Strategies

1. Using electrically powered equipment instead of internal combustion equipment where feasible.
2. Locating staging and stockpile areas, and supply and construction vehicle routes as far away from sensitive receptors as possible.
3. Establishing and enforcing construction site and haul road speed limits.
4. Restricting the use of bells, whistles, alarms, and horns to safety warning purposes.
5. Designing equipment to conform with local noise standards.
6. Locating equipment as far from sensitive receptors as possible.
7. Equipping all construction vehicles and equipment with appropriate mufflers and air inlet silencers.
8. Restricting hours of construction to periods permitted by local ordinances.
9. Locating noisy equipment within suitable sound-absorbing enclosures.
10. Erecting sound wall barriers or noise attenuation berms between noise generation sources and sensitive receptors.
11. Scheduling construction activities to avoid breeding seasons of sensitive species and peak recreation use.
12. Locating redirected roadways as far from sensitive receptors as possible.

No potentially significant unavoidable noise impacts are associated with the Preferred Program Alternative.

5.6.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. According to this definition, no areas of controversy relate to noise. In addition, no areas of concern are associated with noise.

5.6.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

5.6.3.1 ALL REGIONS

Historically, the noise character of the five Program regions and the upper watershed areas was dominated by sounds from natural sources. Beginning in the 1850s, the advent of mining, timber harvesting, and other human activities brought higher noise levels associated with these uses. The development of new highways, water resources, and residential communities added construction, vehicular, and urban noises.

Noise level measurements are expressed in units called "decibels" and are related to human perception of loudness on a scale called "dBA." Another measurement, L_{dn} (day-night sound level), is the average sound level for a 24-hour period. L_{dn} is usually expressed in dBA. The noise planning standards and the noise level control ordinances in the communities within the five Program regions are fairly uniform, typically ranging within 5 dBA for a similar land use category. Land use categories throughout the Program study area range from undeveloped rural land to densely developed urban land. The noise levels associated with the range of land uses occurring in the Program area, in turn, range from quiet to very noisy.

Based on the results of environmental noise studies conducted in the United States and in the study area, planners and decision makers generally accept that a consistent and direct relationship exists between population density and the associated noise level environment. The more rural and less populated (and less developed) areas in the study area typically have lower noise levels (measured in dBA L_{dn}) than the more urban and densely populated (and more developed) areas. Table 5.6.-1 presents this relationship between population density and associated noise levels in the study area.

Table 5.6-1. Relationship Between Population Density and Average Day-Night Noise Levels

LOCATION	PERSONS/SQ. KM	L_{dn} (dBA)
Rural		
Undeveloped	8	35
Partially developed	23	40
Suburban		
Quiet	77	45
Normal	230	50
Urban		
Normal	770	55
Noisy	2,300	60
Very noisy	7,700	65

Source:
National Research Council, USA.

It was assumed for this analysis that the affected environment includes the range of population density and land use categories presented in Table 5.6-1, plus potentially noisier land uses, such as industrial and commercial, and areas adjacent to transportation corridors and airports.

5.6.4 ASSESSMENT METHODS

For this analysis, the primary sources of project-related noise were assumed to be construction and operations activities. Because construction-related impacts would occur only during the construction period, they are considered direct and short-term impacts. Typical sources of construction-related noise would include the following:

- Heavy equipment operation.
- Blasting operations at fill material quarry sites.
- Truck traffic along major access and haul routes associated with hauling fill and spoil material.
- Vehicle traffic associated with the construction labor force.

Facility operation and maintenance activities also would become noise sources. Because operations-related impacts would continue throughout the operation of the Program, these impacts are considered indirect and long term. Localized increases in noise levels would occur at spillways, pumping generation plants, and switchyards. Traffic and boating activities associated with recreational use of enlarged reservoirs could generate additional noise.

The specific locations of potential new facilities and the associated site-specific noise generation characteristics for each alternative are not yet known. Therefore, the following assumptions about the noise-generating potential of the alternatives were made:

- Standardized levels of construction and operations would occur for each alternative.

- The proximity of people and sensitive receptors to proposed sources of noise would be equal for all alternatives.

- The density of population or sensitive receptors in the area of potential effect would be equal for all alternatives.

For this analysis, the evaluation of potential noise effects from the alternatives primarily is concerned with the amount of construction activities and the extent and type of facilities likely to be constructed and operated for each alternative and Program element.

5.6.5 SIGNIFICANCE CRITERIA

Potential noise-related impacts are considered significant if the construction or operations of facilities associated with a particular implementation alternative or Program element would cause a substantial increase in the existing (ambient) noise conditions in the affected area. Average day-night noise levels for rural, suburban, and urban locations are shown in Table 5.6-1.

5.6.6 NO ACTION ALTERNATIVE

Under the No Action Alternative, expected and potential noise sources would continue as at present. Trends in population growth could increase some levels of noise in some areas, but substantial changes are not anticipated.

5.6.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For noise impacts, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs, and the Storage element are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 5.6.8.

5.6.7.1 DELTA REGION

Ecosystem Restoration Program

Construction-related noise is associated with restoration projects. In most cases, the noise would be short term, and impacts generally are considered less than significant. However, construction could result in significant adverse impacts on residents, recreation users, and sensitive wildlife species, depending on where specific projects are constructed. These impacts will be identified in project-specific analysis and can be mitigated to a less-than-significant level.

Installing new fish screens at certain diversions in the Delta Region could be accompanied by construction-related noise. Wetlands development and other habitat restoration efforts would involve activities that could cause construction-related noise. Potentially significant noise impacts would be direct and short term, and can be mitigated to a less-than-significant level. Agricultural-related noise would decrease when land use was converted for habitat, resulting in a potential noise benefit.

Water Quality, Water Transfer, and Watershed Programs

The Water Quality, Water Transfer, and Watershed Programs are not expected to affect existing noise levels in the Delta Region.

Levee System Integrity Program

Land conversion to create buffer areas associated with improved levees and flood control operations in the Delta Region could result in decreased agricultural operations-related noise impacts; however, in the short term, construction activities would increase noise levels. Improving existing levee systems and constructing new levees, as well as dredging, would result in potentially significant construction-related noise impacts. These construc-tion-related noise impacts are direct but short term and can be mitigated to a less-than-significant level.

Water Use Efficiency Program

Both beneficial and significant adverse noise impacts could result from modifying existing filtration plants; developing new pipelines, well fields, and pump stations; and increasing or decreasing pumping. These impacts are associated with construction- and operations-related activities in agricultural and urban environments. Potentially significant adverse noise impacts can be mitigated to a less-than-significant level.

Storage

Construction- and operations-related noise impacts are associated with storage. Construction-related noise levels that exceed local noise standards would last for short, intermittent periods and, in most cases, would be located at a sufficient distance from sensitive receptors to avoid potentially significant impacts. Water diversion facilities and storage conveyance systems could result in operations-related noise impacts through the use of pumps or other mechanical equipment. These potentially significant adverse impacts can be mitigated to a less-than-significant level.

5.6.7.2 BAY REGION

Ecosystem Restoration and Levee System Integrity Programs

Noise impacts in the Bay Region associated with the Ecosystem Restoration Program would be similar to those described for the Delta Region.

Noise levels would increase in the Suisun Marsh while levee rehabilitation is taking place; however, no long-term changes in noise levels are anticipated.

Water Quality, Water Use Efficiency, and Water Transfer Programs, and Storage

The Water Quality, Water Use Efficiency, and Water Transfer Programs, and Storage are not expected to increase noise levels in the Bay Region.

Watershed Program

Construction associated with Watershed Program activities in the Bay Region could generate noise. Noise impacts would be short term and generally are considered less than significant. However, construction activities could result in significant impacts on residents, recreation users, and sensitive wildlife species, depending on where specific projects are constructed. These impacts will be identified in project-specific analysis and can be mitigated to a less-than-significant level.

5.6.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration and Watershed Programs

Noise impacts in the Sacramento River and San Joaquin River Regions associated with the Ecosystem Restoration and Watershed Programs would be similar to those described for the Delta Region.

Water Quality Program

Land conversion activities intended to reduce drainage-related pollution in the San Joaquin River Region could result in decreased agricultural operations-related noise. Revegetation of agricultural lands could reduce the level of noise, as less farm equipment would be operated on the land—such as tractors, pumps, and harvesters.

Activities to improve existing and to construct new filtration and treatment facilities could result in both construction- and operations-related noise impacts. Short- and long-term noise impacts can be mitigated to a less-than-significant level.

Levee System Integrity, Water Use Efficiency, and Water Transfer Programs

The Levee System Integrity, Water Use Efficiency, and Water Transfer Programs are not expected to increase noise levels in the Sacramento River or San Joaquin River Region.

Storage

The noise impacts in the Sacramento River and San Joaquin River Regions associated with the Storage element would be similar to those described for the Delta Region.

5.6.7.4 OTHER SWP AND CVP SERVICE AREAS

Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs, and Storage

None of these Program elements are expected to affect noise levels in the Other SWP and CVP Service Areas.

5.6.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For noise impacts, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

5.6.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

Construction- and operations-related noise impacts are associated with the Conveyance element. Construction-related noise levels that exceed local noise standards would last for short, intermittent periods and, in most cases, would be located at a sufficient distance from sensitive receptors to avoid potentially significant adverse impacts. New pumps in conveyance systems could result in significant operations-related noise impacts that can be mitigated to a less-than-significant level.

Construction of the diversion facility on the Sacramento River could require the permanent relocation of roadways, which could result in significant long-term adverse noise impacts. These impacts can be mitigated to a less-than-significant level.

5.6.8.2 ALTERNATIVE 1

Alternative 1 includes fewer conveyance facilities than the Preferred Program Alternative; therefore, the magnitude of noise impacts would be less. Although fewer conveyance facilities are included in this alternative, noise associated with conveyance system pumps could result in significant operations-related noise impacts.

5.6.8.3 ALTERNATIVE 2

Noise impacts associated with Alternative 2 would be similar to those described for the Preferred Program Alternative if a diversion facility is built, although the magnitude may be greater given the difference in size of the diversion facility.

5.6.8.4 ALTERNATIVE 3

Alternative 3 includes an isolated facility. Consequently, the level of direct, short-term, construction-related and indirect, long-term, operations-related noise impacts is potentially greater than for all the other alternatives.

5.6.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of existing conditions to the Preferred Program Alternative and Alternatives 1, 2, and 3. This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions are essentially the same impacts as those identified in Sections 5.6.7 and 5.6.8, which compare Program alternatives to the No Action Alternative.

The analysis indicates an increase in noise levels for any Program alternative when compared to existing conditions. As population levels would not increase under the existing conditions scenario, noise impacts for all Program alternatives would be greater when compared to existing conditions instead of the No Action Alternative. However, at the programmatic level, these differences are not significant.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any potentially significant environmental consequences other than those identified in the comparison of Program alternatives to the No Action Alternative.

Program benefits include reductions in noise attributed to land use conversion. Changes in land use from existing cultivated agricultural land uses to riparian habitat, for example, would reduce noise associated with farm machinery.

The following potentially significant adverse noise impacts are associated with the Preferred Program Alternative:

- Increased noise from heavy equipment operation during construction.
- Increased noise from increases in traffic along major access and haul routes, and increased vehicle traffic associated with the construction labor force.
- Increased noise from facility operation of spillways, pumping generating plants, and switchyards.
- Increased noise from automobile or boat traffic associated with recreational use at enlarged reservoirs.
- Increased traffic noise from permanently relocated roadways.

Impacts can be reduced to a less-than-significant level with mitigation strategies. No potentially significant unavoidable noise impacts are associated with the Preferred Program Alternative.

5.6.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For noise, the analysis and conclusions regarding the significance of the Preferred Program Alternative's incremental contribution to cumulative impacts (and the ability to avoid, reduce, or mitigate those cumulative impacts) are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.6.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts. At the programmatic level, the analysis did not identify any impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level. Sections 5.6.7 and 5.6.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on noise in the Delta, Sacramento River, and San Joaquin River Regions: American River Water Resources Investigation, American River Watershed Project, CVPIA actions not yet fully implemented, CCWD Multi-Purpose Pipeline Project, Delta Wetlands Project, ISDP, Montezuma Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento River Flood Control System Project, Sacramento Water Forum Process, EBMUD Supplemental Water Supply Project, Sacramento County Municipal and Industrial Water Supply Contracts, West Delta Water Management Program, and urbanization. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.6.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. The Preferred Program Alternative would cause no long-term increase in noise levels but may cause potentially significant adverse noise impacts from short-term uses of the environment. Most short-term impacts would be construction related and would cease when construction is complete. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen noise impacts.

Potential long-term noise benefits could result from Program actions that increase open space by converting agricultural land to wildlife habitat.

Irreversible and Irretrievable Commitments. No irreversible or irretrievable commitments of resources related to noise impacts are associated with the Preferred Program Alternative.

5.6.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

Mitigation strategies have been identified that can be used to avoid or minimize construction- and operations-related noise impacts. Additional site-specific mitigation measures could be developed to further minimize potential noise impacts when locations for specific facilities are identified.

Measures to avoid impacts include:

- Using electrically powered equipment instead of internal combustion equipment where feasible.
- Locating staging and stockpile areas, and supply and construction vehicle routes as far away from sensitive receptors as possible.
- Establishing and enforcing construction site and haul road speed limits.
- Restricting the use of bells, whistles, alarms, and horns to safety warning purposes.
- Designing equipment to conform with local noise standards.
- Locating equipment as far from sensitive receptors as possible.

Measures to minimize impacts include:

- Equipping all construction vehicles and equipment with appropriate mufflers and air inlet silencers.
- Restricting hours of construction to periods permitted by local ordinances.
- Locating noisy equipment within suitable sound-absorbing enclosures.
- Erecting sound wall barriers or noise attenuation berms between noise generation sources and sensitive receptors.
- Scheduling construction activities to avoid breeding seasons of sensitive species and peak recreation use.
- Locating redirected roadways as far from sensitive receptors as possible.

5.6.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

No potentially significant unavoidable noise impacts are associated with the Preferred Program Alternative.

5.7 Transportation

The CALFED Bay-Delta Program would result in short-term traffic and railway disruptions due to road closings and traffic diversions. Long-term transportation benefits could include road improvements and rerouting traffic to improve flow.

5.7 Transportation

5.7.1 SUMMARY

Transportation plays a vital role in the functioning of society by providing for the mobility of people and goods. Transportation systems enable people to access job markets and participate in recreational, cultural, educational, and social activities. Transportation substantially affects the economy, both as a consumer of resources and a supplier of jobs.

The CALFED Bay-Delta Program (Program) study area is served by a complex system of roads, highways, freeways, and rail lines. New roadway networks have facilitated growth and urbanization along their corridors. Commercial shipping routes originate at the Golden Gate and traverse the San Francisco, San Pablo, and Suisun Bays. These routes continue to commercial and industrial ports in the Delta waterways. An extensive system of commercial ports also extends from San Luis Obispo to San Diego within the Program's geographic area.

Preferred Program Alternative. Program elements would not alter or modify any existing commercial shipping routes or commercial ports in any Program region.

The Preferred Program Alternative could involve relocating highways, constructing new bridges, and replacing or relocating local roads. During construction of bridges or road segments, traffic may be temporarily detoured. If detour locations are nearby, easily accessed, and adequate for the traffic demand, impacts on traffic likely would be minimal. If detours are extensive during the construction period, some impact on existing traffic volumes could occur from the rerouted traffic. Some roads could be improved or permanently rerouted, diverting traffic from or attracting traffic to established routes. New storage could provide additional recreation resources, which could result in an increase in local traffic flows. These impacts are considered significant, but mitigation is available to reduce impacts to a less-than-significant level.

Construction activities associated with the Levee System Integrity Program would directly affect only the Delta Region. Construction activities could affect traffic if roads along or adjacent to the levees were temporarily closed, requiring traffic to be detoured. A significant unavoidable impact could occur if a road was closed permanently, causing traffic volume to shift to an alternate route.

Alternatives 1, 2, and 3. Impacts under Alternatives 1, 2, and 3 would be similar to those described for the Preferred Program Alternative. Alternative 3 has the greatest potential for construction-related impacts on transportation because of its larger-scale conveyance features. Alternative 1, conversely, has the least potential for construction-related impacts on transportation because it involves fewer conveyance facilities.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses. See the text in this chapter for more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Increasing local traffic flows as the public accesses recreational resources at new storage facilities (3)

Changing traffic flows as roads are temporarily rerouted around construction sites (1,3).

Relocating or permanently closing roads (3).

Detouring traffic as new roadways and railroad bridges are constructed around storage facility construction (1,2).

Adding construction vehicles to existing traffic levels, especially on narrow, two-lane local roads with winding routes (4).

Closing two-lane roads to one lane in order to facilitate roadway improvements or relocations in association with the Watershed Program (1,4).

Impeding or blocking patrol or rescue boats in Delta sloughs where fish barriers and flow control structures are installed (5).

Creating safety conflicts by operating large, slow-moving, dredging equipment on Delta waterways (6).

Mitigation Strategies

1. Providing convenient and parallel detours to routes closed during construction.
2. Allowing trains to use existing tracks while bridges are being built.
3. Encouraging use of public transportation and carpooling for construction workers.
4. Clearly marking roadway intersections with warnings where visibility is poor in the project vicinity.
5. Providing boat portage or a stationary jib crane, relocating boat launch facilities, or relocating emergency access roads.
6. Requiring contractors to use appropriate state and federal safety protocols.

Bold indicates a potentially significant unavoidable impact.

5.7.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. According to this definition, no areas of controversy are related to transportation.

5.7.3 AFFECTED ENVIRONMENT/ EXISTING CONDITIONS

5.7.3.1 DELTA REGION

The Delta Region is serviced by several major freeways. I-5 and State Route 99 (SR 99) run north-south through the region. I-80 and U.S. 50 run east-west through Sacramento. Other minor highways run from Sacramento and Stockton to small cities and towns in the region. New roadway networks have facilitated growth and urbanization along their corridors and within parts of the upper watershed areas of each Program region.

Local roads in the Delta are often narrow with winding routes and can be hazardous to the unwary traveler. Traffic occasionally includes slow, over-sized farm equipment, which also poses safety problems.

The rail lines servicing the Delta Region are the Southern Pacific; Western Pacific; and Atchison, Topeka and Santa Fe (ATSF) lines. These lines run from Sacramento to Stockton, with the Southern Pacific line extending from these major cities to other smaller cities in the Delta Region.

Commercial shipping routes originating at the Golden Gate traverse the San Francisco Bay, San Pablo Bay, Suisun Bay, and Delta waterways, continuing to commercial and industrial ports. In the Delta Region, commercial and industrial ports are situated along rivers. Two ports are located along the Sacramento River between Sacramento and Walnut Grove. Another commercial port is at Isleton, also along the Sacramento River. An additional commercial port is near Terminous, on the Little Potato Slough; and two ports are adjacent to one another—on the Old River and Middle River, northeast of Brentwood. Finally, a commercial port, the Port of Stockton, is located in Stockton on the San Joaquin River.

5.7.3.2 BAY REGION

The Bay Region is served by numerous interstate and U.S. freeways. On the west side of the San Francisco Bay, I-280 and U.S. 101 run north-south. U.S. 101 continues north of San Francisco into Marin County. I-880 and I-680 run north-south on the east side of the Bay. I-80 starts in San Francisco, crosses the Bay Bridge, and runs northeast toward Sacramento. SR 92 and SR 84, both highways that allow at-grade crossings, in certain parts of the region become freeways that run east-west and cross the Bay. I-580 starts in San Leandro on the east side of the Bay and runs eastward toward Livermore.

Southern Pacific is the predominant rail line in the Bay Region; however, minor spurs of the Western Pacific and ATSF lines also are present.

The leading ports of California include the complex of harbors in San Francisco Bay. The presence of these natural harbors led to the growth of San Francisco. Numerous commercial ports are located along the northeastern and eastern bayshores of San Francisco, and also at Treasure and Yerba Buena Islands. Shipping routes extend southward into San Francisco Bay, where commercial ports are located along the peninsula in South San Francisco and San Carlos. On the east side of San Francisco Bay, commercial ports are found in Alameda and Oakland. Shipping routes that head north into San Pablo Bay have ports at San Rafael and along the bayshores of Richmond, San Pablo, Hercules, Rodeo, Vallejo, and Mare Island. The shipping route continues through the Carquinez Strait and into Suisun Bay, with ports at Crockett, Martinez, Port Chicago, Pittsburg, and Antioch.

5.7.3.3 SACRAMENTO RIVER REGION

SR 45 follows the Sacramento River north from Sacramento. I-5 parallels SR 45 and the Sacramento River to the west and passes through Redding. SR 99 and SR 70, portions of which are expressway, also run north-south from Sacramento northward toward Chico.

The upper watershed areas west and east of the Sacramento Valley contain a network of state freeways. Major routes on the west side of the valley include SR 29, which runs north-south through Napa and Lake Counties; and several east-west freeways, including SR 20 in Lake County, SR 162 in Glenn County, and SR 36 in Tehama and Trinity Counties. SR 299, also an east-west route, traverses Trinity, Shasta, Lassen, and Modoc Counties in the northern watershed areas. Major east-west routes on the east side of the valley include SRs 70, 49, and 88; U.S. 50; and I-80.

Southern Pacific is the main rail line serving the Sacramento River Region, roughly following the I-5 route. Western Pacific has lines in this area, traveling farther east through Marysville and Oroville. Western Pacific also provides rail service in the upper watershed areas east of the Sacramento Valley through Plumas and Lassen Counties.

A deep water ship channel runs from Cache Slough in the Delta Region to the City of West Sacramento, where the Port of Sacramento is located.

5.7.3.4 SAN JOAQUIN RIVER REGION

I-5 and SR 99 are the two major freeways that run north-south from Stockton through the Central Valley to Bakersfield. SR 41 runs in a north-south direction south of Fresno. Other minor highways connect smaller cities and towns in the Central Valley with the two interstate freeways and SR 152, an expressway that runs east-west and connects Los Banos and Chowchilla.

Several east-west routes traverse areas in the upper watershed on the east side of the San Joaquin Valley, including SR 180 that terminates in Yosemite National Park, SR 168 in Fresno County, and SR 190 and SR 198 in Tulare County.

The San Joaquin River Region is served mainly by the Southern Pacific and ATSF lines, which roughly follow the route of I-5 through the San Joaquin Valley.

No commercial ports or shipping routes are located in this region.

5.7.3.5 OTHER SWP AND CVP SERVICE AREAS

The Other SWP and CVP Service Areas region includes two distinct, noncontiguous areas: in the north, are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

Numerous freeways and expressways serve the southern portion. U.S. 101 travels north and south near the coast from San Luis Obispo south to Los Angeles. I-5 travels north and south through the Central Valley to Los Angeles and on to San Diego. An extensive and intricate freeway system serves the Los Angeles area. I-10 runs east from Los Angeles toward Arizona, while I-8 runs east-west from San Diego to Arizona.

The Southern Pacific line runs north and south near the coast, from the Bay Area through Los Angeles, then southeast toward the Arizona-Mexico border.

The Los Angeles-Long Beach installation on San Pedro Bay is one of the leading ports of California. The growth of Los Angeles led to the creation of its artificial harbors. Other harbors in this area serving commercial shipping are at San Luis Obispo, Santa Barbara, Carpinteria, Port Hueneme, El Segundo, Los Angeles, Long Beach, and San Diego.

5.7.4 ASSESSMENT METHODS

Features of each Program action were reviewed to determine whether any roads, rail lines, or shipping routes would be modified or relocated. Any feature that would change existing conditions was considered a potential impact. Construction-related impacts would occur only during the period of construction and are considered direct short-term impacts. Operations-related impacts would continue throughout the operation of the Program and are considered indirect long-term impacts.

Most transportation-related impacts are linked to construction activities for restoration actions, levee improvements, and storage and conveyance facilities. Few operations-related impacts are anticipated for transportation resources; however, long-term impacts could result from roads improved or rerouted during construction of storage and conveyance facilities and from such features as flow control barriers.

5.7.5 SIGNIFICANCE CRITERIA

The significance of impacts was based primarily on the extent to which activities would change the flow of existing traffic or the volume of traffic on an existing route. Significance of impacts also relates to actions that could affect existing railroad tracks, commercial shipping routes, or ports. Any of the following changes that result from Program actions are considered potentially significant impacts:

- Changes to traffic flows or patterns.
- Attraction to or diversion from an existing route of substantial traffic volumes.
- Changes to a railway route by a major relocation of railroad tracks.
- Changes to commercial shipping routes or ports.
- Creation of a substantial hazard to navigation or a substantial change to the ease of navigation.

5.7.6 NO ACTION ALTERNATIVE

Under the No Action Alternative, no major changes to the existing railway system and commercial shipping routes are likely for any Program region. Traffic flows or patterns in each region could change as outlined below.

5.7.6.1 DELTA AND BAY REGIONS

Existing trends in highway traffic patterns in the Delta and Bay Regions are expected to continue. The Delta Region has experienced considerable growth over the last several years, as people seeking affordable housing move to the area. Because many of these people work in the Bay Region, traffic on the major freeways and highways has increased—directly affecting highway traffic in both regions.

The Bay Region is one of the most populated regions in the study area. Numerous freeways and highways serve the traffic demands of the region. Growth in the area is continuing, as is the traffic demand for the existing roadway system. The anticipated continued increase in traffic volumes on the existing roadways most likely would exacerbate existing highway traffic.

5.7.6.2 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Highway traffic in the Sacramento metropolitan area is heavily congested. The area is expected to continue to experience growth, resulting in continued impacts on traffic. North of the Sacramento urbanized area, however, the major freeways and highways are not heavily congested. Impacts on traffic in the future are unlikely, as this area is not projected for heavy growth.

Areas of the Central Valley that are near urban centers experience fairly heavy highway traffic congestion. Growth near these urban centers is expected to continue, which would further increase impacts.

5.7.6.3 OTHER SWP AND CVP SERVICE AREAS

The Other SWP and CVP Service Areas include San Luis Obispo, Santa Barbara, Ventura, eastern Kern, Los Angeles, Orange, San Bernardino, Riverside, and San Diego Counties—some of the most populated regions in the study area. Numerous freeways and highways serve these counties. Growth in the area is continuing, and so is the traffic demand for the existing roadway system. Continued increases in traffic volumes and associated impacts are anticipated.

The portion of the region served by the CVP's San Felipe Division is not as heavily populated as other portions of the region but is experiencing growth, particularly in the San Jose area.

5.7.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For transportation, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs and the Storage element are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 5.7.8.

No Program alternative would alter or modify any existing commercial shipping routes or commercial ports in any Program region.

5.7.7.1 DELTA REGION

Ecosystem Restoration Program

Potential restoration activities associated with the Ecosystem Restoration Program, such as wetland development or habitat development on levees, could result in local, short-term, potentially significant adverse impacts on transportation. These impacts can be mitigated to less-than-significant levels.

Water Quality, Water Use Efficiency, Water Transfer, and Watershed Programs

The Water Quality, Water Use Efficiency, Water Transfer, and Watershed Programs would not affect transportation in the Delta Region.

Levee System Integrity Program

Roads that are on or near levees being improved could be affected by levee construction work, and traffic would need to be detoured during construction. This potentially significant adverse impact can be mitigated to a less-than-significant level. A significant unavoidable adverse impact could occur if a road was closed or permanently relocated, causing traffic to find an alternate route and increasing the traffic volume and congestion on the new route.

Storage

New storage facilities and associated water diversion and conveyance components could require constructing new roadway and railroad bridges, and relocating some local roads. Construction activities could include constructing a bridge for the ATSF Railroad. If the bridge construction takes place on the current rail line, it would be necessary to temporarily divert train traffic or alter train schedules. This impact is considered potentially significant, but mitigation is available to reduce the impact to a less-than-significant level.

New storage could provide additional recreation resources, which could result in an increase in local traffic flows. This impacts is considered potentially significant, but mitigation is available to reduce the impact to a less-than-significant level.

Possible road relocations and new bridges could involve the long-term rerouting of traffic. Localized highway traffic impacts could occur if the use of the new roads and bridges directs travel through already congested areas. Mitigation exists to reduce this potentially significant impact to a less-than-significant level. Highway traffic may be temporarily detoured during construction of bridges or road segments. Detours also may be necessary if facilities intersect with roadways. If detour locations are nearby, easily accessed, and adequate for the traffic demand, impacts on traffic likely would be less than significant. If a road was closed and no nearby detour was available, traffic would be rerouted altogether. This impact is considered potentially significant and unavoidable.

Dredging operations, spoils disposal, and construction of setback levees could substantially affect transportation. Dredging activities could create additional safety conflicts on Delta roadways and waterways. The addition of construction vehicles to existing roadway traffic levels could affect vehicle safety in areas where congestion already exists or on narrow, two-lane local roads with winding routes. The operation of large, slow-moving dredging equipment on Delta waterways could create safety conflicts for recreational boaters and commercial or rescue craft. Mitigation is available to reduce these potentially significant impacts to a less-than-significant level.

Potential operations-related beneficial impacts on highway transportation could occur if roads are improved during construction of facilities or if traffic is rerouted in a manner that improves the flow of traffic. Potential adverse operations-related transportation impacts are expected to be less than significant.

Fish barriers and flow control structures could interfere with emergency response efforts by impeding or blocking patrol or rescue boats. This potentially significant adverse impact can be mitigated to a less-than-significant level.

5.7.7.2 Bay Region

No direct construction-related impacts on transportation facilities would occur in the Bay Region because no roads, railways, or commercial shipping routes would be modified.

5.7.7.3 Sacramento River and San Joaquin River Regions

Ecosystem Restoration Program

Restoration activities, such as those planned for the Sacramento River and San Joaquin River Regions, could result in localized impacts on traffic flows during construction. The short-term, potentially significant impacts on transportation that are associated with these activities can be mitigated to a less-than-significant level.

Water Quality, Levee System Integrity, Water Use Efficiency, and Water Transfer Programs

The Water Quality, Levee System Integrity, Water Use Efficiency, and Water Transfer Programs are not expected to affect transportation in the Sacramento River or San Joaquin River Region.

Watershed Program

Highway traffic volumes in the upper watershed areas of the Sacramento River and San Joaquin River Regions, away from the metropolitan areas, are expected to grow, along with regional traffic and population. Road improvements and deconstruction of roads in upper watershed areas could result in construction impacts on transportation. Improvements may include road widening, regrading, or paving to minimize sediment erosion. Traffic may be diverted during construction. Impacts on traffic would not be considered potentially significant if detour locations are convenient to the existing traffic demand. If alternative routes are not available, the affected route could be closed to one traffic lane during construction. This potentially significant adverse impact can be mitigated to a less-than-significant level.

Storage

Reservoir projects would generate additional vehicular traffic on roadways serving project sites during the multi-year construction period. Construction-related traffic would include equipment and supply deliveries, concrete trucks, service vehicles, and construction worker transportation. Increased construction traffic would cause some delays but probably would not preclude the use of county roads. Delays and disruptions would be temporary but are considered potentially significant adverse impacts that can be mitigated to a less-than-significant level. Project construction also could result in significant safety conflicts on roadways by adding construction vehicles and equipment to existing roadway traffic levels. This impact is considered significant but can be mitigated to a less-than-significant level.

New storage could provide additional recreation resources, which could result in an increase in local traffic flows. This impact is considered potentially significant, but mitigation is available to reduce the impact to a less-than-significant level.

During reservoir and facility construction, some roads may require improvement or relocation, and traffic diversion may be required. Detours also may be necessary when facilities intersect with roadways. Impacts could be minimal if detour locations are convenient to the existing traffic route; however, travel time could increase and cause some delay. If detours substantially affect traffic flows, a portion of the existing traffic could choose an alternate route, further affecting traffic volumes. This impact is considered potentially significant; mitigation is available to reduce the impact to a less-than-significant level.

Operations-related transportation impacts are expected to be less than significant.

No impacts on railways or commercial shipping routes would occur in the Sacramento River or San Joaquin River Region.

5.7.7.4 OTHER SWP AND CVP SERVICE AREAS

No direct or construction-related impacts on transportation facilities would occur in the Other SWP and CVP Service Areas because no roads, railways, or commercial shipping routes would be modified in the region.

5.7.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For transportation, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

Because conveyance facilities would be constructed only in the Delta Region, impacts on transportation associated with the Conveyance element are not anticipated for the other Program regions. The discussions below relate only to the Delta Region.

5.7.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

Constructing a diversion facility on the Sacramento River could involve relocating several miles of local roads, relocating highways, and constructing new bridges. Several bridges may need to be constructed over the conveyance facility. Traffic would need to be detoured during construction and relocation. The magnitude of the impact would depend on the location and length of time of the detours. These potentially significant adverse impacts can be mitigated to a less-than-significant level.

Fish barriers and flow control structures at Old River near Tracy could cause potentially significant adverse impacts on transportation by impeding or blocking patrol or rescue boats. Mitigation is available to reduce the potentially significant impact to a less-than-significant level.

5.7.8.2 ALTERNATIVE 1

Transportation impacts under Alternative 1 would be similar to those described for the Preferred Program Alternative, without those impacts associated with the diversion facility and enlargement of the Mokelumne River Channel.

5.7.8.3 ALTERNATIVE 2

The impacts on transportation for Alternative 2 would be similar to those described for the Preferred Program Alternative if a diversion facility on the Sacramento River is built, although the magnitude may be greater given the difference in size of the diversion facility.

5.7.8.4 ALTERNATIVE 3

Alternative 3 involves an isolated facility. Consequently, the level of direct, short-term, construction-related impacts on transportation is potentially greater than for all the other Program alternatives.

5.7.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3 to existing conditions. This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions were the same impacts as those identified in Sections 5.7.7 and 5.7.8, which compare the Program alternatives to the No Action Alternative.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any additional potentially significant environmental consequences than were identified in the comparison of Program alternatives to the No Action Alternative.

Long-term benefits to transportation could include road improvements and rerouting traffic to improve flow.

The following potentially significant transportation impacts are associated with the Preferred Program Alternative:

- Increasing local traffic flows as the public accesses recreational resources at new storage facilities.
- Changing traffic flows as roads are temporarily rerouted around construction sites.
- **Relocating or permanently closing roads.**
- Detouring traffic as new roadways and railroad bridges are constructed around storage facility construction.
- Adding construction vehicles to existing traffic levels, especially on narrow, two-lane roads with winding routes.
- Closing two-lane roads to one lane in order to facilitate roadway improvements or relocations in association with the Watershed Program.
- Impeding or blocking patrol or rescue boats in Delta sloughs where fish barriers and flow control structures are installed.
- Creating safety conflicts by operating large, slow- moving, dredging equipment on Delta waterways.

Bold indicates a potentially significant unavoidable impact.

5.7.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. If identified in the analysis, this section also presents any potentially significant adverse cumulative impacts that remain unavoidable regardless of efforts to avoid, reduce, or mitigate them. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For transportation resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.7.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts. At the programmatic level of analysis, the impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level are noted on the list in **bold type**. Sections 5.7.7 and 5.7.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on transportation resources in the Delta, Sacramento River, and San Joaquin River Regions: American River Watershed Project, American River Water Resource Investigation, CCWD Multi-Purpose Pipeline Project, Delta Wetlands Project, ISDP, Pardee Reservoir Enlargement Project, Sacramento River Flood Control System Evaluation, EBMUD Supplemental Water Supply Project, West Delta Water Management Program, and urbanization. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.7.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level—with the exception of relocating or permanently closing roads that is associated with facility construction in the Delta, Sacramento River, and San Joaquin River Regions. At the programmatic level, it is not anticipated that the CALFED Program's contribution to this cumulative impact can be avoided, reduced, or mitigated to a less than cumulatively considerable level. Therefore, this analysis concludes that this impact is cumulatively significant and unavoidable. This conclusion is based on currently available information and the high level of uncertainty as to whether this impact can be avoided, mitigated, or reduced to a level that is less than cumulatively considerable.

Growth-Inducing Impacts. No impacts are anticipated. See the See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. Most short-term uses of the environment relate to construction and would cease when construction is complete. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on transportation.

Some impacts on long-term productivity would be associated with new or relocated roads around existing reservoirs that would be enlarged. These transportation impacts were identified as potentially significant and unavoidable in the impact analysis.

Irreversible and Irretrievable Commitments. Long-term beneficial irreversible changes include accessibility to newly created wildlife or recreation areas developed under the Preferred Program Alternative. Long-term adverse irreversible changes include displacement of roads.

Construction of storage and conveyance features could result in the irretrievable commitment of resources, such as construction materials, labor, energy resources, and land conversion.

5.7.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

Mitigation strategies can be used to avoid or minimize construction- and operations-related transportation impacts.

Measures to avoid impacts include:

- Providing convenient and parallel detours to routes closed during construction.
- Allowing trains to use existing tracks while bridges are being built.

Measures to reduce impacts include:

- Encouraging use of public transportation and carpooling for construction workers.
- Clearly marking roadway intersections with warnings where visibility is poor in the project vicinity.
- Providing boat portage or a stationary jib crane, relocating boat launch facilities, or relocating emergency access roads.
- Requiring contractors to use appropriate state and federal safety protocols.

Some of these mitigation strategies may cause additional adverse impacts. At this programmatic level of analysis, it is impractical to analyze the specific impacts or the measures needed to mitigate those secondary impacts. During review of site-specific projects, the additional impacts created by the application of mitigation strategies, if any, will be analyzed; further measures will be added as necessary to avoid or reduce those impacts.

5.7.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Relocating or permanently closing roads could result in a significant unavoidable transportation impact.

5.8 Air Quality

Most impacts on air quality are associated with construction activities, would last only for the duration of construction, and are considered less than significant. The CALFED Bay-Delta Program could improve air quality by decreasing agricultural operations-related emissions.

5.8 Air Quality

5.8.1 SUMMARY

The quality of the air we breathe plays an important role in the quality of life. Airsheds can be defined on local, regional, and global scales. Some impacts on local airsheds affect the global community. Some CALFED Bay-Delta Program (Program) elements could result in noticeable but minor long-term beneficial impacts on air quality. Short-term adverse air quality impacts associated with the Program primarily are related to construction activities and can be mitigated to a less-than-significant level.

Preferred Program Alternative. A temporary reduction in air quality could result from any Program action that involves construction activities.

Retirement of existing agricultural lands could result in long-term beneficial air quality impacts associated with decreases in emissions from preparing agricultural land, burning fossil fuels, and applying herbicides and pesticides. Potentially significant adverse impacts that could result from land conversion include increased fugitive emissions of wind-blown dust (if land was left as unvegetated, fallowed land) and increased emissions (if land was developed for residential, commercial, or recreational uses). These impacts can be mitigated to less-than-significant levels.

Increasing wetland vegetation could result in a continuous increase in methane gas emissions due to the natural anaerobic decay of the associated vegetation. This increase is considered less than significant.

Modification of existing filtration plants; development of new pipelines, well fields, and pump stations; and increased or decreased pumping activities could result in operations-related air quality impacts (both adverse and beneficial) in agricultural and urban environments.

Increased use in the agricultural sector of pressurized irrigation systems could create a greater reliance on fossil fuels or other energy sources. This increase could adversely affect air quality either locally (with fossil fuels) or regionally if energy is provided from out-of-region facilities. Changes in cultivation practices to accompany increased water use efficiency could result in adverse or beneficial impacts.

Changes in crop type or agricultural acreage could positively or negatively affect air quality. Crop fallowing could result in reduced fugitive dust production and reduced air emissions from declining use of equipment and agricultural chemicals. Crop shifting could result in reduced crop burning. Increased cultivation may increase fugitive dust. Increases in equipment use and cultivation, agricultural chemical use, and crop shifting and burning may increase emissions. Shifts to crops associated with drier topsoil may increase fugitive dust production. Increased crop shifting may increase emissions.

Indirect impacts on air quality could result if Program actions cause a significant reduction in hydropower generation with offsetting reduction in other electrical loads, and if thermal power plants are built to replace electrical power currently generated by hydro powerplants. These indirect impacts can be mitigated to levels that are less than significant (see Chapter 7.9, "Power Production and Energy," for a discussion of these impacts).

Alternatives 1, 2, and 3. Potentially significant, short-term, construction-related impacts are associated with all Program alternatives. Long-term impacts on air quality are considered less than significant.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Direct, short-term air pollutant emissions during construction activities (1,2,3,6,7,8,9,10,11,12,13).

Increased fugitive emissions of wind-blown dust (13).

Increased fugitive emissions of wind-blown dust from unvegetated, fallowed land; shifts to crops associated with drier topsoil; or changes in cultivation practices (13,14).

Increased emissions associated with prescribed burning programs (5).

Increased emissions from increases in equipment use and cultivation, agricultural chemical use, and crop shifting and burning (2,4).

Increased emissions if land use changes lead to higher residential, commercial, or recreational uses (3,15,16).

Increased use of fossil fuels or other energy resources associated with pressurized irrigation systems (2,3,10).

Mitigation Strategies

1. Setting traffic limits on construction vehicles.
2. Maintaining properly tuned equipment.
3. Limiting the hours of operation or amount of equipment.
4. Limiting the use of agricultural chemicals.
5. Coordinating prescribed burning programs with relevant air quality management agencies to ensure that the programs are accounted for in state and federal air quality management plans.
6. Regular, periodic watering of construction sites to control levels of dust in the air.
7. Using soil stabilizers and dust suppressants on unpaved service roadways.
8. Daily contained sweeping of paved surfaces.
9. Limiting vehicle idling time.
10. Using alternatively fueled equipment.
11. Requiring selection of borrow sites that are closest to fill locations.
12. Implementing construction practices that reduce generation of particulate matter.
13. Hydroseeding and mulching exposed areas.
14. Using cultivating practices that minimize soil disturbance.
15. Following air basin management plans to avoid or minimize vehicle-related emissions.
16. Restricting the kinds of recreational vehicles or the times of operation for certain off-road vehicles on fallowed agricultural land to limit the amount of fugitive dust.

No potentially significant unavoidable impacts on air quality are associated with the Preferred Program Alternative.

5.8.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. There are no areas of controversy for this resource category.

5.8.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

This section characterizes the existing air quality environment in the study area, including the regulatory setting.

The federal Clean Air Act (CAA) requires the EPA to establish and maintain standards for common air pollutants (Table 5.8-1). To establish standards, the EPA selected certain common air pollutants that typically are associated with human activities in communities. These pollutants include carbon monoxide (CO), ozone (O_3), nitrogen oxide (NO_x), particulate matter smaller than 10 microns in diameter (PM_{10}), and sulfur dioxide (SO_2).

The EPA established standards for each of these criteria pollutants to manage air quality across the country. The new standards will not become effective until the current ozone standard is met. Most states also have adopted standards for these pollutants. In some cases, the state standards are more stringent than EPA standards, to more precisely reflect local air quality conditions and planning objectives.

For many states, including California, air quality management includes dividing the state into distinct areas, or "air basins," based on meteorological and geographic conditions and, where possible, jurisdictional boundaries. In California, 15 air basins have been delineated for air quality management.

The regulation of air quality within each air basin in California is carried out by individual air quality management agencies or pollution control districts.

The EPA concluded that monitoring the level of criteria pollutants can help determine and manage the relative air quality in a particular area. If the levels of any of the criteria pollutants in a particular geographic area exceed the state or federal standards established for those pollutants, the area is designated as "nonattainment" for those pollutants. Likewise, if standards for pollutants are met in a particular area, the area is designated as "attainment" for those pollutants. In areas where standards may not have been established for certain criteria pollutants, the areas are considered "unclassified" for the pollutants.

The CAA also requires that nonattainment areas for criteria pollutants prepare and implement State Implementation Plans (SIPs) to achieve the standards.

The remainder of this section discusses the existing air quality conditions with respect to air pollutants in the Program study regions. SO_2 is not discussed in this report because it is emitted primarily by industrial sources and is not considered a pollutant of concern in the study area, which is in attainment with state and federal standards for SO_2.

Table 5.8-1. Ambient Air Quality Standards

			STANDARDS, AS PARTS PER MILLION		STANDARDS, AS MICROGRAMS PER CUBIC METER		VIOLATION CRITERIA	
Pollutant	**Symbol**	**Averaging Time**	**California**	**Federal**	**California**	**Federal**	**California**	**Federal**
Ozone	O_3	1 hour	0.09	0.12	180	235	If exceeded	If exceeded on more than 3 days in 3 years
		8 hours	—	0.08	—	160	---	If exceeded by 4th highest value during a 3-year period
Carbon monoxide	CO	8 hours	9.0	9	10,000	10,000	If exceeded	If exceeded on more than 1 day per year
		1 hour	20	35	23,000	40,000	If exceeded	If exceeded on more than 1 day per year
		8 hours (Lake Tahoe only)	6	---	7,000	---	If exceeded	
Inhalable particulate matter	PM_{10}	Annual geometric mean	---	---	30	---	If exceeded	
		Annual arithmetic mean	---	---	---	50		If exceeded
		24 hours	---	---	50	150	If exceeded	If exceeded on more than 1 day per year
Fine particulate matter	$PM_{2.5}$	Annual arithmetic mean	---	---	---	15	---	If exceeded
		24 hours	---	---	---	65	---	If exceeded by 98th percentile over 3 years
Nitrogen dioxide	NO_2	Annual average	---	0.053	---	100	If exceeded	If exceeded
		1 hour	0.25	---	470	---		
Sulfur dioxide	SO_2	Annual average	---	0.03	---	80		If exceeded
		24 hours	0.04	0.14	105	365	If exceeded	If exceeded on more than 1 day per year
		1 hour	0.25	---	655	---	If exceeded	
Lead particles	Pb	Calendar quarter	---	---	---	1.5	If equaled or exceeded	If exceeded
		30 days	---	---	1.5	---		
Sulfate particles	SO_4	24 hours	---	---	25	---	If equaled or exceeded	
Hydrogen sulfide	H_2S	1 hour	0.03	—	42	—	If equaled or exceeded	
Vinyl chloride	C_2H_3Cl	24 hours	0.010	---	26	---	If equaled or exceeded	

Notes:

All standards are based on measurements corrected to 25 degrees C and 1 atmosphere pressure.
Decimal places shown for standards reflect the rounding precision used for evaluating compliance.
National standards shown are the primary (health effects) standards.
Regulations implementing the national 8-hour ozone standard will not become effective until the 1-hour standard has been achieved.
Regulations implementing the national $PM_{2.5}$ standards will not be developed until 2005.

Sources:

California Air Resources Board 1997b; 40 CFR Part 50.

5.8.3.1 DELTA REGION

The Delta Region includes portions of the Sacramento Valley, San Joaquin Valley, San Francisco Bay, and Sacramento Valley Urban Air Basins. During summer, the Pacific high-pressure system can isolate the Delta Region from storms and create inversion layers in the lower elevations that prevent the vertical dispersion of air. Topographic barriers in the Delta Region also can act to prevent lateral dispersion. As a result, air pollutants in the region can become concentrated during summer months, lowering air quality. During winter, when the Pacific high-pressure system moves south, stormy, rainy weather intermittently dominates the Delta Region. Prevailing winter winds from the southeast disperse pollutants, often resulting in clear, sunny weather over most of the region.

5.8.3.2 BAY REGION

The Bay Region is in the San Francisco Bay Area Air Basin. This region has similar weather and pollutant dispersion patterns as the Delta Region, except that more rainfall occurs in the Bay Region during winter. In summer, the Pacific high-pressure system typically remains near the coast, diverting storms to the north. Subsidence of warm air can create frequent summer atmospheric temperature inversions that may be several hundred to several thousand feet deep, often trapping pollutants near the ground and degrading air quality.

Most of the rainfall in the region occurs during winter (November to April), after the Pacific high-pressure system has moved south. Winds during winter predominantly flow from the south and southeast, generally dispersing air pollutants and improving air quality.

The San Francisco Bay Area Air Basin is currently a federally designated nonattainment area for CO, but a SIP has been prepared and is under EPA review. The basin is in attainment of federal standards for O_3, NO_X, and PM_{10} but does not attain state standards for O_3 or PM_{10}.

5.8.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region includes portions of the Sacramento Valley, Northeast Plateau, Lake County, and Mountain Counties Air Basins. Upper watersheds and areas of the region in the Northeast Plateau, Lake County, and Mountain Counties Air Basins are characterized by warm days and cool nights in summer, and cool days and cold nights in winter. Relatively little precipitation occurs in the Northeast Plateau Air Basin area east of the mountains because of the rainshadow effect of the mountains. The Mountain Counties and Lake County Air Basins to the west receive considerably more precipitation, including appreciable snowfall in the higher elevations of the upper watersheds. Winds moving through both of these air basins from a variety of directions throughout the year tend to disperse air pollutants, resulting in relatively good air quality.

The Northeast Plateau Air Basin attains (or is unclassified for) state and federal standards for O_3, CO, and NO_x. For PM_{10}, the area attains (or is unclassified for) federal standards but is in nonattainment in Siskiyou and Modoc Counties for the state standard, which is more stringent than the federal standard. Upper watershed areas of the Sacramento River Region are located in Siskiyou, Modoc, and Lassen Counties in the Northeast Plateau Air Basin. Upper watershed areas in El Dorado, Placer, Nevada, Sierra, Plumas, and Butte Counties are in the Mountain Counties Air Basin. The Lake County and Mountain Counties Air Basins attain (or are unclassified for) both federal and state standards for all pollutants. Air quality problems in the Mountain Counties Air Basin include O_3 and PM_{10}. State O_3 standards are violated in all but the Plumas and Sierra Counties portion of the air basin. Federal O_3 standards are violated in the El Dorado and Placer Counties portion of the air basin. State PM_{10} standards are violated in most portions of the air basin. Federal PM_{10} standards are not violated in the Mountain Counties Air Basin.

For the portion of the region in the Sacramento Valley Air Basin, during summer, the Pacific high-pressure system can create inversion layers in the lower elevations that prevent the vertical dispersion of air. As a result, air pollutants in this portion of the region can become concentrated during summer, lowering air quality. During winter, when the Pacific high-pressure system moves south, stormy, rainy weather intermittently dominates the region. Prevailing winter winds from the southeast disperse pollutants, often resulting in clear, sunny weather and better air quality over most of this portion of the region.

The Sacramento Valley Air Basin is currently a federally and state-designated attainment area for NO_X. The urbanized area in Sacramento County is a federally designated nonattainment area for PM_{10}, but the remainder of the Sacramento Valley Air Basin attains the federal PM_{10} standard. The entire basin is in nonattainment (federal and state standards) for CO and O_3.

5.8.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region contains portions of the San Joaquin Valley, Mountain Counties, and San Francisco Bay Area Air Basins. With respect to that portion of the region that lies in the San Joaquin Valley Air Basin, in summer, when the Pacific high-pressure system moves north, no major storms or precipitation occur, creating daily inversion layers characterized by a layer of cool air over warm air. Surrounding mountains and upper watersheds of the region are at an elevation higher than that of summer inversion layers. As a result, the region is highly susceptible to pollutant accumulation over time. In winter, the influence of the Pacific high-pressure system moves south and gives rise to alternate periods of unsettled stormy weather and stable, rainless conditions with winds from the southwest. Most of the San Joaquin Valley is in the rainshadow of the Coast Ranges and depends on cold, unstable northwesterly flow for its precipitation, which produces showers following frontal passages.

The San Joaquin Valley Air Basin is currently a federally designated nonattainment area for CO, O_3, and PM_{10}; but the state has completed SIPs for each of these criteria pollutants, currently under review by EPA. The basin attains both state and federal NO_X standards.

The portion of the San Joaquin River Region that is in the Mountain Counties Air Basin (including Mariposa, Tuolumne, Calaveras, and Amador Counties) is characterized by warm days and cool nights in summer, and cool days and cold nights in winter. The area receives considerable precipitation, including appreciable snowfall in the higher elevations of the upper watersheds. Winds moving through this air basin from a variety of directions throughout the year tend to disperse air pollutants, resulting in relatively good air quality. The Mountain Counties Air Basin attains (or is unclassified for) both federal and state standards for all pollutants.

With respect to the small portion of the San Joaquin River Region that is included in the San Francisco Bay Area Air Basin, in summer, the Pacific high-pressure system typically remains near the coast, diverting storms to the north. Subsidence of warm air can create frequent summer atmospheric temperature inversions that may trap pollutants near the ground and degrade air quality. Most of the rainfall in this portion of the region falls during winter (November to April), after the Pacific high-pressure system has moved south. Winds during winter predominantly flow from the south and southeast, generally dispersing air pollutants and increasing air quality.

5.8.3.5 OTHER SWP AND CVP SERVICE AREAS

The Other SWP and CVP Service Areas region includes two distinct, noncontiguous areas: in the north, are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

The SWP service area includes portions of the South Central Coast, South Coast and San Diego, and Mohave Desert and Salton Sea Air Basins. The CVP service area includes portions of the San Francisco Bay Area and North Central Coast Air Basins.

In the South Central Coast and the South Coast and San Diego Air Basins, the Pacific high-pressure system often stays near the coast during summer and can create inversion layers that prevent the vertical dispersion of air. As a result, air pollutants in this portion of the region can become concentrated during summer months, lowering air quality. During winter, when the Pacific high-pressure system moves south, stormy, rainy weather intermittently dominates the region. Prevailing winter winds from the southeast disperse pollutants, resulting in better air quality conditions over most of this portion of the region.

The South Central Coast Air Basin attains (or is unclassified for) state and federal standards for CO and NO_x but does not attain either the federal or state standard for O_3. For PM_{10}, the South Central Coast Air Basin attains (or is unclassified for) federal standards but is in nonattainment for the state standard. The South Coast and San Diego Air Basin attains state and federal standards for CO and NO_x. Because this latter basin does not attain either the federal or state standard for O_3, the district has submitted a SIP to EPA for approval. The South Coast and San Diego Air Basin also does not attain federal or state standards for PM_{10}.

The Mojave Desert and Salton Sea Air Basin is characterized by warm days and cool nights in summer, and cool days and cold nights in winter. Most of the sparse annual rainfall in this portion of the region occurs during November to April.

Predominant winds out of the northwest in winter, spring, and fall, and out of the south in summer tend to disperse air pollutants, resulting in relatively good air quality. The Mojave Desert and Salton Sea Air Basin attains (or is unclassified for) state and federal standards for CO and NO_x but does not attain federal or state standards for O_3 and PM_{10}.

The North Central Coast Air Basin (NCCAB) is comprised of Monterey, Santa Cruz, and San Benito Counties. The basin lies along the central coast of California. The semi-permanent high-pressure cell in the eastern Pacific is the basic controlling factor in the climate of the air basin. In summer, air descends in the Pacific High, forming a stable temperature inversion of hot air over a coastal layer of cool air. The warmer air aloft acts as a lid to inhibit vertical air movement, lowering air quality during summer.

In fall, the relatively stationary air mass is held in place by the Pacific High pressure cell, which allows pollutants to build up over a few days. It is most often during this season that the north or east winds develop to transport pollutants from either the San Francisco Bay Area or the Central Valley into the NCCAB.

During winter, the Pacific High migrates southward and has less influence on the air basin. The general absence of deep, persistent inversions and the occasional storm systems usually result in good air quality for the overall basin in winter and early spring.

The NCCAB attains (or is unclassified for) state and federal standards for CO, NO_2, and SO_2. For PM_{10}, the NCCAB attains (or is unclassified for) federal standards but is in non-attainment for state standards. For O_3, the NCCAB attains (or is unclassified for) federal standards but is in moderate non-attainment for state standards.

5.8.4 ASSESSMENT METHODS

The majority of air quality impacts would result from construction associated with Program activities. Because construction-related impacts would occur only during the period of construction, they are considered direct and short-term impacts. Air emissions of concern associated with construction include PM_{10} as fugitive dust, as well as CO and NO_X from construction vehicle exhaust.

Operations-related impacts from activities such as pumping operations, changes in agricultural activities, and traffic and boating activities associated with recreational use of expanded storage reservoirs also could result in changes to air quality. Operations-related air quality impacts are considered indirect and long-term. Air emissions of concern associated with these activities include PM_{10}, CO, and NO_X (dust and exhaust emissions), as well as emissions from herbicides and pesticides used in agriculture.

In 1997, legislation was enacted directing EPA to develop new standards to address particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$). These standards go into effect in 2005; however, a satisfactory way of monitoring compliance with new standards has not been developed. Future site-specific projects may need to comply with $PM_{2.5}$ standards.

5.8.5 SIGNIFICANCE CRITERIA

The criteria used to evaluate potential air quality impacts are based on standardized air emission levels.

Potential air quality impacts are considered potentially significant if the construction or operations of facilities associated with a particular implementation alternative or Program element would cause substantial adverse changes to the existing (ambient) air quality conditions in the affected area. The range of such changes includes producing emissions that would either on their own or when combined with existing emissions:

- Violate federal or state ambient air quality standards.
- Cause a lowering of attainment status.
- Conflict with adopted air quality management plan policies or programs.

5.8.6 NO ACTION ALTERNATIVE

Existing trends in air quality can reasonably be expected to continue if no action is taken. Under the No Action Alternative, total air emissions are expected to increase over existing conditions, even assuming that emissions allowable from individual and mobile sources would be regulated more strictly.

5.8.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For air quality, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs, and Storage elements are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 5.8.8.

5.8.7.1 DELTA REGION

Ecosystem Restoration Program

The installation of new fish screens could cause construction-related air quality impacts in the Delta Region. This impact is considered potentially significant. Mitigation is available to reduce the impact to a less-than-significant level.

Development of wetlands would involve activities that could cause construction-related air quality impacts. Increasing wetland vegetation could result in a continuous increase in methane gas emissions due to the natural anaerobic decay of the associated vegetation. This increase is considered less than significant.

Water Quality Program

The Water Quality Program is not expected to affect air quality in the Delta Region.

Levee System Integrity Program

Setback areas associated with improved levees and flood control operations could result in decreased emissions for lands previously in active agricultural use. Improvement of existing levee systems and construction of new levees, as well as dredging, would result in construction-related air quality impacts.

Water Use Efficiency Program

Modification of existing filtration plants; development of new pipelines, well fields, and pump stations; and increased or decreased pumping activities could result in construction- and operations-related air quality impacts (both adverse and beneficial) in agricultural and urban environments. Most of these impacts are expected to be less than significant; however, mitigation is available to reduce impacts to a less-than-significant level.

Increased use in the agricultural sector of pressurized irrigation systems could create a greater reliance on fossil fuels or other energy sources. The increase could adversely affect air quality either locally (with fossil fuels) or regionally if energy is provided from out-of-region facilities. Changes in cultivation practices to accompany increased water use efficiency could result in adverse or beneficial impacts. Most of these impacts are expected to be less than significant; however, mitigation is available to reduce impacts to a less-than-significant level.

Water Transfer Program

The Water Transfer Program could affect air quality primarily through changes in crop type or agricultural acreage. The extent of impacts depends on the source of water and the timing, magnitude, and pathway of each transfer.

Potential beneficial air quality impacts are associated with the origin of the transferred water. The benefits resulting from crop fallowing include reduced fugitive dust production and reduced air emissions from declining use of equipment and agricultural chemicals. However, temporary land fallowing can increase the potential for barren soils to be eroded by wind if no cover crop or crop residue remains in the field. Transfers based on crop shifting can reduce the need to burn stubble (typically associated with grain crops, especially rice).

Potentially significant adverse impacts primarily are associated with the destination of the transferred water. Increased cultivation may increase fugitive dust. Increases in equipment use and cultivation, agricultural chemical use, and crop shifting and burning may increase emissions. Mitigation is available to reduce potentially significant impacts to less-than-significant levels.

Watershed Program

Although no prescribed burning in the Delta Region is planned in the Watershed Program, prescribed burning programs in adjacent watersheds are potentially significant sources of O_3 precursor emissions and PM_{10} emissions. If federal land management agencies undertake new prescribed burning programs, these programs may require evaluation for compliance with EPA CAA conformity regulations. Continuation of existing prescribed burning programs normally would be exempt from CAA conformity requirements. Mitigation is available to reduce potentially significant adverse impacts to a less-than-significant level.

Storage

Potentially significant adverse air quality impacts may be associated with construction of storage facilities and associated water diversion and conveyance components. These projects could be of sufficient magnitude that construction-related pollutants of concern (NO_X, CO, and PM_{10}) may occur at levels exceeding ambient air quality standards for extended periods, thereby potentially contributing significantly to regional air quality degradation. The actual extent to which the construction of the storage facilities would contribute to regional air pollution can be determined only when specific project locations for the storage facilities are identified. Mitigation is available to reduce potentially significant adverse impacts to less-than-significant levels.

The operations-related impacts associated with in-Delta storage features are not expected to be significant.

Facility operation and maintenance activities are not considered potentially significant sources of air pollutant emissions. Recreational use of an enlarged reservoir could result in traffic and boating emissions that also are considered less than significant.

5.8.7.2 BAY REGION

Ecosystem Restoration and Levee System Integrity Programs

Ecosystem Restoration and Levee System Integrity Program impacts would be similar to those discussed for the Delta Region and would be focused in the Suisun Marsh, but the magnitude of the impacts would be less because fewer projects are planned for the Bay Region.

Water Quality, Water Transfer, and Water Use Efficiency Programs

The Water Quality, Water Transfer, and Water Use Efficiency Programs are not expected to affect air quality in the Bay Region.

Watershed Program

Prescribed burning programs in upper and lower watershed areas are potentially significant sources of O_3 precursor emissions and PM_{10} emissions. If federal land management agencies undertake new prescribed burning programs, the programs may require evaluation for compliance with EPA CAA conformity regulations. Continuation of existing prescribed burning programs normally would be exempt from CAA conformity requirements. Mitigation is available to reduce potentially significant adverse impacts to less-than-significant levels.

Vehicle travel and construction activities associated with erosion control and habitat restoration programs would result in minor quantities of O_3 precursor and PM_{10} emissions that are considered less than significant.

Storage

No storage facilities would be developed in the Bay Region; therefore, no impacts on air quality in the region are associated with the Storage Program.

5.8.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration, Water Use Efficiency, Water Transfer, and Watershed Programs

Activities associated with implementation of the Ecosystem Restoration, Water Use Efficiency, Water Transfer, and Watershed Programs would be similar to those discussed previously for the Delta and Bay Regions. Additionally, river channel deepening and subsidence reversal activities could cause air pollutant emissions during construction. Air emissions from operation of diesel- and gasoline-powered equipment include O_3 precursors (non-methane organic gas [NMOG], volatile organic compounds [VOCs], and NO_x), PM_{10}, CO, and toxic air contaminants. These impacts are considered potentially significant but can be mitigated to less-than-significant levels.

Water Quality Program

Land conversion activities intended to reduce drainage-related pollution could result in decreased operations-related emissions, especially for lands previously under active agricultural cultivation. Revegetation of previously cultivated lands would reduce potential fugitive dust (PM_{10}) and exhaust emissions (NO_X and CO) from operation of farm equipment.

Retirement of existing agricultural lands could result in long-term beneficial air quality impacts associated with decreases in emissions from preparing agricultural land, burning fossil fuels, and applying herbicides and pesticides. Potentially significant adverse impacts that could result from land conversion include increased fugitive emissions of wind-blown dust (if land was left as unvegetated, fallowed land) and increased emissions (if land was developed for residential, commercial, or recreational uses). These impacts can be mitigated to less-than-significant levels.

Improvement of existing and construction of new filtration and treatment facilities as part of the Water Quality Program could result in construction- and operations-related air quality impacts. These impacts are considered less than significant.

Storage

The impacts on air quality in the Sacramento River and San Joaquin River are similar to those described for the Delta Region.

5.8.7.4 OTHER SWP AND CVP SERVICE AREAS

All Programs

No direct effects on air quality from Program actions are anticipated in the Other SWP and CVP Service Areas. Because of the programmatic nature of this document, the indirect impacts of potential growth on air quality are unknown and therefore cannot be analyzed.

5.8.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For air quality resources, the Conveyance element results in environmental consequences that differ among the alternatives, as described below.

5.8.8.1 PREFERRED PROGRAM ALTERNATIVE

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

Direct short-term air pollutant emissions would accompany construction of new facilities.

Construction-related pollutants of concern (NO_X, CO, and PM_{10}) may exceed ambient air quality standards for short, intermittent periods during construction but are not expected to result in sufficient quantities to significantly contribute to regional air quality degradation. Depending on the extent and duration of construction activities, these impacts could be significant; however, mitigation is available to reduce potentially significant impacts on air quality to a less-than-significant level.

Increases in NO_x and CO could result from electrical power generation required to operate new and existing pumps at increased capacities. Potential changes in energy use at the pumping facilities also may indirectly affect air quality at thermal power generation plants; however, these changes are not expected to result in potentially significant impacts.

Construction of new facilities also would involve operations-related air quality impacts. Potential operations-related air quality impacts are expected to be less than significant.

Indirect impacts on air quality could result if Program actions cause a significant reduction in hydropower generation with offsetting reduction in other electrical loads, and if thermal power plants are built to replace electrical power currently generated by hydro powerplants. These indirect impacts can be mitigated to levels that are less than significant (see Chapter 7.9, "Power Production and Energy," for a discussion of these impacts).

5.8.8.2 ALTERNATIVE 1

Impacts on air quality under Alternative 1 would be similar to those described for the Preferred Program Alternative, without the impacts associated with a diversion facility on the Sacramento River and enlargement of the Mokelumne River channel.

5.8.8.3 ALTERNATIVE 2

Construction-related impacts on air quality under Alternative 2 would be similar to those described for the Preferred Program Alternative.

5.8.8.4 ALTERNATIVE 3

Construction-related impacts on air quality under Alternative 3 would exceed those of the Preferred Program Alternative because more construction would be required for an isolated facility. Depending on the extent and duration of construction activities, these impacts could be significant; however, mitigation is available to reduce potentially significant impacts on air quality to a less-than-significant level.

5.8.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3 to existing conditions. This programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions were essentially the same impacts as those identified in Sections 5.8.7 and 5.8.8, which compare the Program alternatives to the No Action Alternative.

The analysis indicates no potentially significant adverse or beneficial impacts on air quality resources when the Program alternatives are compared to existing conditions. As population levels and demand would not increase under existing conditions, air quality impacts would be slightly higher under existing conditions than under the No Action Alternative. At the programmatic level, however, these differences would not be significant.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any additional potentially significant environmental consequences than were identified in the comparison of Program alternatives to the No Action Alternative.

The following potentially significant air quality impacts are associated with the Preferred Program Alternative:

- Direct, short-term air pollutant emissions during construction activities.
- Increased fugitive emissions of wind-blown dust.
- Increased fugitive emissions of wind-blown dust from unvegetated, fallowed land; shifts to crops associated with drier topsoil; or changes in cultivation practice.
- Increased emissions associated with prescribed burning programs.
- Increased emissions from increases in equipment use and cultivation, agricultural chemical use, and crop shifting and burning.

- Increased emissions if land use changes lead to higher residential, commercial, or recreational uses.
- Increased use of fossil fuels or other energy resources associated with pressurized irrigation systems.
- Indirect emissions impacts if thermal power plants are built to replace lost hydropower generation.

No potentially significant unavoidable impacts on air quality are associated with the Preferred Program Alternative.

5.8.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For air quality resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts (and the ability to avoid, reduce, or mitigate those cumulative impacts) are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 5.8.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate these impacts. At the programmatic level, the analysis did not identify any impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level. Sections 5.8.7 and 5.8.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on air quality resources in the Delta, Bay, Sacramento River, and San Joaquin River Regions: American River Water Resource Investigation, American River Watershed Project, other CVPIA actions not yet fully implemented, Delta Wetlands Project, CCWD Multi-Purpose Pipeline Project, Delta Wetlands Project, ISDP, Montezuma Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento River Flood Control System Evaluation, Sacramento Water Forum process, EBMUD Supplemental Water Supply Project, Sacramento County municipal and industrial water supply contracts, urbanization, West Delta Water Management Program, and Sacramento River Conservation Area Program. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 5.8.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. Generally, implementing the Preferred Program Alternative would not result in any potentially significant short- or long-term adverse impacts on air quality resources.

Most short-term impacts would be related to construction and would cease when construction is complete. Where possible, avoidance and mitigation measures would be carried out as a standard course of action to lessen impacts on air quality. No potentially significant long-term unavoidable impacts on air quality are associated with the Preferred Program Alternative.

Irreversible and Irretrievable Commitments. No irreversible or irretrievable commitments of air quality resources are associated with the Preferred Program Alternative.

5.8.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

The following mitigation strategies can be used, as required, to reduce emissions of pollutants of concern. Measures to avoid impacts include:

- Setting traffic limits on construction vehicles.
- Maintaining properly tuned equipment.
- Limiting the hours of operation or amount of equipment.
- Limiting the use of agricultural chemicals.
- Coordinating prescribed burning programs with relevant air quality management agencies to ensure that the programs are accounted for in state and federal air quality management plans.

Measures to minimize impacts include:

- Regular, periodic watering of construction sites to control levels of dust in the air.
- Using soil stabilizers and dust suppressants on unpaved service roadways.
- Daily contained sweeping of paved surfaces.
- Limiting vehicle idling time.
- Using alternatively fueled equipment.
- Requiring selection of borrow sites that are closest to fill locations.
- Implementing construction practices that reduce generation of particulate matter.
- Hydroseeding and mulching exposed areas.

- Using cultivating practices that minimize soil disturbance.
- Following air basin management plans to avoid or minimize vehicle-related emissions.
- Restricting the kinds of recreational vehicles or the times of operation for certain off-road vehicles on fallowed agricultural land to limit the amount of fugitive dust.

5.8.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

No potentially significant unavoidable impacts on air quality were identified for the Preferred Program Alternative.