Chapter 5
Surface Hydrology and Water Quality

5.1 Introduction

This chapter describes the environmental setting for water supply, surface hydrology, water quality, and the regulatory framework associated with these resource areas. In this document, water supply refers to surface water diversions, and not the quantity of surface water in the watershed. This chapter also evaluates the environmental impacts, and the significance of those impacts, on surface hydrology and water quality that could result from the Lower San Joaquin River (LSJR) alternatives and southern Delta water quality (SDWQ) alternatives, and, if applicable, describes mitigation measures that would reduce or avoid any significant impacts. In addition, this chapter evaluates other potential hydrologic changes that could impact other resources, which are further evaluated in the appropriate resource chapter.

Chapter 1, *Introduction*, defines the plan area. The study area for this chapter includes all areas that may be affected by the alternatives, including: the plan area and the San Joaquin River (SJR) from Brandt Bridge through the Stockton Deepwater Ship Channel near the city of Stockton. This chapter also describes the surface hydrology and water quality of the Upper San Joaquin River (Upper SJR) (upstream of the Merced River confluence), since it flows into the LSJR, influencing flows and water quality at Vernalis. However, the Upper SJR is not considered part of the plan area for the purposes of evaluating the LSJR alternatives. Figure ES-1 depicts the SJR Basin, and Figure ES-2 depicts the plan area.

As described in Chapter 1, *Introduction*, the extended plan area generally includes the area upstream of the rim dams. The area of potential effects for this area is similar to that of the plan area and includes the zone of fluctuation around the numerous reservoirs that store water on the Stanislaus and Tuolumne Rivers (Merced does not have substantial upstream reservoirs that would be affected). It also includes the upper reaches of the Stanislaus, Tuolumne, and Merced Rivers. Unless otherwise noted, all discussion in this chapter refers to the plan area. Where appropriate, the extended plan area is specifically identified.

As shown in more detail in the impacts analysis below, the LSJR alternatives would change the three eastside tributary river flows and the LSJR flows, primarily during February–June. Changing river flows changes the water volume in the river, which can affect the concentration of constituents in the water, including pollutants and the component ions that contribute to salinity (or electrical conductivity [EC]). Changes in flows also have the potential to affect water temperatures, surface water diversions, reservoir operations, and salinity. Methods for estimating hydrologic impacts and results are presented in detail in Appendix F.1, *Hydrologic and Water Quality Modeling*, and measured data are presented in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*.[1]

[1] The analyses in Appendix F.1, *Hydrologic and Water Quality Modeling*, and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, describe salinity (EC) using microSiemens per centimeter (μS/cm). This chapter primarily describes salinity using deciSiemens per meter (dS/m) or μS/cm. The units in the 2006 Bay-Delta Plan (mmhos/cm) are equivalent to the dS/m units used in this document; the conversion is 1 dS/m = 1000 μS/cm. EC is electrical conductivity; a widely accepted indirect method

In Appendix B, *State Water Board's Environmental Checklist*, the State Water Board provides a preliminary determination regarding whether a proposed project would cause any potentially significant impact for each environmental category in the Checklist and provides a brief explanation for each determination. Impacts identified in Appendix B as "Potentially Significant" are discussed in are discussed in detail in this chapter. If an impact was considered to be less than significant or have no impact in Appendix B, it is not discussed any further.

Section IX of the checklist in Appendix B addresses hydrology and water quality impacts. Section IX impacts were addressed as follows.

- Impacts in Section IX(a) and (f) of Appendix B regarding water quality objectives, waste discharge requirements, or the degradation of water quality, are discussed in detail in this chapter. The potential impact that increased water temperature or other changes to water quality associated with the plan alternatives have on fisheries resources in the Lower SJR and the three eastside tributaries[2] is discussed in detail in Chapter 7, *Aquatic Biological Resources*; therefore, the discussion of water temperature in this chapter covers only a description of the baseline conditions and modeling results.
- Impacts in Section IX(c), (d), and (i) of Appendix B regarding erosion, sediment, and flooding are addressed in Chapter 6, *Flooding, Sediment, and Erosion*.
- Impacts in Section IX(b) regarding hydrologic impacts on groundwater are addressed in Chapter 9, *Groundwater Resources.*
- Impacts in Section IX(e), (g), (h), (i), and (j) were determined by the State Water Board to either be less than significant or have no impact and are briefly discussed in Appendix B.

In addition to the Section IX hydrologic impacts listed above, hydrologic changes could also impact other resources. The impacts on these resources are discussed and disclosed in Chapters 6 through 17 of this document.

Sections IX(a) and (f) of Appendix B ask if a proposed project would "[v]iolate any water quality standards or waste discharge requirements" and "[o]therwise substantially degrade water quality," respectively. The State's Water Board regulations allow the checklist (Appendix B) to be modified as appropriate to meet the particular circumstances of a project. (Cal. Code Regs., tit. 23, § 3777, subd. (a)(2).) The water quality analysis in this chapter emphasizes how potential changes in salinity associated with the LSJR and SDWQ alternatives affect agricultural beneficial uses. Salinity is emphasized because agricultural beneficial use is the most sensitive to salinity, salinity is the main water quality constituent likely to be affected by the plan amendments[3], salt is a constituent of great concern in the southern Delta because salinity (EC) values sometimes exceed water quality objectives, and there are sufficient EC data available to evaluate effects quantitatively. Changes to flow are also emphasized because they could increase other pollutant concentrations such that water quality objectives are exceeded. Therefore, specific impacts determined to be potentially significant include the following: (1) the LSJR flow alternatives could violate water quality objectives for salinity if they resulted in an increase in the number of months with EC above the water quality objectives for salinity

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to determine the salinity of water, which is the concentration of dissolved salts (often expressed in parts per thousand or parts per million). EC and salinity are therefore used interchangeably in this document.

[2] In this document, the term *three eastside tributaries* refers to the Stanislaus, Tuolumne, and Merced Rivers.

[3] These plan amendments are the *project* as defined in State CEQA Guidelines, Section 15378.

at Vernalis or southern Delta compliance stations (i.e., Old River near Middle River, Old River at Tracy Road Bridge, and SJR at Brandt Bridge); (2) if they degrade water quality by increasing Vernalis and/or southern Delta EC such that agricultural beneficial uses are impaired; and (3) if they substantially degrade water quality due to increases in pollutant concentrations caused by reduced river flows. For water quality impacts associated with temperature refer to Chapter 7, *Aquatic Biological Resources*, and to service providers refer to Chapter 13, *Service Providers*.

The potential impacts of the LSJR on flow and SDWQ alternatives on water quality that are analyzed in this chapter are summarized in Table 5-1. The impact analysis presented in Section 5.4, *Impact Analysis*, below describes the significance thresholds for determining whether a potential impact on water quality is significant. This recirculated substitute environmental document (SED) provides an analysis with and without adaptive implementation because the frequency, duration, and extent to which each adaptive implementation method would be used, if at all, within a year or between years under each LSJR alternative is unknown. The analysis, therefore, discloses the full range of impacts that could occur under an LSJR alternative, from no adaptive implementation to full adaptive implementation. As such, Table 5-1 summarizes impact determinations with and without adaptive implementation.

Impacts related to the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1) are presented in Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* and the supporting technical analysis is presented in Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1).* Chapter 16, *Evaluation of Other Indirect and Additional Actions*, includes discussion of impacts related to actions and methods of compliance.

Table 5-1. Summary of Impact Determinations

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
Impact WQ-1: Violate water quality standards by increasing the number of months with EC above the water quality objectives for salinity at Vernalis or southern Delta compliance stations			
No Project Alternative (LSJR/SDWQ Alternative 1)	See note.[b]	Less than significant	NA
LSJR Alternatives 2, 3, and 4	There would be an overall reduction in monthly exceedances of EC values for the interior southern Delta compliance stations.	Less than significant	Less than significant
SDWQ Alternative 2	There would be an overall reduction of EC values above the new constant 1.0 dS/m EC objective when compared to existing EC objectives.	Less than significant	NA
SDWQ Alternative 3	There would be a reduction of EC values above the new constant 1.4 dS/m EC objective when compared to existing EC objectives such that there would no longer be any violations.	Less than significant	NA

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
Impact WQ-2: Substantially degrade water quality by increasing Vernalis or southern Delta salinity (EC) such that agricultural beneficial uses are impaired			
No Project Alternative (LSJR/SDWQ Alternative 1)	See note.[b]	Less than significant	NA
LSJR Alternatives 2, 3, and 4	The range of average EC values during the irrigation season of April–September in the SJR at Vernalis and in the southern Delta channels is expected to be reduced; accordingly, it is not anticipated that agricultural beneficial uses would be impaired.	Less than significant	Less than significant
SDWQ Alternatives 2 and 3	These alternatives do not have the ability to result in an increase in EC because the baseline 0.7 dS/m Vernalis EC objective would continue to be maintained as part of the program of implementation. Therefore, these alternatives would not cause a change in flow or water quality. Accordingly, it is not anticipated that agricultural beneficial uses would be impaired.	No Impact	NA
Impact WQ-3: Substantially degrade water quality by increasing pollutant concentrations caused by reduced river flows			
No Project Alternative (LSJR/SDWQ Alternative 1)	See note.[b]	Significant	NA
LSJR Alternatives 2, 3, and 4	Flows would generally increase, and no months with low to median flows (10^{th} and 50^{th} percentiles) would experience flow reductions greater than 33% of the baseline flows on the Stanislaus, Tuolumne, or Merced Rivers or the LSJR. Therefore, the change in concentrations would not substantially degrade water quality.	Less than significant	Less than significant

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
SDWQ Alternatives 2 and 3	These alternatives do not have the ability to result in an increase in pollutant concentrations because the baseline 0.7 dS/m Vernalis EC objective would continue to be maintained as part of the program of implementation. These alternatives would not cause a change in flow or water quality.	No impact	NA

1 dS/m = 1000 microSiemens per centimeter (1000 µS/cm)
dS/M = deciSiemens per meter
EC = salinity (electrical conductivity)
NA = Not applicable

[a] Four adaptive implementation methods could occur under the LSJR alternatives, as described in Chapter 3, *Alternatives Description,* and summarized in Section 5.4.2, *Methods and Approach*, of this chapter. There are no adaptive implementation or adaptive implementation methods for the SDWQ alternatives.

[b] The No Project Alternative (LSJR/SDWQ Alternative 1) would result in the continued implementation of flow objectives and salinity objectives established in the 2006 Bay-Delta Plan. See Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative impact discussion and Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative technical analysis.

5.2 Environmental Setting

This section describes the surface water hydrologic conditions (reservoir operations, stream flows, and diversions) and water quality conditions for the SJR basin as a whole, the Upper SJR, the LSJR, the three eastside tributaries, and the southern Delta. The following topics, which are important to the modeling approach and subsequent impact analysis, are included: unimpaired flows;[4] watershed infrastructure; historic river flows and the regulations and diversions that affect flow; hydropower; and water quality. Additional information about unimpaired and historical flows is in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*.

Some additional topics are discussed for the southern Delta including the effect of Delta operations on flow and water surface elevation. The hydrology and water quality of the southern Delta is strongly influenced by the SJR inflow at Vernalis and the Central Valley Project (CVP) and the State Water Project (SWP) export pumping near Tracy.

This information is provided to establish the baseline physical conditions for comparison with the changes that are expected for the LSJR and SDWQ alternatives in Section 5.4, *Impact Analysis*.

[4] *Unimpaired flow* represents the water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. It differs from natural flow because unimpaired flow is the flow that occurs at a specific location under the current configuration of channels, levees, floodplain, wetlands, deforestation and urbanization.

5.2.1 San Joaquin River Basin and Southern Delta Hydrology and Water Quality

Following is a summary of unimpaired flow and the measured (historical) flows of the SJR Basin and southern Delta as a whole, as well as a general discussion of existing water quality conditions, including water quality impairments identified within the SJR Basin and southern Delta. Specific details of flow and water quality associated with the Upper SJR, the three eastside tributaries, the LSJR, and the southern Delta are presented in Sections 5.2.2 through 5.2.8.

Unimpaired and Historical Flow

In the Sierra Nevada, with the combination of rainfall runoff, winter snowpack accumulation, and spring snowmelt, there is a typical monthly progression of fall storm flows, winter storm flows and snowpack accumulation, spring snowmelt, and summer groundwater discharge (i.e., baseflow) (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001; Cain et al. 2003). These seasonal flow characteristics are observed in all three eastside tributaries to the SJR in nearly all years, with wide variations in runoff volume from year to year.

The hydrology of the SJR as measured at Vernalis is greatly altered from the unimpaired runoff conditions. Unimpaired flow is the river flow at a specified location that would occur if all runoff from the watershed remained in the river, without storage or diversion. Construction of many dams and agricultural diversions have altered the natural hydrology of the SJR and its major tributaries (McBain and Trush 2000; Kondolf et al. 2001; Cain et. al 2003; Brown and Bauer 2009). The unimpaired monthly hydrology is used to describe the LSJR alternatives, which reflect the year-to-year variations in monthly runoff that are observed in Central Valley hydrology and approximate flows of a more natural pattern. Therefore, it is important to describe and understand the unimpaired flows of the SJR Basin and three eastside tributary watersheds. Runoff from the SJR Basin and three eastside tributary watersheds shows wide annual, monthly (i.e., seasonal changes), and daily (i.e., storm events) variations and is modified by reservoir storage, diversions, and agricultural return flows from irrigated lands.

The SJR Basin is subject to two types of floods; prolonged rainstorms during the winter and rapid snowpack melting in the late spring and early summer of heavy snowfall years. Floods along foothill streams (without storage dams) and the LSJR often exceed channel capacities and damage urban and agricultural levees or flood portions of these areas. Floods are generally controlled below dams because the reservoir operations include sufficient flood storage space to reduce the reservoir releases to the specified maximum flood control flows, except for rare events when the spillways must be used (e.g., January 1997). Table 5-2 shows the watershed areas, median annual unimpaired runoff, and storage reservoirs for the SJR at Friant Dam and the three eastside tributaries.

Table 5-2. Watershed Characteristics for the SJR at Friant Dam and the LSJR Eastside Tributaries

Characteristic	Stanislaus River	Tuolumne River	Merced River	SJR at Friant Dam
Drainage Area of Tributary at Confluence with the SJR	1,195 square miles (980 square miles [82%] upstream of Goodwin Dam)	1,870 square miles (1,533 square miles [82%] upstream of La Grange Dam)	1,270 square miles (1,067 square miles [84%] upstream of Merced Falls)	1,660 square miles
Miles Downstream to Mouth	59 miles below Goodwin Dam	52 miles below La Grange Dam	52 miles below Crocker-Huffman Dam	NA
Average and Median Annual Unimpaired Flow (1922–2003)	1,120/1,080 TAF	1,853/1,720 TAF	960/894 TAF	1,732/1,453 TAF
Major Storage Reservoir	New Melones Dam and Reservoir (2,400 TAF)	New Don Pedro Dam and Reservoir (2,030 TAF)	New Exchequer Dam, Lake McClure (1,020 TAF)	Friant Dam, Millerton Lake (520 TAF)
Total Watershed Storage	2.85 MAF	2.94 MAF	1.04 MAF	1.15 MAF

Source: Adjusted from Cain et al. 2003.
NA = Not applicable
TAF = thousand acre-feet
MAF = million acre-feet

Water Quality and Impairments

Beneficial uses are designated for waters within a specified area by the State Water Board and each regional water board in their respective water quality control plans (WQCPs). The 2006 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (2006 Bay-Delta Plan) identifies beneficial uses within the Bay-Delta Estuary (See Section 5.3, *Regulatory Background*, for a discussion of the 2006 Bay-Delta Plan). Additionally, the Central Valley Regional Water Quality Control Board's *Fourth Edition Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan) (Central Valley Water Board 2011) identifies beneficial uses of the Delta and SJR areas within its jurisdiction. Water bodies in the plan area are used for many purposes, as evidenced by the number of beneficial uses shown in Table 5-3.

Table 5-3. Designated Beneficial Uses for Waterbodies in the Bay-Delta and the SJR Basin

Name[a]	Abbreviation[a]	Beneficial Uses[b]
Municipal and Domestic Supply	MUN	Uses of water for community, military, or individual water supply systems including drinking water supply
Agricultural Supply	AGR	Uses of water for farming, horticulture, or ranching including irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing
Industrial Service Supply	IND	Uses of water for industrial activities that do not depend primarily on water quality, including mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well pressurization
Industrial Process Supply	PRO	Uses of water for industrial activities that depend primarily on water quality
Hydropower Generation	POW	Uses of water for hydropower generation
Groundwater Recharge	GWR	Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers
Navigation	NAV	Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels
Water Contact Recreation	REC-1	Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible, including swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, and use of natural hot springs
Non-Contact Water Recreation	REC-2	Uses of water for recreational activities involving proximity to water but where there is generally no body contact with water or any likelihood of ingestion of water, including picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, and aesthetic enjoyment in conjunction with the above activities
Commercial and Sport Fishing	COMM	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms, including uses involving organisms intended for human consumption or bait purposes
Warm Freshwater Habitat	WARM	Uses of water that support warm water ecosystems, including preservation or enhancement of aquatic habitats, vegetation, fish, and wildlife, including invertebrates
Cold Freshwater Habitat	COLD	Uses of water that support cold water ecosystems, including preservation or enhancement of aquatic habitats, vegetation, fish, and wildlife, including invertebrates
Wildlife Habitat	WILD	Uses of water that support terrestrial or wetland ecosystems, including preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), and wildlife water and food sources

Name[a]	Abbreviation[a]	Beneficial Uses[b]
Rare, Threatened, or Endangered Species	RARE	Uses of water that support aquatic habitats necessary, at least in part, for the survival and successful maintenance of plant and animal species established under state or federal law as rare, threatened, or endangered
Migration of Aquatic Organisms	MIGR	Uses of water that support habitats necessary for migration and other temporary activities by aquatic organisms, such as anadromous fish
Spawning, Reproduction, and/or Early Development	SPWN	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish
Shellfish Harvesting	SHELL	Uses of water that support habitats suitable for the collection of filter feeding shellfish (e.g., clams, oysters, mussels) for human consumption, commercial, or sport purposes
Estuarine Habitat	EST	Uses of water that support estuarine ecosystems, including preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, and wildlife (e.g., estuarine mammals, waterfowl, shorebirds)

Source: Central Valley Water Board 2011; State Water Board 2006.
[a] The names, abbreviations, and beneficial use descriptions are not identical in each water quality control plan.
[b] Potential beneficial use identified in the Basin Plan.

Under Clean Water Act (CWA) Section 303(d),[5] states, territories, and authorized tribes are required to develop a ranked list of water-quality limited segments of rivers and other water bodies under their jurisdictions where effluent limitations in point-source discharge permits are not stringent enough to implement applicable water quality standards. Listed waters are those that do not meet water quality standards. The law requires that action plans, or total maximum daily loads (TMDLs), be developed to attain and maintain water quality. TMDL is defined as the sum of the individual waste load allocations from point sources, load allocations from nonpoint sources and background loading, plus an appropriate margin of safety.

State and Regional Water Boards develop lists of Section 303(d) state water bodies that do not meet applicable water quality standards (in California, beneficial uses, water quality objectives, and the state's anti-degradation policy serve as water quality standards for purposes of the CWA) and waters not expected to meet those standards with the implementation of technology-based controls. In October 2011, United States Environmental Protection Agency (USEPA) issued its final decision and gave final approval to the water bodies and pollutants added to California's Section 303(d) list. Table 5-4 shows the constituents identified in the Section 303(d) list for impaired waters in the study area plus portions of the Upper SJR.

[5] Clean Water Act section 303(d) requires states, territories, and authorized tribes to develop a ranked list of water quality limited segments of rivers that do not meet water quality standards.

Table 5-4. Clean Water Act Section 303(d) Listed Pollutants and Sources for the Study Area and the Upper SJR

Pollutant/Stressor	Listed Source	Location of Listing
Arsenic	Source unknown	Upper SJR (Bear Creek to Mud Slough)
Benzenehexachloride (alpha-HCH)	Source unknown	LSJR (Merced River to Tuolumne River)
Boron	Agriculture	LSJR (Merced River to Tuolumne River), Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Chlorpyrifos	Agriculture, urban runoff/ storm sewers	Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), southern Delta, Stockton Ship Channel, Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Dacthal	Agriculture	LSJR (Stanislaus River to Delta boundary), Upper SJR (Bear Creek to Mud Slough)
Dichlorodiphenyldic hloroethylene (DDE)	Agriculture	LSJR (Merced River to Tuolumne River), LSJR (Stanislaus River to Delta boundary)
Dichlorodiphenyltric hloroethane (DDT)	Agriculture	LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), Southern Delta, Stockton Ship Channel, Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Dissolved Oxygen (low DO)	Source unknown, organic enrichment, municipal point sources, urban runoff/ storm sewers, hydromodification	Middle River (in southern Delta), Old River (SJR to Delta-Mendota Canal), Stockton Ship Channel
Diazinon	Agriculture, urban runoff/ storm sewers	Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Tuolumne River to Stanislaus River), southern Delta, Stockton Ship Channel, Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Mud Slough to Merced River)
Diuron	Agriculture	LSJR (Stanislaus River to Delta boundary)
Escherichia coli (E. coli)	Source unknown	Merced River (Lower), LSJR (Stanislaus River to Delta boundary), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Group A pesticides	Agriculture	Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), southern Delta, Stockton Ship Channel, Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)

Pollutant/Stressor	Listed Source	Location of Listing
Invasive species	Source unknown	Southern Delta, Stockton Ship Channel, Upper SJR (Friant Dam to Mendota Pool)
Mercury	Resource extraction, industrial-domestic wastewater, atmospheric deposition, nonpoint source	Lake McClure, New Don Pedro Reservoir, New Melones Reservoir, Tulloch Reservoir, Woodward Reservoir, Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), southern Delta, Stockton Ship Channel, Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Salinity (EC)	Agriculture	LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), southern Delta, Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)
Selenium	Agriculture	Upper SJR (Mud Slough to Merced River)
Temperature, water	Source unknown	Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary)
Total dissolved solids (TDS)	Source Unknown	Old River (SJR to Delta-Mendota Canal)
Toxaphene	Source unknown	LSJR (Stanislaus River to Delta boundary)
Unknown toxicity	Source unknown, agriculture	Merced River (Lower), Tuolumne River (Lower), Stanislaus River (Lower), LSJR (Merced River to Tuolumne River), LSJR (Tuolumne River to Stanislaus River), LSJR (Stanislaus River to Delta boundary), southern Delta, Stockton Ship Channel, Upper SJR (Mendota Pool to Bear Creek), Upper SJR (Bear Creek to Mud Slough), Upper SJR (Mud Slough to Merced River)

Source: State Water Board 2011.
Note: In addition to the pollutants listed here, the Stockton Ship Channel was on the 303 (d) list for several additional pollutants, including: dioxin, furan compounds, pathogens, and PCBs (polychlorinated biphenyls).

Section 303(d) requires that states evaluate and rank water quality impairments that cannot be resolved through point source controls and, in accordance with the priority ranking, develop a TMDL for those pollutants USEPA identifies under Section 304(a)(2) as suitable for such calculation. Table 5-5 contains a list of completed or ongoing TMDL projects in the SJR Basin and southern Delta.

Table 5-5. Summary of Completed and Ongoing Total Maximum Daily Loads in the SJR Basin and the Southern Delta

Pollutant/Stressor	Water Bodies Addressed	TMDL Status
Dissolved Oxygen	SJR-Stockton Deep Water Ship Channel (DWSC) from Stockton to Disappointment Slough	TMDL report completed—January 2005 State-Federal approval—February 2007
Chlorpyrifos and diazinon	LSJR	TMDL report completed—October 2005 State-Federal approval—December 2006
Chlorpyrifos and diazinon	SJR and Delta	TMDL report completed—June 2006 State-Federal approval—October 2007
Mercury/methylmercury	Delta	TMDL report completed—April 2010
Mercury/methylmercury	Reservoirs	Ongoing
Pesticides	Basin-wide	Ongoing
Organochlorine pesticides	SJR tributaries; Delta	Ongoing
Salt and boron	LSJR	TMDL report completed—October 2005 State-Federal approval—February 2007
Selenium	LSJR	TMDL report completed—August 2001 State-Federal approval—March 2002

Source: Central Valley Water Board 2013.
TMDL = total maximum daily load

There are numerous constituents of concern that impair water quality in the study area, as identified in Table 5-4. For example, salinity is an important parameter of concern for the southern Delta and Bay-Delta that reflects the total ionic content of the water, ranging from very low levels deemed fresh water, like those present in the plan area, to the high salinity content of seawater in SF Bay.

The SJR is unusual because salinity tends to be lower downstream (e.g., at Vernalis) than upstream of the Merced River confluence. High salinity upstream of the Merced River confluence is due to heavy contributions of salts from Salt and Mud Sloughs, as well as water re-circulated from the Delta via the Delta-Mendota Canal (DMC) and agricultural return flows. As water moves downstream, the Stanislaus, Tuolumne, and Merced Rivers dilute the salinity in the SJR because they have relatively high flows, but contribute little salt to the system. Current water quality objectives specify that SJR water entering the southern Delta at Vernalis should remain at or below 1.000 dS/m during September through March and at or below 0.700 dS/m during April through August. Because of the relatively low salinity in the three eastside tributaries, it has been possible to attain this objective by increasing releases from New Melones Reservoir on the Stanislaus River when necessary. Salinity conditions in the LSJR, Stanislaus, Tuolumne, and Merced Rivers are described in more detail below and in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*.

A TMDL for controlling salt and boron loads to the LSJR was adopted in 2005. Implementation of the TMDL is described in the Central Valley Water Board's 2004 final staff report on amendments to the Basin Plan for the Central Valley (Central Valley Water Board 2004). The amendment recommends the implementation of a real-time water quality management program (RTMP) that would facilitate the control and timing of wetland and agricultural drainage to coincide with periods when dilution flow in the SJR is sufficient to meet Vernalis salinity objectives. The U.S. Bureau of Reclamation

(USBR) entered into an updated Management Agency Agreement with the Central Valley Water Board in 2014 that details USBR's responsibility to assist in the development and implementation of the RTMP. However, even with the TMDL load allocations, water quality objectives at Vernalis could still be exceeded. When this occurs, USBR would continue to be responsible for ensuring that the Vernalis salinity objectives are met in accordance with its water rights. Responsibility is assigned to the USBR because of the agency's large contribution to the salinity problem in the SJR basin. The water development programs of the USBR have been responsible for reducing flows in the SJR (by operating Millerton Reservoir and the Madera and Friant-Kern canals) and replacing some of that water with relatively saline water from the Delta-Mendota Canal. The main way that USBR currently fulfills its obligation to attain water quality objectives at Vernalis is by releasing relatively clean Stanislaus River water from New Melones.

Chloride, bromide, sulfate, and boron are specific ions that contribute to overall salinity and are constituents of concern; however, in the plan area, only boron is included on the 303(d) and TMDL lists. Salinity can affect multiple beneficial uses. As a habitat feature, salinity can define the types and distribution of aquatic organisms based on their adaptation to fresh water versus brackish, or saline water in the Delta. Agricultural users are also concerned with boron and salinity, since some crops are sensitive to these constituents, which can affect crop yields. Municipal water users have concerns regarding the ability to utilize recycled water when the source water has high EC values. The presence of bromide in municipal water sources is a concern since bromide is the precursor to the formation of harmful byproducts of the water disinfection process, however there are no 303(d) listing for bromide in the plan area.

As indicated above in Table 5-4, the lower portions of the Stanislaus, Tuolumne, and Merced Rivers, and the SJR to the Delta are listed as impaired due to elevated water temperatures. Water temperature conditions in the eastside tributaries and the LSJR are affected by the operation of the reservoirs and by river diversions used for agriculture. During the warmer months, water released from the three large reservoirs on the Stanislaus, Tuolumne, and Merced Rivers is relatively cool. Cool water accumulates in the reservoirs during the rainy season and during spring runoff. The cool water at the bottom of the reservoirs is minimally affected by seasonal warming that occurs at the surface during the warmer months. However, when cool water is released from the bottom of the reservoirs through the late spring, summer, and fall, the cool water supply can become depleted, potentially causing the temperature of the water that is released to the river to become warmer. While large releases may deplete cool water in reservoirs, they can also help to reduce warming along the length of a river during the warmer months. Higher flows result in faster travel times, which allow water to move farther downstream before warming to reach equilibrium with environmental conditions. Baseline water temperature conditions are described in detail in Appendix F.1, *Hydrologic and Water Quality Modeling*.

Temperature and salinity are the two main water quality parameters that may be affected by the alternatives. The plan alternatives involve changing flow in the eastside tributaries, LSJR and the southern Delta, which would affect these parameters. A discussion of the LSJR flow alternatives and the water temperature modeling results that show expected changes in water temperature is included in this chapter; however, the discussion of the potential impacts on fisheries associated with changes to water temperature can be found in Chapter 7, *Aquatic Biological Resources*.

In addition to salinity and water temperature, other water quality impairments in the SJR Watershed and southern Delta, include turbidity and suspended sediment, dissolved oxygen (DO), pesticides, herbicides, nutrients, and trace metals. The entire Delta is identified on the Section

303(d) list as impaired by unknown toxicity, which refers to the mortality of aquatic organisms and/or sublethal effects (e.g., reduced growth or reproductive success) observed during aquatic toxicity bioassays. The unknown toxicity can be caused by one or more individual toxicants that have not been identified. Poor water quality associated with the presence of pollutants can result in significant impacts on aquatic life. Trace metals, pesticides, and herbicides can be toxic to aquatic life at relatively low concentrations. Temperature and DO are of concern because the eastside tributaries, LSJR, and southern Delta serve as a migration and rearing corridor for anadromous salmonids, which are sensitive to these parameters. In the past, low DO concentrations in the Stockton Deepwater Ship Channel are thought to have negatively affected migrating adult salmonids in the fall. Excess nutrients can cause blooms of nuisance algae and aquatic vegetation, and their decay can result in low DO concentrations. Several locations in the southern Delta are listed as impaired due to low DO concentrations and a TMDL for DO was adopted in 2005 that includes measures to improve DO conditions in the Stockton Deepwater Ship Channel that include aeration facilities at the Port of Stockton.

5.2.2 Upper San Joaquin River

Unimpaired and Historical Flow

The SJR Watershed upstream of Friant Dam covers an area of about 1,660 square miles. The SJR Watershed upstream of the Merced River confluence is approximately 5,800 square miles, but most of the runoff originates upstream of Friant Dam. Several reservoirs in the upper portion of the SJR Basin, including Edison, Florence, Huntington, Mammoth Pool, and Shaver Lake, are primarily used for seasonal storage for hydroelectric power generation. These upstream reservoir operations affect inflows to Millerton Lake, the reservoir behind Friant Dam. The average annual unimpaired runoff estimated at Friant Dam is about 1,732 thousand acre-feet (TAF) and the median runoff is about 1,453 TAF. The reservoir provides a maximum storage of 520 TAF, provides flood control for the SJR, provides downstream releases to supply senior water rights diversions, and provides diversions into the Madera and Friant-Kern Canals. Flood control storage space in Millerton Lake is limited, and additional flood control is provided by the upstream reservoirs.

USBR must maintain sufficient flow between Friant Dam and Gravelly Ford to meet the needs of downstream prior water rights holders. USBR must supply a minimum flow of 5 cubic feet per second (cfs) below the last water right diversion located about 40 miles downstream of Friant Dam near Gravelly Ford. A maximum river release of about 125 cfs in the summer months supplies these downstream riparian and water right users. The maximum flood control release from Friant Dam (established by the U.S. Army Corps of Engineers (USACE) is 8,000 cfs. USBR is undertaking the SJR Restoration Program[6] which will eventually provide water throughout the year to reconnect the upstream river below Friant to the SJR at the mouth of the Merced River. In 2006, parties to *NRDC v. Rodgers* executed a stipulation of settlement that calls for, among other things, restoration of flows on the Upper SJR from Friant Dam to the confluence of the Merced River. Required release flows from Friant Dam for each water year type have been identified, but the amount of this Upper SJR water that would be observed at the mouth of the Merced River is as yet uncertain.

[6] Implementation of the settlement and the Friant Dam release flows required by the San Joaquin River Restoration Program are expected to increase the existing SJR flows at Stevinson in the near future.

Hydrologic conditions are often described using cumulative distribution. The cumulative distribution of a particular variable (e.g., flow at a location) provides a basic summary of the distribution of values. The percentile (percent cumulative distribution) associated with each value indicates the percent of time that the values were less than the specified value. For example, a 10th percentile value of 2 indicates that 10 percent of the time, the values were less than 2. The 0th percentile is the minimum value, the 50th percentile is the median value, and the 100th percentile is the maximum value. In many cases, the 10th and 90th percentiles are selected to represent relatively low and relatively high values rather than the minimum and maximum because they are representative of multiple years rather than the 1 year with the highest value and the 1 year with the lowest value. A monthly year-by-year assessment is not necessary because increases in monthly values during some years may be counteracted by decreases during other years. Therefore, the evaluation of change in hydrologic parameters in this chapter and other chapters of this SED was based on the monthly cumulative distribution of values rather than individual changes in monthly values.

Table 5-6a shows the monthly cumulative distribution of SJR unimpaired runoff (cfs) at Friant Dam for 1922–2003. The range of monthly runoff is summarized with a cumulative distribution at each 10th percentile from the minimum to the maximum. The median (50 percent cumulative) monthly values provide a good summary of the seasonal pattern. The maximum runoff was in April, May, and June. The minimum runoff was in September, October, and November. The estimated median unimpaired flow pattern in the February–June period was 1,340 cfs in February, 1,925 cfs in March, 3,966 cfs in April, 6,916 cfs in May, and 5,430 cfs in June. The range of flows in these months is quite large from year to year.

Table 5-6b shows the monthly cumulative distribution of historical (observed) flow below Friant Dam (cfs) for 1985–2009 (most recent 25-year period). The highest median flows of 200 cfs are in June, July, and August. The highest historical flows (90 percent cumulative) were greater than 2,000 cfs in February–June, indicating that flood control releases were made in a few years for each of these months. The historical average annual flow volume released from Friant Dam was approximately 400 TAF, which was 25 percent of unimpaired flow. The median annual flow volume was approximately 130 TAF, indicating that the flood releases in a few years raised the average flow volume below Friant Dam to approximately three times the median flow.

Table 5-6a. Monthly Cumulative Distribution of SJR Unimpaired Flow (cfs) at Friant Dam for 1922–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	81	95	121	161	204	305	957	1,216	587	260	150	75	362
10	115	171	237	296	541	1,079	2,134	3,400	2,029	667	233	127	803
20	157	223	267	384	760	1,353	2,583	3,907	2,487	754	282	169	936
30	171	257	345	535	956	1,545	2,889	5,063	3,552	920	363	194	1,128
40	206	290	508	632	1,111	1,731	3,399	6,084	4,675	1,462	440	226	1,250
50	266	354	584	768	1,340	1,925	3,966	6,916	5,430	1,868	556	259	1,453
60	301	436	723	1,105	1,800	2,146	4,194	7,560	6,209	2,365	701	312	1,856
70	338	546	894	1,332	2,050	2,614	4,693	8,283	8,052	2,968	840	382	2,048
80	389	706	1,187	1,833	2,889	3,334	5,194	9,677	9,793	4,319	1,191	551	2,410
90	544	1,101	1,892	2,743	3,741	3,773	5,879	11,456	10,789	5,982	2,056	699	3,044
Maximum	2,048	4,151	7,489	11,953	8,506	7,895	10,300	17,826	19,597	12,225	4,558	2,853	4,642
Average	315	563	969	1,351	1,837	2,342	3,978	7,043	6,275	2,736	850	404	1,732

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-6b. Monthly Cumulative Distribution of SJR Historical Flow (cfs) below Friant Dam for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	61	56	36	32	39	36	97	121	136	150	124	114	64
10	107	73	58	39	67	88	107	126	153	172	152	132	81
20	124	96	78	58	78	92	119	144	182	198	191	157	103
30	146	107	93	85	87	109	139	158	194	209	199	173	114
40	155	118	97	94	95	119	144	165	244	219	208	183	121
50	158	120	103	96	100	137	156	181	281	232	232	189	132
60	160	125	104	100	110	174	192	218	301	260	245	219	161
70	174	133	110	111	127	422	253	262	345	281	261	237	302
80	190	147	117	118	457	1,004	1,258	1,016	637	573	278	251	766
90	215	173	164	203	2,260	2,076	4,652	4,672	2,946	739	318	292	1,305
Maximum	357	378	1,147	9,144	6,514	6,548	7,367	7,637	6,535	5,322	464	383	1,657
Average	165	129	156	468	674	802	1,172	1,172	973	659	239	209	411

cfs = cubic feet per second
TAF = thousand acre-feet

Figure 2-7 shows the monthly unimpaired and historical SJR flows below Friant Dam for the most recent 10-year period of 2000–2009. The average unimpaired flow for this 10-year period was 1,687 TAF (97 percent of the 1922–2003 average). The historical flows were much less than the unimpaired flows except in wet years when flood releases were more than half of the unimpaired runoff (e.g., 2005 and 2006). Most of the runoff was seasonally stored in upstream reservoirs and in Millerton Lake and diverted to the Friant-Kern and Madera canals for irrigation. During high-flow years, however, there are considerable flood control releases from Friant Dam.

Additional flow enters the SJR from the Chowchilla and the Fresno Rivers and smaller creeks. These two rivers have smaller watersheds that do not extend to the crest of the Sierra Nevada and, consequently, have much less runoff, most of which is stored for irrigation uses. In wet years, some flood flows from the Tulare Lake Basin (i.e., Kings River) enter the SJR through Fresno Slough to the Mendota Pool. Local runoff from the Bear Creek Watershed in the vicinity of Merced and runoff with agricultural drainage and managed wetlands and wildlife refuges in the Grasslands Watershed provides additional SJR flow upstream of the Merced River. Flow and water quality in the SJR upstream of the Merced River is measured at Stevinson, upstream of Salt Slough, and at Fremont Ford, upstream of Mud Slough. Mud Slough is a combination of runoff, irrigation drainage, and discharge from the San Luis Drain that bypasses tile drainage around the Grasslands wildlife refuges and waterfowl clubs.

Water Quality

Water upstream from Friant Dam has low mineral and nutrient concentrations due to the insolubility of granitic soils in the watershed and the river's granite substrate (SCE 2007). As the SJR and tributary streams flow from the Sierra Nevada foothills across the eastern valley floor, their mineral concentration increases. Sediment is likely captured behind the many dams. Water quality in various segments of the SJR below Friant Dam is degraded because of low flow and discharges from agricultural areas and wastewater treatment plants. Water quality downstream is generally influenced by releases from Friant Dam, with contributions from agricultural and urban return flows as the river approaches the Merced River confluence. It generally becomes degraded the farther downstream it gets from the dam. Downstream of the dam, the river is identified on the 303(d) list for constituents associated with agricultural uses, such as pesticides (chlorpyrifos, diazinon, Dichlorodiphenyltrichloroethane [DDT]), salinity (EC), and unknown toxicity (State Water Board 2011) (Table 5-4).

Water temperatures below Friant Dam and Mendota Dam are dependent on water temperatures of inflow from the Delta Mendota Canal and, occasionally, the Kings River system via James Bypass. Water temperature conditions downstream are also dependent on inflow water temperatures during flood flows from upstream. SJR water temperatures south of the confluence of the Merced River are influenced greatly by the water temperature of Salt Slough inflow, which contributes the majority of streamflow in this area (USBR 2007).

5.2.3 Merced River

Unimpaired and Historical Flow

The Merced River flows into the SJR at river mile (RM) 118 and is the most upstream of the three eastside tributaries with existing fish populations. The Merced River is 135 miles long and drains a

1,270 square-mile watershed. Approximately 52 miles of the Merced River are downstream of the Crocker-Huffman Dam, the most downstream barrier to fish migration. Three of the four dams on the Merced River, known collectively as the Merced River Development Project, are owned by Merced Irrigation District (Merced ID), and Merced Falls Dam is owned by Pacific Gas and Electric Company (PG&E). Three of the dams are licensed by the Federal Energy Regulatory Commission (FERC). The Merced River unimpaired flow is essentially the same as the Lake McClure inflow because there are no major storage reservoir or diversions upstream. The runoff from the Yosemite Valley flows unimpaired downstream to Lake McClure.

Merced ID provides surface water and electric service to approximately 164,000 acres in Merced County (Merced ID 2008a). Merced ID diverts from the Merced Falls reservoir via the Northside Canal and from the Merced River via the Main Canal at the Crocker-Huffman Diversion Dam during the irrigation season. These diversions have averaged approximately 525 TAF per year (TAF/y) (Stillwater Sciences 2001).

Flows released from the Crocker-Huffman Dam to the Merced River must satisfy FERC requirements, as well as the Davis-Grunsky Contract and the Cowell Agreement requirements. Merced ID holds the FERC license (Project Number 2179) for the Merced River Hydroelectric Project, which was issued on April 18, 1964. FERC Project Number 2179 required the licensee to provide minimum stream flows (Table 5-7) in the Merced River at Shaffer Bridge, approximately 24 miles downstream from the Crocker-Huffman Dam.

Table 5-7. FERC Project Number 2179 Stream Flow Requirements for the Merced River at Shaffer Bridge (cfs)

Period	Normal Year	Dry Year
June 1–October 15	25	15
October 16–October 31	75	60
November 1–December 31	100–200	75–150
January 1–May 31	75	60

Note: On December 4, 2015, FERC released a final EIS for the relicensing of the Merced Irrigation District's and PG&E's hydroelectric projects. A new FERC license could alter the existing Merced River flow requirements.
cfs = cubic feet per second
FERC = Federal Energy Regulatory Commission

Releases from the Crocker-Huffman Dam must be greater than the FERC minimum flow requirements at Shaffer Bridge to satisfy the Cowell Agreement and the Davis-Grunsky Contract. The 1926 Cowell Agreement (pursuant to a Merced Superior Court order) calls for the Merced ID to maintain monthly flows downstream of the Crocker-Huffman Dam to satisfy water right adjudications for downstream water users. The flows are 50 cfs October–February and are 100 cfs to 250 cfs during the March–September irrigation season. This water is diverted from the river at a number of private ditches between Crocker-Huffman Dam and Shafter Bridge in accordance with the Cowell Agreement beneficiaries so that the FERC minimum flows at Shaffer Bridge are satisfied. The Davis-Grunsky Contract provides minimum flow standards of 180 cfs in dry years (less than 450,000 AF runoff) and 220 cfs in all other years from November–March at Crocker-Huffman Dam (and Shaffer Bridge) for Chinook salmon spawning and rearing. A flood control release limit of 6,000 cfs was established by USACE for the combination of Dry Creek and the Merced River flows at Stevinson.

Table 5-8a shows the monthly cumulative distribution of Merced River unimpaired runoff (flow, cfs) at New Exchequer Dam for 1922–2003. The range of monthly runoff is summarized with a cumulative distribution at each 10th percentile from the minimum to the maximum. The maximum runoff was in April, May, and June. The minimum runoff was in August, September, October, and November. The estimated median unimpaired flow pattern in the February–June period was 969 cfs in February, 1,303 cfs in March, 2,391 cfs in April, 3,955 cfs in May, and 2,451 cfs in June. The range of flows in these months is quite large from year to year.

Table 5-8b shows the monthly cumulative distribution of historical (observed) Merced River flow (cfs) at Stevinson (downstream of Dry Creek) for 1985–2009 (most recent 25-year period). The average unimpaired flow for this 25-year period was 937 TAF (98 percent of the 1922-2003 average). The highest median flows were in April and May, which are the months with highest unimpaired runoff. The highest historical Merced River flows (90 percent cumulative) were greater than 1,500 in February–June, indicating that flood control releases were made in a few years in each of these months. The monthly ranges of historical Merced River flows were large only in the months with flood control releases. The median flows in the summer months of July–September were less than 150 cfs. The historical average annual flow volume for the Merced River at Stevinson was 438 TAF, approximately 47 percent of the average unimpaired flow for this period. The median annual flow volume was 267 TAF, indicating that flood releases in a few years raised the average flow volume in the Merced River to approximately 1.5 times the median flow.

Table 5-8a. Monthly Cumulative Distributions of Merced River Unimpaired Flow at Stevinson (cfs) for 1922–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	8	20	17	54	55	131	519	637	212	62	-	-	150
10	23	59	89	162	337	601	1,352	1,650	741	129	27	-	412
20	33	86	129	214	461	851	1,562	2,179	870	191	42	4	498
30	46	102	167	326	579	970	1,927	2,832	1,400	292	63	22	566
40	63	126	256	377	801	1,102	2,155	3,295	1,923	416	83	34	669
50	81	152	354	571	969	1,303	2,391	3,955	2,451	529	121	58	894
60	96	222	448	763	1,235	1,518	2,667	4,332	2,868	721	183	79	1,070
70	116	302	560	1,069	1,821	1,875	2,880	4,730	3,462	842	221	102	1,158
80	159	372	862	1,500	2,578	2,489	3,246	5,223	4,403	1,344	273	133	1,412
90	255	699	1,647	2,579	3,514	2,718	3,643	6,400	5,633	1,991	514	203	1,718
Maximum	835	4,346	6,058	10,306	6,295	6,013	7,206	9,194	11,025	5,719	1,578	798	2,787
Average	115	335	703	1,073	1,496	1,643	2,473	3,932	2,875	909	208	93	960

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-8b. Monthly Cumulative Distribution of Historical Merced River Flow (cfs) at Stevinson for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	32	131	171	129	69	166	136	91	25	6	18	25	73
10	75	183	199	205	218	236	167	139	104	34	30	45	102
20	159	231	218	226	243	250	183	191	126	59	65	78	140
30	263	246	227	242	269	272	307	313	156	97	88	95	193
40	298	248	236	259	312	285	357	647	180	125	100	114	220
50	325	254	255	318	323	313	449	669	192	136	125	127	267
60	374	271	293	421	351	363	622	734	257	178	145	186	324
70	440	329	385	563	453	1,047	985	857	377	210	163	211	476
80	526	423	473	697	933	2,360	1,425	1,409	609	321	313	371	703
90	914	568	631	826	1,605	2,733	2,868	2,628	2,200	840	645	720	1,185
Maximum	1,861	635	2,019	7,347	6,990	2,964	4,616	4,113	3,185	2,456	722	1,127	1,275
Average	435	316	410	754	912	969	1,019	1,013	599	361	215	259	438

cfs = cubic feet per second
TAF = thousand acre-feet

Figure 2-8 shows the monthly unimpaired and historical Merced River flow at Stevinson for the recent 10-year period of 2000–2009. Unimpaired flow at New Exchequer Dam averaged 884 TAF/y, and the historical releases (including flood flows in 2000, 2005 and 2006) averaged 403 TAF/y. The peak historical flows were in April and May of 2006 because Lake McClure was nearly full, and this relatively high flow of 4,500 cfs was for flood control purposes. The majority of the historical flow volume was observed in the wet years with flood control releases. Lake McClure is the smallest of the tributary reservoirs and is generally filled and drawn down each year.

Major Dams and Reservoirs

The New Exchequer powerhouse has a capacity of approximately 95 megawatts (MW) with a maximum head of 400 feet (ft) and a maximum flow of approximately 3,200 cfs (Merced ID 2008b). The hydropower facilities at the rim dams[7] operate each day to maximize energy generation efficiency and revenue, thereby giving preference to full generation during peak energy demand periods (generally 9AM–9PM). This is done by operating the turbine-generators at a constant high flow for a portion of the day and shutting them off for the remainder of the day. Water released for peaking power is regulated downstream at the approximately 10 TAF McSwain Reservoir, with a normal daily fluctuation of several feet. The McSwain Dam powerhouse has a capacity of 9 MW, with a maximum head of approximately 55 f., and a maximum flow of approximately 2,700 cfs (Merced ID 2008c). Merced Falls Dam, downstream of McSwain Dam is a small diversion dam (for MID's Northside Canal) with a small hydroelectric generator owned by Pacific Gas & Electric with a capacity of approximately 3.4 MW, a maximum head of about 50 ft., and a maximum flow of approximately 1,750 cfs (Merced ID 2008b). The Crocker-Huffman Dam, the furthest downstream

[7] In this document, the term *rim dams* is used when referencing the three major dams and reservoirs on each of the eastside tributaries: New Melones Dam and Reservoir on the Stanislaus River; New Don Pedro Dam and Reservoir on the Tuolumne River; and New Exchequer Dam and Lake McClure on the Merced River.

dam on the Merced River, diverts water to the Merced ID main canal and Merced River Hatchery and releases water to the Merced River.

Water Quality

Some water quality characteristics in the Merced River, such as water temperature, are affected by reservoir operations and by changes in river flow attributable to water supply and hydropower generation activities. Appendix F.1, *Hydrologic and Water Quality Modeling*, contains a description of baseline water temperatures on the Merced River, and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, includes a presentation of existing salinity conditions.

EC generally increases as water moves downstream in the Merced River because of the relatively high EC in agricultural drainage and groundwater discharge to the river. The increase in EC is generally greater when the river flow is low due to the reduced dilution of the agriculture drainage under low flow conditions. However, near the confluence with the SJR, the measured monthly EC in the Merced River (at Stevinson) is still generally low, usually ranging from approximately 0.050 to 0.400 dS/m.

5.2.4 Tuolumne River

Unimpaired and Historical Flow

The Tuolumne River flows into the SJR at RM 83, approximately 8 miles upstream of the Stanislaus River confluence and 35 miles downstream of the Merced River. The Tuolumne River is 155 miles long and drains a 1,870 square mile watershed from its headwaters in the Sierra Nevada to its confluence with the SJR, approximately 10 miles west of Modesto. Approximately 52 miles of the river are downstream of La Grange Dam, the furthest downstream impediment to fish passage. Existing dams, water diversions, and downstream minimum flow agreements influence the hydrology of the Tuolumne River. Hetch Hetchy (360 TAF), Cherry Lake (270 TAF) and Lake Eleanor (27 TAF) in the Upper Tuolumne River Watershed provide hydropower and water supply for San Francisco and other Bay Area cities.

New Don Pedro, which is owned and operated by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID), is the major storage reservoir on the Tuolumne River. The 2.0 MAF reservoir stores water for irrigation, hydroelectric generation, fish and wildlife enhancement, recreation, and flood control (340 TAF for flood control). Water released from the New Don Pedro Dam is impounded and regulated by the LaGrange Dam and Reservoir. LaGrange Dam, located 2.5 miles downstream of New Don Pedro, is the diversion point for the TID and MID canals.

TID and MID have senior water rights on the Tuolumne River and control much of the river flow in most years. Under the Raker Act, which authorized the construction of the Hetch Hetchy system, the City and County of San Francisco (CCSF) must recognize the prior rights of TID and MID to receive a certain amount of the daily natural flow of the Tuolumne River as measured at La Grange Dam when the water can be beneficially used by the districts. Under the Raker Act, CCSF must bypass 2,350 cfs, or the entire natural daily flow of the Tuolumne River whenever the flow is less than that amount. From April 15–June 13 (peak snowmelt) CCSF must bypass 4,066 cfs (FERC 1996).

The 1966 Fourth Agreement, between CCSF, TID, and MID, in part, sets forth the parties' responsibilities for water banking and operations involving New Don Pedro Reservoir, including sharing responsibility for additional instream flow requirements imposed as a result of FERC licensing. CCSF does not actually divert or store water in New Don Pedro Reservoir; instead it has a water bank account in the reservoir that provides flexibility in satisfying TID's and MID's Raker Act entitlements and its Fourth Agreement obligations. Under the Fourth Agreement, CCSF is allocated 570,000 AF of storage in Don Pedro Reservoir, with an additional 170,000 AF of storage when flood control is not required, to a maximum of 740,000 AF of storage space. Certain excess flows above the Raker Act requirements are credited to CCSF, which then "banks" the amount of water for later use. CCSF debits the water bank account when it diverts or stores water that would otherwise be within the districts' entitlements. A negative balance (CCSF bank depleted) would require prior agreement with the two irrigation districts. The Fourth Agreement also states that in the event any future changes to the New Don Pedro FERC water release conditions negatively impact the two irrigation districts, CCSF, MID, and TID would apportion the burden prorated at 51.7121 percent to CCSF and 48.2879 percent to MID and TID (CCSF/TID/MID 1966).

Figure 5-1 shows two examples of how water supplies are divided (on a daily basis) between TID and MID and CCSF under different hydrologic regimes. During a dry year in 1992, only 68 TAF (mostly in April) accrued for CCSF (68 TAF is equivalent to 1,143 cfs for 30 days). CCSF asked customers to conserve water and bought additional supplies from the California Department of Water Resources' (DWR's) emergency drought water bank due to the drought conditions that year. Rain and snow returned to the Sierra Nevada in 1993, allowing full water deliveries and replenishing surface storage in the Tuolumne River Watershed (including water banked by CCSF in New Don Pedro) and the Bay Area.

The 1922-2003 average calculated volume of water potentially available to CCSF under the Raker Act was approximately 750 TAF/y, roughly the amount CCSF can bank in New Don Pedro Reservoir under the Fourth Agreement between CCSF and MID and TID, which represents approximately 40 percent of the Tuolumne River unimpaired flow at La Grange of 1,853 TAF/y for the 1922–2003 evaluation period. According to a San Francisco Public Utilities Commission (SFPUC) planning document, an average of 244 TAF/y is diverted from the Tuolumne River at Early Intake, located below Hetch Hetchy, Cherry, and Eleanor Reservoirs, based on data from 1989-2005, which represents 32.5 percent of the average annual unimpaired flow at that location (City and County of San Francisco 2008). This CCSF diversion represents approximately 13 percent of the 1,853 TAF/y average annual unimpaired flow at La Grange.

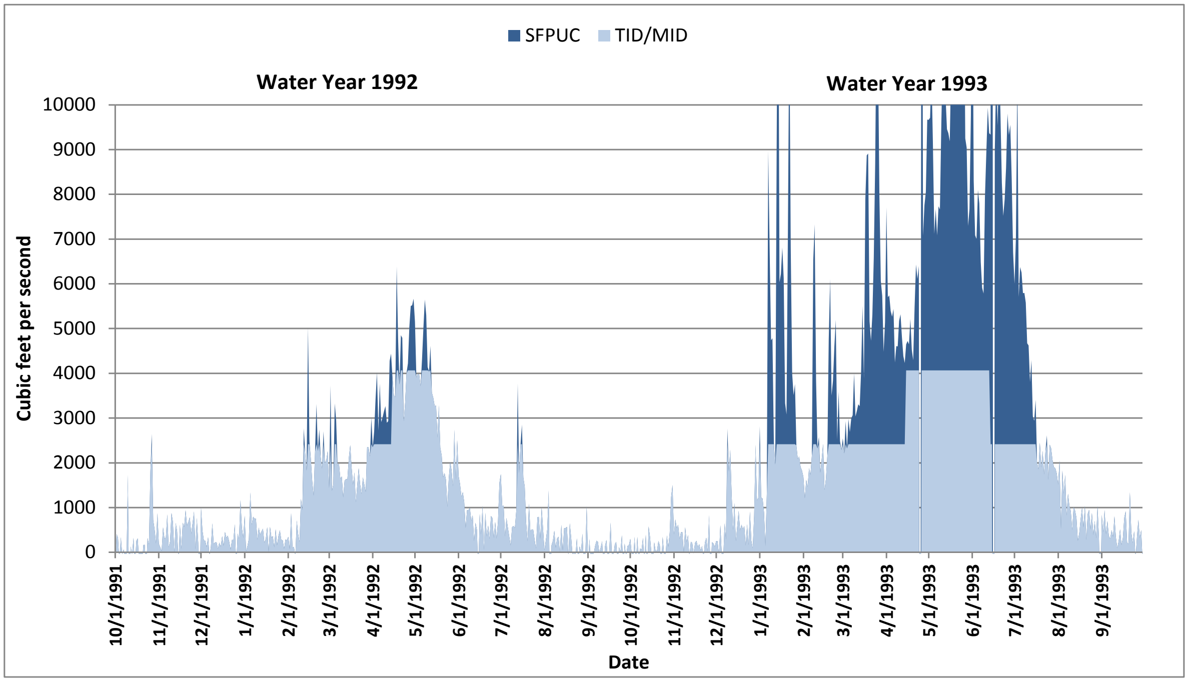

Figure 5-1. Division of Water Supply between Turlock and Modesto Irrigation Districts (TID/MID) and the City and County of San Francisco (CCSF) for 1992 and 1993 (Source: California Department of Water Resources in Environmental Defense 2004)

The average diversion into TID's canal into Turlock Lake is 575 TAF/y and another 310 TAF/y are diverted to MID's canal into the Modesto Reservoir. These diversions (885 TAF/y) represent approximately 50 percent of the median unimpaired flow of 1,776 TAF. A total of 1,175 TAF/y are diverted from the Tuolumne River, representing approximately 65 percent of the average unimpaired runoff. The FERC license (Project Number 2299) for the New Don Pedro Project was amended in 1995 to establish higher release flows on the Tuolumne River below La Grange Dam. Higher flows are required when the runoff is greater. Approximately 95 TAF are allocated on a monthly pattern in the driest years, with a maximum of approximately 300 TAF allocated in years with higher runoff. Pulse flows were specified for fish attraction to their spawning grounds in October and outmigration in April and May.

Table 5-9a gives the monthly cumulative distribution of Tuolumne River unimpaired flows for 1922–2003. Each month has a range of runoff depending on the rainfall and accumulated snowpack. The peak runoff for the Tuolumne River is observed in May and June, and relatively high runoff (median monthly runoff greater than 2,000 cfs) is observed February–June. The minimum flows are observed in August, September, and October. The median runoff for the February–June period was 2,085 cfs in February, 2,566 cfs in March, 4,498 cfs in April, 7,343 cfs in May, and 5,648 cfs in June. The average Tuolumne River runoff represents approximately 30 percent of the unimpaired flow at Vernalis. Because 290 TAF/y is diverted upstream of New Don Pedro Reservoir, the average inflow to New Don Pedro is approximately 1,563 TAF/y (85 percent of the Tuolumne River unimpaired flow).

Table 5-9b gives the monthly cumulative distribution of the historical flows for the Tuolumne River observed at Modesto for the recent period of 1985–2009. The average unimpaired flow for this 25-year period was 1,823 TAF (98 percent of the 1922–2003 average). The release flow requirements changed in 1995, as described above. The average monthly historical flows were approximately 500 cfs in the summer and fall (July–December), and were 1,000 cfs–2,000 cfs in the winter and spring (January–June). The median historical annual river flow was 361 TAF. The average annual historical flow was 811 TAF, more than 2.25 times the median, suggesting that the majority of the historical flow was the result of flood control releases in wet years. The average historical flow was approximately 45 percent of the average unimpaired flow, but the majority of this historical flow was observed in the wet years with flood control releases. New Don Pedro Reservoir allows considerable carryover storage from one year to the next.

Figure 2-9 shows the monthly unimpaired and the historical Tuolumne River flow at Modesto for the recent 10-year period of water years 2000–2009. The historical monthly flows at Modesto were generally lower than the unimpaired flows in the winter and spring months and were often slightly higher than the unimpaired flows in the late summer and fall months. The peak historical flow was in April and May of 2006 because New Don Pedro Reservoir was nearly full, and the high release flow of 8,000 cfs was for flood control purposes. The unimpaired flow at New Don Pedro Dam averaged 1,738 TAF/y and the historical releases (including flood flows in 2000, 2005, and 2006) averaged 695 TAF/y for the 10-year period. On an annual basis, the historical La Grange Dam releases averaged approximately 40 percent of the unimpaired flow, but on a daily basis the releases were usually much less than 40 percent of the unimpaired flow, with flood control releases providing the majority of the flow below LaGrange Dam.

Table 5-9a. Monthly Cumulative Distributions of Tuolumne River Unimpaired Flow (cfs) for 1922–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	0	21	55	81	142	379	1,326	1,724	283	166	0	0	383
10	64	134	219	359	752	1,354	2,719	3,467	1,509	283	52	19	842
20	87	150	332	529	1,046	1,881	3,136	4,730	2,280	364	104	42	1,055
30	116	239	423	685	1,216	2,093	3,706	5,620	3,708	559	153	63	1,189
40	149	284	550	887	1,514	2,358	4,144	6,162	4,850	919	212	85	1,414
50	178	382	783	1,213	2,085	2,566	4,498	7,343	5,648	1,119	289	125	1,776
60	193	564	920	1,715	2,496	2,870	4,927	8,071	6,722	1,781	359	165	2,024
70	254	804	1,322	2,130	2,924	3,449	5,366	8,744	7,468	2,329	447	221	2,176
80	329	1,153	1,774	2,818	4,034	4,163	5,809	9,355	8,923	3,114	563	294	2,516
90	609	1,636	3,562	4,224	5,360	5,511	6,473	10,710	10,040	4,942	901	374	3,109
Maximum	2,486	8,765	10,565	16,806	10,718	9,411	11,097	15,617	17,077	10,598	3,337	1,745	4,631
Average	265	807	1,441	2,020	2,586	3,088	4,601	7,258	5,913	2,012	432	205	1,853

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-9b. Monthly Cumulative Distribution of Historical Tuolumne River Flow (cfs) at Modesto for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	135	162	176	154	166	239	271	144	104	97	97	111	134
10	166	204	193	205	243	260	362	274	115	109	120	121	155
20	233	227	237	287	266	288	389	412	143	134	142	167	202
30	251	254	253	369	418	301	538	465	210	198	190	185	264
40	337	294	314	462	458	353	683	604	248	241	241	222	303
50	408	317	408	543	474	742	752	734	255	253	264	256	361
60	579	445	429	643	1,373	1,113	1,006	871	386	330	357	422	550
70	629	472	457	834	2,467	3,589	1,788	1,359	479	353	444	514	1,112
80	728	494	745	1,396	3,163	4,746	3,402	2,943	981	503	556	689	1,440
90	1,098	544	1,765	2,262	5,371	5,524	5,512	4,556	4,262	1,769	996	974	2,273
Maximum	1,794	1,212	4,996	15,498	8,782	6,182	8,264	7,964	5,481	3,291	1,437	2,365	2,399
Average	542	414	735	1,453	1,964	2,041	1,971	1,752	1,047	602	422	498	811

cfs = cubic feet per second
TAF = thousand acre-feet

Major Dams and Reservoirs

The hydroelectric power plant of New Don Pedro Dam has four units with a combined capacity of 203 MW and a maximum flow of 5,500 cfs (TID and MID 2011). Water released from the New Don Pedro Dam is regulated at La Grange Dam and Reservoir, which is also the diversion point for the MID and TID canals. A small hydroelectric power plant with a capacity of 4 MW and a maximum flow of 750 cfs is used to release water from the TID canal to the Tuolumne River, just downstream of La Grange Dam. Because New Don Pedro turbine capacity is generally greater than the canal diversions and river releases, it is operated for only part of each day (peaking energy); daily fluctuations in flow and water elevation in La Grange Reservoir are normal.

Water Quality

Water quality is generally considered somewhat degraded below Don Pedro Reservoir as a result of agricultural irrigation return flow and some urban and agricultural runoff (CCSF 2008). Total dissolved solids (TDS) content and turbidity generally increase in a downstream direction (CCSF 2008). The Tuolumne is identified on the 303(d) list for constituents associated with agricultural uses, such as pesticides (e.g., chlorpyrifos, diazinon, DDT), and temperature (State Water Board 2011).

Reservoir operations and changes in river flow attributable to water supply and hydropower generation activities affect some water quality characteristics in the Tuolumne River. Primary among them is water temperature. Water temperature in flowing streams depends on the temperature of the water source, air temperature, flow, surface area, and exposure to solar radiation. Reductions in stream flow when air temperature is high usually result in increases in water temperature. Storage of water in reservoirs may increase or decrease water temperatures. In the warmer months, water temperature increases in a downstream direction as the river leaves the foothills of the Sierra Nevada and flows to the floor of the San Joaquin Valley (CCSF 2008).

EC generally increases as water moves downstream in the Tuolumne River because of the relatively high EC in agricultural drainage and groundwater discharge to the river. The increase in EC is generally greater when the river flow is low. However, near the confluence with the SJR, the measured monthly EC in the Tuolumne River (at Modesto) is still generally low. The Tuolumne River EC values generally have been 0.050–0.300 dS/m (Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*).

5.2.5 Stanislaus River

Unimpaired and Historical Flow

Stanislaus River joins the SJR about 3 miles upstream of Vernalis at RM 75 and 8 miles downstream of the Tuolumne River mouth. The Stanislaus River is 161 miles long and drains approximately 1,195 square miles of mountainous and valley terrain. New Melones Reservoir, which is located just downstream of the confluence of the three forks of the Stanislaus River, is the major storage reservoir on this river. It has a storage capacity of approximately 2.4 MAF. Tulloch Dam and power plant, located 6 miles downstream of New Melones Dam, is part of the Tri-Dam Project, which is a power generation project that includes Donnells and Beardsley Dams, located upstream of New Melones Reservoir. The water released from New Melones Dam (for peaking power) is regulated in Tulloch Reservoir. Goodwin Dam is located approximately 2 miles from Tulloch Reservoir, and approximately 59 miles of the Stanislaus River are downstream of Goodwin Dam to the confluence with the LSJR.

South San Joaquin Irrigation District (SSJID), Oakdale Irrigation District (OID), Stockton East Water District (SEWD), and Central San Joaquin Water Conservation District (CSJWCD) divert water from the Stanislaus River at Goodwin Dam. As described in Chapter 2, Section 2.5.2, ~~Under the 1988 Agreement~~, senior water rights holders SSJID and OID jointly hold rights ~~with USBR~~ to divert 600 TAF from New Melones Reservoir when the projected annual inflow to New Melones is greater than 600 TAF. OID and SSJID have an agreement to equally divide the available water, each receiving 300 TAF. USBR contracted with SEWD and CSJWCD for maximum delivery of 155 TAF/y. Riparian diversions are approximately 20 TAF/y (Table F.1.2-2). The maximum diversion from the Stanislaus River is therefore 77~~5~~5 TAF/y. ~~This represents approximately 67 percent of~~ To put this number into context, the average unimpaired Stanislaus River runoff of 1,120 TAF/y. However, diversions may be limited by availability. For example, i~~I~~f annual inflow to New Melones is projected to be less than 600 TAF, the OID and SSJID diversions are governed by the 1988 Agreement, which ~~limits~~ entitles OID and SSJID ~~diversions~~ to the inflow plus one-third of the inflow deficit (600 TAF minus the inflow in TAF) (OID 2012).

The inflow to New Melones is seasonally shifted from the unimpaired flow by the upstream hydropower operations. The annual inflow to New Melones is about the same as the unimpaired runoff because, although there are several upstream storage reservoirs for hydroelectric generation, there are no major upstream diversions for consumptive uses.

Table 5-10a gives the monthly cumulative distribution of Stanislaus River unimpaired flows at New Melones dam for 1922–2003. Each month has a range of runoff depending on the rainfall and accumulated snowpack. The peak runoff for the Stanislaus River is observed in May and June and relatively high runoff (median monthly runoff greater than 1,000 cfs) is observed February–June. The lowest median flows of approximately 150 cfs are observed in August, September, and October. The median runoff for the February–June period was 1,251 cfs in February, 1,704 cfs in March, 3,247 cfs in April, 4,657 cfs in May, and 2,757 cfs in June. The average Stanislaus River runoff represents approximately 18 percent of the average unimpaired flow at Vernalis.

Table 5-10b gives the monthly cumulative distribution of the historical flows for the Stanislaus River observed at Ripon for the recent period of 1985–2009. The average unimpaired flow for this 25-year period was 1,081 TAF (97 percent of the 1922–2003 average). The Stanislaus release flow requirements have generally increased during this period. The average monthly historical flows were approximately 500–600 cfs in the summer and fall (July–December) and were approximately 850–1,250 cfs January–June. The average annual historical flow was 584 TAF, approximately 1.5 times the median flow, suggesting that a few years had substantial flood control releases. The average historical flow was approximately 52 percent of the average unimpaired flow, but the majority of this historical flow was observed in a few wet years with flood control releases. New Melones Reservoir allows considerable carryover storage from one year to the next.

Table 5-10a. Monthly Cumulative Distributions of Stanislaus River Unimpaired Flow (cfs) <u>at New Melones Dam</u> for 1922–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	0	35	56	47	25	218	586	723	190	0	0	0	155
10	48	95	146	218	398	827	1,683	1,634	681	107	33	16	467
20	70	125	189	301	576	1,142	2,108	2,637	978	213	60	37	593
30	90	155	217	400	781	1,326	2,509	3,020	1,629	308	92	57	680
40	107	170	310	512	954	1,569	2,900	3,807	2,105	426	111	68	892
50	128	229	399	664	1,251	1,704	3,247	4,657	2,757	556	152	80	1,088
60	155	288	515	923	1,759	2,023	3,485	5,236	3,215	814	180	89	1,250
70	175	381	726	1,402	1,884	2,304	3,868	5,781	3,664	1,029	222	115	1,356
80	195	520	951	1,895	2,339	2,622	4,274	6,361	4,184	1,368	302	162	1,570
90	253	804	2,028	2,940	3,417	3,802	4,631	7,153	5,572	1,810	425	216	1,921
Maximum	1,438	6,155	6,704	10,724	9,250	6,742	7,271	9,675	10,627	4,659	1,246	643	2,952
Average	157	463	858	1,322	1,685	2,076	3,226	4,585	2,953	867	203	112	1,120

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-10b. Monthly Cumulative Distribution of Historical Stanislaus River Flow (cfs) at Ripon for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	251	218	179	168	183	260	251	349	218	262	215	207	191
10	323	290	222	194	220	308	507	532	464	339	305	273	309
20	339	312	262	240	297	381	595	742	578	408	327	304	330
30	391	317	304	313	312	501	742	841	591	434	356	316	344
40	434	322	316	378	349	643	813	877	609	480	368	325	384
50	479	373	341	404	435	854	902	1,091	712	502	404	369	421
60	505	392	402	458	623	1,013	976	1,302	848	560	417	416	480
70	556	414	442	614	850	1,138	1,112	1,424	1,016	654	522	458	607

80	613	428	817	1,064	1,510	2,250	1,299	1,506	1,176	743	657	490	798
90	819	627	943	1,508	2,824	2,980	1,850	1,592	1,312	1,099	1,197	978	1,172
Maximum	1,951	962	3,194	6,273	6,499	4,887	4,537	4,130	1,867	1,876	1,792	1,702	1,537
Average	579	409	559	898	1,111	1,291	1,102	1,205	843	631	559	497	584

cfs = cubic feet per second
TAF = thousand acre-feet

Figure 2-10 shows the monthly unimpaired and historical Stanislaus River flow at Ripon for the recent 10-year period of water years 2000–2009. The historical (observed) monthly flows at Ripon are generally lower than the unimpaired flows in the winter and spring months and are often slightly higher than the unimpaired flows in the summer and fall months. The peak historical flows during this period were in 2006 because New Melones Reservoir was nearly full, and relatively high flows of 2,000 cfs–4,500 cfs were released for flood control purposes. The average unimpaired flow was 1,100 TAF/y and the average historical flow was 611 TAF/y for this 10-year period. The historical flow therefore averaged approximately 55 percent of the unimpaired flow on an annual basis, but the daily releases were usually less than 55 percent of the unimpaired flow, with flood control releases providing the majority of the flow below Goodwin Dam.

Major Dams and Reservoirs

New Melones reservoir has two hydroelectric generators with a combined capacity of approximately 300 MW (CEC 2012) and a maximum flow of 8,300 cfs. Tulloch Dam and power plant are located approximately 6 miles downstream of New Melones Dam. The water released from New Melones Dam (for peaking power) is regulated in Tulloch Reservoir, which has a capacity of 67 TAF (CALFED 2009). Tulloch reservoir operates with a seasonal variation in water depth and has a 3-foot daily fluctuation (from peaking hydropower releases)(Lake Tulloch Alliance 2007). The Tulloch hydroelectric plant has a capacity of 17 MW, with a maximum flow of approximately 2,000 cfs (CALFED 2009). Goodwin Dam is approximately two miles downstream of Tulloch Dam and is the diversion dam for the OID and SSJID canals. Water may also be gravity fed into the Goodwin Tunnel for deliveries to the CSJWCD and SEWD. The water supply diversions and river releases pass through Tulloch powerhouse. Because New Melones hydroelectric units are operated for only part of each day to release the daily diversions and river flow, daily fluctuations in flow and water elevations in Tulloch Reservoir are normal.

Water Quality

Some water quality characteristics in the Stanislaus River are affected by reservoir operations and by changes in river flow attributable to water supply and hydropower generation activities. Appendix F.1, *Hydrologic and Water Quality Modeling*, contains a description of baseline water temperatures on the Merced River, and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, includes a presentation of measured salinity conditions.

On July 2, 1969, USBR signed a Memorandum of Agreement (MOA) with the Central Valley Water Board to provide for the scheduled releases of water from New Melones Dam for water quality purposes in order to maintain DO and TDS concentrations in the Stanislaus River and the SJR, respectively. Under this MOA, releases from New Melones Dam up to 70 TAF in any one year must be scheduled to maintain DO at or above 5 mg/L in the Stanislaus River and the TDS mean monthly concentration at a maximum of 500 mg/L in the SJR immediately below the mouth of the Stanislaus River (Central Valley Water Board 2011).

EC generally increases as water moves downstream in the Stanislaus River because of the relatively high EC in agricultural drainage and groundwater discharge to the river. The increase in EC is generally greater when the river flow is low. However, near the confluence with the SJR, the measured monthly EC in the Stanislaus River (at Ripon) is still generally low, usually ranging from approximately 0.075 to 0.150 dS/m.

5.2.6 Lower San Joaquin River

Unimpaired and Historical Flow

The drainage area of the SJR above Vernalis includes approximately 12,250 square miles. Vernalis is the measurement location for SJR inflow to the southern Delta. The flow from upstream of the Merced River together with the tributary flows from the Stanislaus, Tuolumne, and Merced Rivers, intermittent flows from the westside creeks, and agricultural drainage and groundwater seepage flows, contribute to the SJR flow at Vernalis.

The State Water Board initially established SJR at Vernalis flow objectives in the 1995 Bay-Delta Plan, which are also included in the current 2006 Bay-Delta Plan and in the State Water Board's ~~Revised~~ Water Right Decision 1641 (D-1641) (revised March 15, 2000), which is the decision that implements the water quality objectives of the 1995 Bay-Delta Plan. These flow objectives require minimum flows February 1–June 30 that depend on the SJR water year type and the Delta outflow (i.e., X2[8] requirements), which depend on the Eight River Index (the sum of unimpaired Sacramento River and SJR runoff)[9]. The 30-day April–May pulse flow requirements increase when the X2 requirement is at or west of Chipps Island (75 kilometers [km], requiring an outflow of approximately 11,400 cfs). The SJR flow objectives are given in Table 5-11. In addition, the Vernalis flow objective in October is 1,000 cfs with an additional pulse flow requirement (for attraction of adult Chinook salmon) that increases the monthly average flow to 2,000 cfs in most years.[10]

D-1641 and the 2006 Bay-Delta Plan authorized a staged implementation of the April 15–May 15 pulse flow objectives to allow for scientific experimentation by conducting the Vernalis Adaptive Management Plan (VAMP). D-1641 also established the condition for the water rights of various San Joaquin River Group Authority members to provide water for VAMP and the October pulse flow objective. As a result of the implementation of VAMP, the Vernalis flow objectives have not been fully implemented because alternative pulse flows were provided under VAMP (2000–2011), which

[8] X2 is the location of the 2 parts per thousand salinity contour (isohaline), 1 meter off the bottom of the estuary measured in kilometers upstream from the Golden Gate Bridge. The abundance of several estuarine species has been correlated with X2. In the 2006 Bay-Delta Plan, a salinity value--or electrical conductivity (EC) value--of 2.64 millimhos/centimeter (mmhos/cm) is used to represent the X2 location. Note, in this SED, EC is generally expressed in deciSiemens per meter (dS/m). The conversion is 1 mmhos/cm = 1 dS/cm.

[9] The *Eight River Index* is the sum of the unimpaired runoff for the Sacramento River at Bend Bridge, Feather River inflow to Oroville, Yuba River at Smartville, American River inflow to Folsom Reservoir, Stanislaus River inflow to New Melones Reservoir, Tuolumne River inflow to Don Pedro Reservoir, Merced River inflow to Lake McClure, and SJR inflow to Millerton Lake.

[10] The October flow requirement includes up to an additional 28 TAF pulse/attraction flow during all water year types. The amount of additional water will be limited to that amount necessary to provide a monthly average flow of 2,000 cfs. The additional 28 TAF is not required in a critical year following a critical year.

now has ended. The VAMP flows are considered baseline and are included in the modeling described below.

Table 5-11. 2006 Bay-Delta Plan Flow Requirements at Vernalis

Water Year Type	Feb–June Flows (cfs)	April–May, 30-day Pulse Flows (cfs)
Critical	710 or 1,140	3,110 or 3,540
Dry	1,420 or 2,280	4,020 or 4,880
Below Normal	1,420 or 2,280	4,620 or 5,480
Above Normal	2,130 or 3,420	5,730 or 7,020
Wet	2,130 or 3,420	7,330 or 8,620

Source: State Water Board 2006.
cfs = cubic feet per second

Table 5-12a gives the monthly cumulative distribution of the SJR at Vernalis unimpaired flows for 1922–2003. Each month has a range of runoff depending on the seasonal rainfall and accumulated snowpack. The median (50 percent) monthly flows generally characterize the seasonal runoff pattern and are largely the sum of the unimpaired runoff from the rivers draining the Sierra Nevada described above. The peak runoff for the SJR at Vernalis is observed in May, with relatively high median monthly runoff (> 15,000 cfs) observed in April, May, and June. The lowest median flows of approximately 500 cfs are observed in September and October. The median flows for the February–June period were 6,294 cfs in February, 8,227 cfs in March, 15,205 cfs in April, 23,054 cfs in May, and 16,240 cfs in June. The majority of the average SJR at Vernalis runoff originated above the four major storage dams (Friant, New Melones, New Don Pedro, and Exchequer Dams), since only approximately 500 TAF (8 percent) of the Vernalis flow was from the westside creeks and the valley floor watersheds located below the four major storage dams.

Table 5-12b gives the monthly cumulative distribution of the historical SJR flows observed at Vernalis for the recent period of 1984–2009. The average unimpaired flow for this 25-year period was 5,964 TAF (97 percent of the 1922–2003 average). The release flow requirements on the three eastside tributaries have generally increased during this period. The average monthly historical flows were approximately 2,000–2,500 cfs in the summer and fall (Jul–December) and were approximately 4,000–6,000 cfs January–June. The median historical annual SJR flow volume at Vernalis was 1,707 TAF. The average annual historical SJR at Vernalis flow volume was 2,777 TAF, approximately 1.5 times the median flow, suggesting that a few years had substantial flood control releases. The average historical SJR flow at Vernalis was approximately 46 percent of the average unimpaired flow for this 25-year period, but the majority of this historical flow was observed in a few wet years with flood control releases.

Table 5-12a. Monthly Cumulative Distributions of SJR Unimpaired Flow (cfs) at Vernalis for 1922–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	135	226	270	370	469	1,065	3,421	4,332	1,271	596	179	119	1,060
10	266	482	756	1,090	2,203	4,328	8,453	10,196	5,050	1,248	390	228	2,565
20	402	679	961	1,631	3,242	5,925	9,345	13,532	6,683	1,558	556	298	3,294
30	472	799	1,191	2,174	4,063	6,502	11,451	16,697	10,444	2,167	705	349	3,626
40	573	875	1,687	2,771	4,846	7,239	13,180	19,843	13,957	3,397	821	449	4,372
50	611	1,141	2,264	3,544	6,294	8,227	15,205	23,054	16,240	4,044	1,095	528	5,804
60	771	1,607	3,037	5,522	8,656	9,940	16,063	26,775	19,258	5,671	1,475	631	6,471
70	919	2,118	4,004	6,582	10,908	11,608	18,291	28,163	23,256	7,338	1,746	767	7,370
80	1,093	3,163	5,635	10,125	15,598	15,808	19,438	31,439	27,828	10,359	2,165	1,102	8,745
90	1,433	4,567	10,127	16,209	22,086	18,631	24,588	39,962	34,832	15,453	3,969	1,409	11,035
Maximum	6,937	25,787	35,970	61,733	41,703	42,337	43,320	57,955	63,738	34,979	11,891	5,812	18,978
Average	889	2,346	4,557	6,880	9,459	10,839	15,639	23,881	18,722	6,728	1,720	832	6,176

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-12b. Monthly Cumulative Distribution of Historical SJR Flow (cfs) at Vernalis for 1984–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	788	956	895	816	758	1,422	1,168	892	481	447	483	574	656
10	1,047	1,125	1,040	1,160	1,375	1,768	1,457	1,480	1,059	709	712	872	886
20	1,343	1,285	1,292	1,437	1,789	2,097	1,905	1,968	1,115	1,110	980	939	1,144
30	1,435	1,565	1,405	1,816	2,008	2,196	2,262	2,141	1,435	1,163	1,118	1,132	1,259
40	1,734	1,685	1,548	2,106	2,175	2,429	2,545	2,638	1,660	1,306	1,236	1,335	1,385
50	2,003	1,759	1,688	2,319	2,534	2,736	2,751	2,755	1,748	1,400	1,557	1,452	1,707
60	2,567	2,004	2,085	2,500	3,152	3,421	3,173	3,560	2,157	1,682	1,913	1,970	1,928
70	2,703	2,146	2,231	3,784	6,227	8,279	4,956	4,808	2,747	2,055	2,027	2,145	3,448
80	3,181	2,528	2,587	4,625	7,796	12,285	8,012	8,490	4,238	2,624	2,604	2,484	4,206
90	3,836	2,771	4,081	5,582	11,607	14,887	19,796	14,933	12,398	4,990	3,491	3,835	6,644
Maximum	6,153	3,290	12,192	30,377	35,057	25,035	27,937	26,055	17,760	13,193	5,442	5,758	8,588
Average	2,396	1,904	2,435	4,131	6,144	6,594	6,355	5,804	3,951	2,514	1,845	1,956	2,777

cfs = cubic feet per second
TAF = thousand acre-feet

Figure 2-11 shows the monthly unimpaired historical flow at Vernalis for the recent 10-year period of water years 2000–2009. The unimpaired flows at Vernalis averaged 6,056 TAF/y and the historical releases (including flood flows in 2000, 2005, and 2006) average 2,915 TAF/y. The historical Vernalis flows average approximately 48 percent of the unimpaired flow, but the releases were usually much less than 48 percent of the unimpaired, with flood control releases providing the majority of the flow. The historical monthly flows at Vernalis were generally lower than the unimpaired flows in the winter and spring months and were often slightly higher than the unimpaired flows in the fall months.

Water Quality

Salinity and water temperature are the two main water quality constituents of concern that might be affected by the alternatives. Appendix F.1, *Hydrologic and Water Quality Modeling*, contains a description of baseline water temperatures on the LSJR, and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, includes a presentation of measured salinity conditions. Both water temperature and salinity are constituents included on the 303(d) list as impairments for the LSJR (Table 5-4) (State Water Board 2011).

The EC measurements at three stations located on the LSJR between the Merced River and the Tuolumne River (Newman, Crows Landing, and Patterson) were generally similar, usually ranging from 1.000 to 1.500 dS/m but with higher values of 1.500–2.000 dS/m in the dry years of 1988–1994 and EC values of less than 0.500 dS/m during high flows of more than 5,000 cfs (Appendix F.2).

In the SJR between the Tuolumne River and the Stanislaus Rivers, EC values were measured at Maze by DWR prior to 1992 and since 2007. Values were estimated from the Vernalis flow and EC subtracting the Stanislaus flow and EC for the intermediate years. During wet years, the Maze EC measurements ranged from less than 0.250 dS/m to approximately 1.000 dS/m. In contrast, the Maze EC ranged 1.000 dS/m–2.000 dS/m in the 1988–1994 dry period, but the EC has been less than 1.250 dS/m since 2000. This EC data suggests that the SJR at Maze has a moderate salinity with EC values generally less than 1.000 dS/m, except when the flow is less than 1,000 cfs.

5.2.7 Extended Plan Area

Water quality in upstream reservoirs above populated areas in the Stanislaus and Tuolumne Watersheds is good (Kennedy-Jenks Consultants 2013). There are no substantial reservoirs upstream on the Merced River. The Stanislaus and Tuolumne Rivers both have 303(d) listings for mercury in different locations in the extended plan area and the Tuolumne River has some listings for *E.coli (*Kennedy-Jenks Consultants 2013). In addition, taste and odor complaints have been identified (but not listed on 303(d)) at Phoenix Lake reservoir on Sullivan Creek, which flows into the northern arm of Don Pedro Reservoir but not directly to the Tuolumne River (Kennedy-Jenks Consultants 2013). Much of the Upper Merced River Watershed is in Yosemite National Park and water quality is good (Kennedy-Jenks Consultants 2014). There are no 303(d) listed water bodies above Lake McClure on the Merced River (Kennedy-Jenks Consultants 2014).

5.2.8 Southern Delta

This section describes the environmental setting with regards to southern Delta flows and exports. There are four major channels in the southern Delta: the SJR from Vernalis past Stockton; Old River from the head of Old River to Clifton Court Forebay, Grant Line Canal from Old River to Clifton Court Forebay, and Middle River from Old River to Victoria Canal. ~~Old River, between Clifton Court Forebay and Franks Tract, and Middle River downstream of Victoria Canal are also important southern Delta channels (Figure 2-12). While it mostly falls within the boundaries of the South Delta Water Agency (SDWA), the southern Delta generally includes all channels south or west of the SJR channel, some of which may be outside of SDWA boundaries.~~

Flows and CVP and SWP Exports

As mentioned earlier, the SJR enters the Delta at Vernalis. The Old River channel diverges from the SJR downstream of Mossdale and connects with Middle River and Grant Line Canal. The CVP and SWP intakes are located on Old River at the western end of the southern Delta. About half of the SJR flow is diverted west into Old River and about half of the SJR flow continues north toward Stockton. Water flows in the southern Delta are influenced by SJR inflow at Vernalis, channel flow splits, tidal flows, temporary barriers, water export facilities, local agricultural diversions, agricultural drainage, and municipal treated wastewater discharges.

Downstream of Vernalis, flow from the SJR splits at the head of Old River and either continues downstream in the SJR toward Stockton or enters Old River and flows toward the CVP and SWP pumps. When Vernalis flow is greater than approximately 17,500 cfs, a portion of the flow entering the southern Delta enters through Paradise Cut, about 5 miles upstream of the head of Old River. The amount of flow entering Old River (including flow through Paradise Cut) is affected by the agricultural barriers and the combined pumping rates of CVP and SWP relative to SJR inflows at Vernalis. When the combined CVP and SWP pumping rates are low, the flow split to Old River is roughly 50/50. The flow into Old River increases by approximately 5 percent of the combined CVP and SWP pumping. When the rock barrier at the head of Old River is installed for SJR fish protection, the flow into Old River is reduced to approximately 250 cfs of leakage through the rock barrier (Jones and Stokes 2001) or approximately 500 cfs if the culverts are open.

The South Delta Temporary Barriers Project was initiated by DWR in 1991 and consists of four rock barriers placed at various locations across southern Delta channels. Three of the barriers are installed to increase the channel water elevations for agricultural diversions. The head of Old River barrier has been installed in April and May of many years since 1992 (not in years with flows above 5,000 cfs) to improve juvenile Chinook salmon fish migration from the SJR. As discussed further Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives,* this barrier has been installed during the fall of most years since 1963 to improve flow and DO conditions in the downstream SJR near Stockton for the benefit of adult fall-run Chinook salmon migrating to upstream spawning locations.

The two major water diversions in the southern Delta are the SWP (Banks Pumping Plant) and the CVP (Jones Pumping Plant). The Contra Costa Water District (CCWD) also diverts water from the southern Delta. Many small agricultural diversions (siphons and pumps) divert water from throughout the Delta during the spring and summer irrigation season. The CVP Jones Pumping Plant, formerly known as Tracy Pumping Plant, is located about 5 miles northwest of Tracy. The Jones Pumping Plant consists of six pumps with a permitted diversion capacity of 4,600 cfs. The total CVP water supply contracts total approximately 3,500 TAF/y for the Jones Pumping Plant. Most of the CVP water exports come from the SJR when SJR flows at Vernalis are greater than CVP exports.

The Banks Pumping Plant has a physical pumping capacity of 10,300 cfs. However, flow diverted from the Delta into Clifton Court Forebay is limited by a USACE permit to a maximum of 6,680 cfs during much of the year. SWP water is either pumped into the South Bay aqueduct, pumped into San Luis Reservoir for seasonal storage, pumped further south in the California Aqueduct to Kern County Water agency, pumped over the Coastal Range in the Coastal Aqueduct, or pumped over the Tehachapi Pass to southern California contractors. Based on SWP contracts, the total water supply demand for the Banks Pumping plant is approximately 4,1~~0~~00 TAF/y.

The CVP and SWP export pumping are controlled under the 2006 Bay-Delta Plan objectives (as implemented through D-1641). Both the CVP and the SWP have maximum permitted pumping (or diversion) rates. Delta outflow requirements may limit pumping if the combined Delta inflow is not enough to satisfy the in-Delta agricultural diversions and the full capacity CVP and SWP pumping. When pumping is limited by hydrology, the Cooperative Operating Agreement (COA) governs the CVP and SWP share in reservoir releases and Delta pumping. When pumping is limited for fish protection (e.g., Old and Middle River [OMR] limits) the CVP and SWP generally share the allowable pumping.

The 1995 Bay-Delta Plan introduced the E/I ratio, which limits the combined export rate to a specified monthly fraction of the combined Delta inflow. The E/I ratio is 35 percent February–June and 65 percent June–January. The February E/I can be increased to 45 percent under low-flow conditions. This E/I objective allows a maximum pumping amount that is often similar to the allowable exports under the Delta outflow objectives, but sometimes the E/I ratio is more limiting than the required outflow. Sometimes the exports must be further reduced to increase the Delta outflow to satisfy the salinity requirements at Emmaton and Jersey Point or at the CCWD Rock Slough diversion. The SJR/export ratio was introduced as part of the 2009 National Marine Fisheries Service's Biological Opinion Stanislaus River Reasonable and Prudent Alternative (RPA), including Action 3.1.3 (NMFS BO), and limits exports to be 100 percent of the SJR inflow in critical years, 50 percent of the SJR inflow in dry years, 33 percent of the SJR inflow in below normal years, and 25 percent of the SJR inflow in above normal or wet years. These ratios effectively limit exports to 1,500 cfs for April and May unless the SJR is higher than the minimum flow required in these months (also discussed in Chapter 2, *Water Resources*). More detail about Delta regulations is provided in Appendix F.1, *Hydrologic and Water Quality Modeling.*

Tables 5-13a through 5-13c show the monthly historical CVP and SWP export pumping for 1985–2009. The CVP pumping was relatively constant through the year, with median monthly pumping of 3,500–4,200 cfs October–March. This water was used to fill the CVP portion of San Luis Reservoir to allow peak CVP water deliveries April–September. CVP pumping has been reduced April–June of most years for fish protection, with a median pumping of 2,133 cfs in April, 1,270 cfs in May, and 2,991 cfs in June. CVP pumping has been highest in July–September, with median pumping of more than 4,000 cfs. The median CVP annual pumping was approximately 2,500 TAF, which is considerably less than the total CVP demands (contracts) of 3,500 TAF. The SWP median monthly pumping was similar to the CVP pumping; the median SWP pumping was 3,000 cfs to 3,800 cfs October–March. The majority of this water was used to fill the SWP portion of San Luis Reservoir to allow peak SWP water deliveries April–September, although some water is pumped over the Tehachapi Mountains to southern California through the fall and winter months. SWP pumping has been reduced April–June of most years for fish protection, with a median pumping of 2,101 cfs in April, 1,031 cfs in May, and 1,911 cfs in June. SWP pumping has been highest in July–September with median pumping of 5,586 cfs in July, 5,539 in August, and 4,746 cfs in September. The median SWP annual pumping was approximately 2,600 TAF which is considerably less than the total SWP south-of-Delta demands (contracts) of 4,100 TAF.

The combined pumping is almost always greater than the SJR flow at Vernalis, so a considerable volume of Sacramento River water flows toward the pumps through OMR channels in almost all months. The median monthly pumping was 6,800 cfs–7,500 cfs October–March. The combined pumping was reduced for fish protection April–June, with a median pumping of 4,227 cfs in April, 2,810 cfs in May, and 4,630 cfs in June. The highest combined pumping was in the summer, with a median pumping of 9,000 cfs–10,000 cfs July–September.

Table 5-13a. Monthly Cumulative Distributions of Historical CVP Export Pumping (cfs) for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	967	954	33	1,373	557	739	816	843	790	897	989	1,594	1,338
10	2,030	2,060	1,565	2,169	2,520	1,955	1,433	857	1,096	2,914	2,677	3,333	1,932
20	3,594	2,775	2,437	2,882	3,183	2,331	1,651	936	1,725	3,838	3,911	4,001	2,079
30	3,924	3,573	3,325	3,137	3,561	2,690	1,827	1,064	2,512	4,105	4,250	4,207	2,308
40	4,117	3,705	3,591	3,490	3,710	3,378	2,022	1,179	2,912	4,241	4,347	4,272	2,475
50	4,202	3,895	3,735	3,935	3,879	3,551	2,133	1,270	2,991	4,311	4,366	4,279	2,489
60	4,236	4,098	3,864	3,985	3,936	3,903	2,164	1,390	3,025	4,340	4,375	4,289	2,501
70	4,297	4,173	4,025	4,100	4,008	4,064	2,198	1,506	3,355	4,374	4,386	4,331	2,561
80	4,310	4,218	4,129	4,202	4,196	4,105	2,357	1,736	3,980	4,395	4,399	4,361	2,627
90	4,332	4,282	4,149	4,271	4,312	4,178	2,728	2,047	4,388	4,424	4,427	4,379	2,681
Maximum	4,350	4,324	4,275	4,358	4,368	4,355	3,326	2,985	4,439	4,463	4,430	4,393	2,714
Average	3,637	3,437	3,298	3,483	3,617	3,325	2,558	1,822	2,845	4,007	3,998	3,969	2,413

cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-13b. Monthly Cumulative Distributions of Historical SWP Export Pumping (cfs) for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	344	732	113	302	234	0	17	500	269	533	1,580	999	1,524
10	1,292	1,292	1,650	1,989	1,741	1,053	700	628	474	1,952	2,649	2,509	1,700
20	1,857	2,094	2,765	2,918	1,951	1,898	1,326	735	745	2,995	3,855	2,850	2,071
30	2,586	2,279	3,010	3,146	2,614	2,706	1,770	849	1,058	3,643	4,118	3,517	2,381
40	2,850	2,714	3,657	3,470	3,445	2,868	1,921	939	1,353	4,437	4,445	3,897	2,535
50	3,027	3,192	3,841	3,712	3,749	2,985	2,101	1,031	1,911	5,586	5,539	4,746	2,605
60	3,973	3,730	4,201	4,996	4,670	3,379	2,131	1,199	2,163	6,042	6,274	5,211	2,629
70	4,674	3,827	4,262	5,752	4,851	3,812	2,448	1,365	2,561	6,235	6,549	5,848	2,819
80	5,037	5,131	5,854	6,464	4,969	5,223	2,686	1,698	3,616	6,329	6,749	6,493	3,179
90	5,973	5,312	6,532	7,440	6,267	5,848	3,018	1,901	5,045	6,694	6,988	6,939	3,520
Maximum	6,455	5,834	6,838	7,801	7,391	6,888	3,868	2,617	5,965	7,162	7,147	7,149	3,688
Average	3,342	3,297	3,940	4,328	3,718	3,633	2,546	1,607	2,382	4,648	5,121	4,624	2,606

SWP = State Water Project
cfs = cubic feet per second
TAF = thousand acre-feet

Table 5-13c. Monthly Cumulative Distributions of Historical CVP and SWP Combined Export Pumping (cfs) for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual (TAF)
Minimum	1,732	1,687	2,088	1,674	2,263	2,062	1,464	1,377	1,760	1,431	2,569	4,140	2,945
10	4,455	3,956	3,411	4,589	4,108	3,234	2,529	1,585	1,886	4,866	5,634	5,300	3,519
20	5,226	5,192	4,789	5,901	5,571	3,903	3,269	1,748	2,545	7,018	7,538	6,984	4,364
30	5,640	5,748	6,476	6,223	6,336	5,839	3,752	2,011	3,330	7,839	8,502	7,521	4,698
40	6,371	6,213	7,197	7,120	6,771	6,950	4,137	2,527	4,252	8,914	8,839	8,177	4,976
50	7,237	6,823	7,468	7,477	7,454	7,019	4,227	2,810	4,630	9,943	9,921	9,120	5,035
60	8,127	7,671	7,875	8,918	8,450	7,052	4,390	2,982	4,951	10,335	10,657	9,568	5,179
70	8,871	8,141	8,305	9,883	8,728	7,551	4,513	3,067	6,517	10,577	10,956	10,152	5,354
80	9,254	9,325	9,577	10,495	9,143	8,015	4,758	3,287	7,367	10,713	11,161	10,816	5,887
90	10,276	9,413	10,696	11,532	10,261	8,849	5,211	3,812	9,330	10,972	11,300	11,217	6,155
Maximum	10,767	9,958	10,913	12,018	11,499	11,029	5,989	4,692	10,378	11,536	11,555	11,511	6,305
Average	6,978	6,734	7,238	7,811	7,334	6,958	5,105	3,429	5,227	8,655	9,119	8,593	5,019

CVP = Central Valley Project
SWP = State Water Project
cfs = cubic feet per second
TAF = thousand acre-feet

Southern Delta Water Levels and Flows

This section summarizes the baseline water level and flow conditions in the southern Delta channels as currently managed with the DWR Temporary Barrier Program (TBP). The temporary barriers are installed during the irrigation season in Old River near the DMC, in Grant Line Canal at Tracy Boulevard Bridge, and in Middle River upstream of Victoria Canal. The temporary barriers (weirs) block the tidal flows during ebb tide (falling water elevations, water moving downstream towards the estuary) and thereby maintain higher elevations during ebb tides. This section also summarizes modeling results that show how tidal elevations and flows in the southern Delta channels are affected by CVP and SWP pumping and by the TBP (DWR and USBR 2005). Some recent changes in the operational design of the barriers would affect these results slightly, but not materially.

Because water levels in the southern Delta channels are tidally influenced, they are always changing (fluctuating). Because agricultural diversions (siphons and pumps) may be limited at lower water levels (elevations) a general goal in the southern Delta channels has been to maintain suitable water elevations for the beneficial use of water for agriculture. Flow conditions in a tidal channel are more difficult to determine than for a river. Water elevations in a river will always increase with higher flows, whereas fluctuations in tidal elevations and tidal flows would be gradually reduced with higher net channel flows. Tidal elevations can be averaged over a monthly lunar cycle, with the average high tide (mean high water [MHW]) or the average low tide (mean low water [MLW]) calculated. Because low water levels in the southern Delta channels have the greatest effect on agricultural diversions, the MLW provides a good measure of water level conditions.

In a river, the direction of flow is downstream and flows typically dilute any salt discharge and transports the salt downstream. However, the direction and magnitude of flow for a network of tidal channels is more difficult to calculate. The tidal flow during each ebb tide moves water one direction (~~towards the estuary~~downstream) and the tidal flow during each flood tide moves water in the opposite direction (~~away from the estuary~~upstream). EC will increase in a tidal channel having a high salinity discharge both upstream and downstream of the discharge; the increase in salinity will be less ~~if the tidal flows are large (from a greater tidal mixing volume) or~~ if the net flow is large (from greater dilution). The increase in salinity will also be less if tidal flows are large (i.e., greater tidal mixing volume and spreading of the salinity) if the discharge is temporary or if the tidal flows can carry the water to locations where it will be more likely to be transported away from the region.

Effects of Pumping and Barriers on Water Levels and Flows

The natural tidal elevations and tidal flows that would occur in the southern Delta channels with a specific SJR inflow at Vernalis but without the CVP Jones and SWP Banks pumping diversions would be the highest possible water elevations, the greatest possible tidal flows, and the highest net flows in the southern Delta channels. This maximum possible combination of water levels, tidal flows, and net flows can be used to compare the changes (reductions) in water levels and flows in the southern Delta channels caused by exports or TBP conditions. This summary of the southern Delta channel tidal elevations and tidal flows is based on Section 5.2, *Delta Tidal Hydraulics*, of the *Draft South Delta Improvement Program Environmental Impact Statement/Environmental Impact Report* (SDIP EIS/EIR) (DWR and USBR 2005).

The major effect on southern Delta tidal elevations and tidal flows results from CVP and SWP pumping. The CVP Jones plant maximum pumping capacity is 4,600 cfs, and these pumps operate throughout the tidal cycle. The SWP Banks plant is operated to use off-peak energy, and the Clifton Court Forebay (CCF) gates are typically closed during the flood tide prior to the high tide each day to allow the maximum possible high tide elevations in the southern Delta channels (with CVP pumping). The CCF gates are also closed during low tide elevations if the water level in Old River is less than the CCF water elevation. CVP and SWP pumping will reduce the tidal elevations, with current maximum pumping of approximately 12,000 cfs lowering the high tide elevations by 1.5 ft. and lowering the low tide elevations by approximately 0.75 ft. The tidal flows in the channels are reduced substantially (50 percent less with full pumping). The net flows in Old River and Grant Line Canal (from the SJR diversion to Old River) are not changed substantially by pumping. Slightly more SJR water is diverted into Old River by CVP and SWP pumping (approximately 5 percent of the pumping flow). Most of the water needed to supply higher CVP and SWP pumping moves south in the Old and Middle River (OMR) channels from the central Delta; the net flows are increased, while the tidal flows are only reduced slightly in OMR channels downstream (i.e., north) of the pumping plants. The tidal elevations and tidal flows are more substantially affected by the temporary barriers, which reduce~~block~~ tidal flow.

Figure 5-2 shows the actual (measured) effects of the temporary barriers on tidal elevations at the Old River at the DMC barrier, located just upstream of the DMC intake in 2003. The measured daily minimum and maximum tidal elevations in Old River upstream and downstream of the temporary barrier near the DMC intake demonstrate the effect of the barrier (weir), which was installed with an elevation of approximately +2 ft. MSL (mean sea level). All of the tidal elevations show the typical lunar-cycle fluctuations (i.e., 14-day period). The minimum tidal elevations were between 0.0 and -1.0 ft. downstream of the barrier, and were increased to between 0.0 and +1 ft. MSL above the barrier when the barrier was installed (with culverts open) in early April. The minimum elevations were increased to between 1.0 and 2.0 ft. MSL above the barrier when the culverts were closed in early June (after the VAMP period). The minimum and maximum tidal elevations at Martinez for 2003 are shown for reference as the full tidal elevation range. The effect of the temporary barrier on minimum tidal elevations (MLW) was an increase of approximately 2 ft. above the barrier. Pumping does not appear to have any large effect on tidal elevations near the DMC. The temporary barrier affects flow in Old River upstream of the barrier, as discussed below.

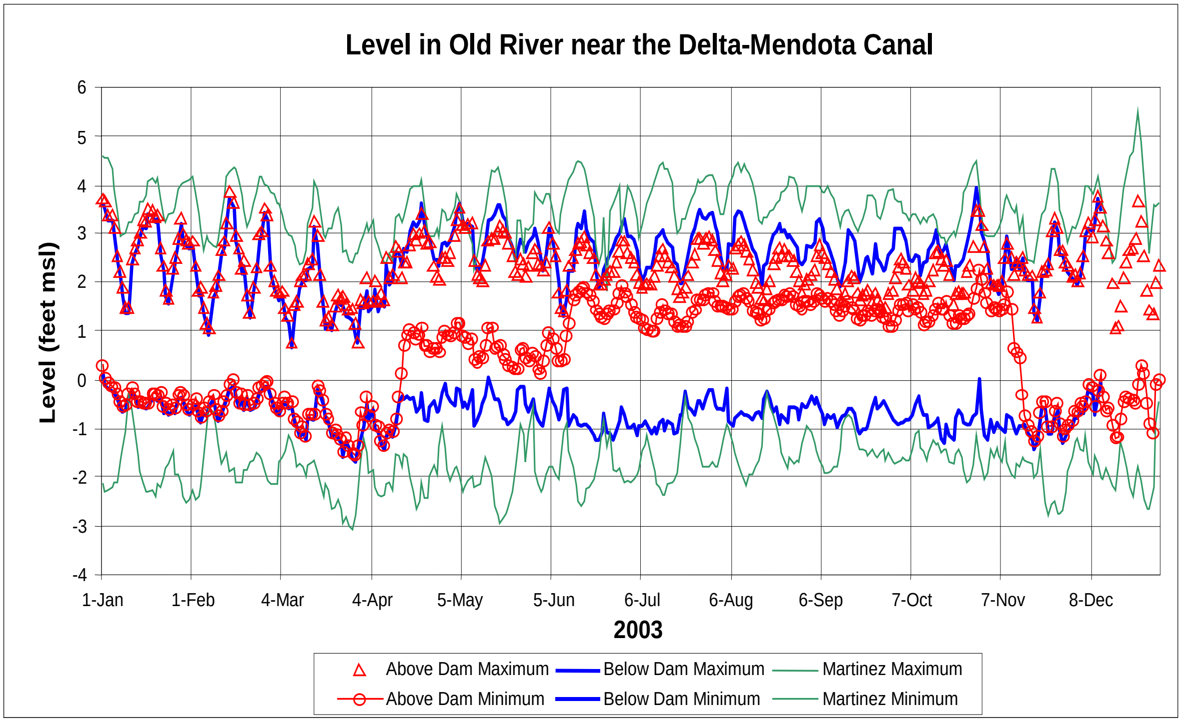

Figure 5-2. Measured Daily Minimum and Maximum Tidal Elevations in Old River Upstream and Downstream of the Temporary Barrier (near the DMC Intake) Compared to the Tidal Elevations at Martinez for 2003 (Source: DWR and USBR 2005 Figure 5.2-46) (msl = mean sea level)

A series of 1-month Delta Simulation Model II (DSM2) simulations for representative historical tidal variations of July 1985 were used in the SDIP to show the effects of CVP and SWP pumping and the effects of the temporary barriers. The simulated SJR at Vernalis flow was 1,640 cfs, the CVP pumping was 4,530 cfs, and the SWP pumping was 7,150 cfs for July 1985. The natural tidal level and flow variations in the southern Delta channels without any CVP or SWP pumping or temporary barriers were simulated as a reference. Figures 5-3a and 5-3b shows the DSM2-simulated tidal level and tidal flow volumes at the Old River at the DMC barrier location (upstream of the DMC entrance), with no CVP and no SWP pumping. The tidal flow volume was calculated from the tidal flow during each ebb or flood tide period. The daily ebb-tide or flood-tide flow volume (acre-feet [AF]) is equivalent to the average tidal flow (cfs) for the 12-hour period of flood tide (positive) or ebb tide (negative) during each day. The water level ranged from approximately –0.8 ft. to approximately 4.0 ft. MSL, with a median of 1.4 ft. MSL. The DSM2-simulated average downstream tidal flow was 1,340 cfs (during 12 hours each day), the average upstream tidal flow was –1,480 cfs (during 12 hours each day), and the net (upstream) tidal flow was –70 cfs. The simulated SJR diversion to Old River was 975 cfs, and the net flow in Grant Line Canal was 395 cfs (much less than the SJR diversion to Old River because of agricultural diversions); therefore, this upstream flow in Old River at the DMC barrier location resulted from agricultural diversions along Old River upstream of the barrier.

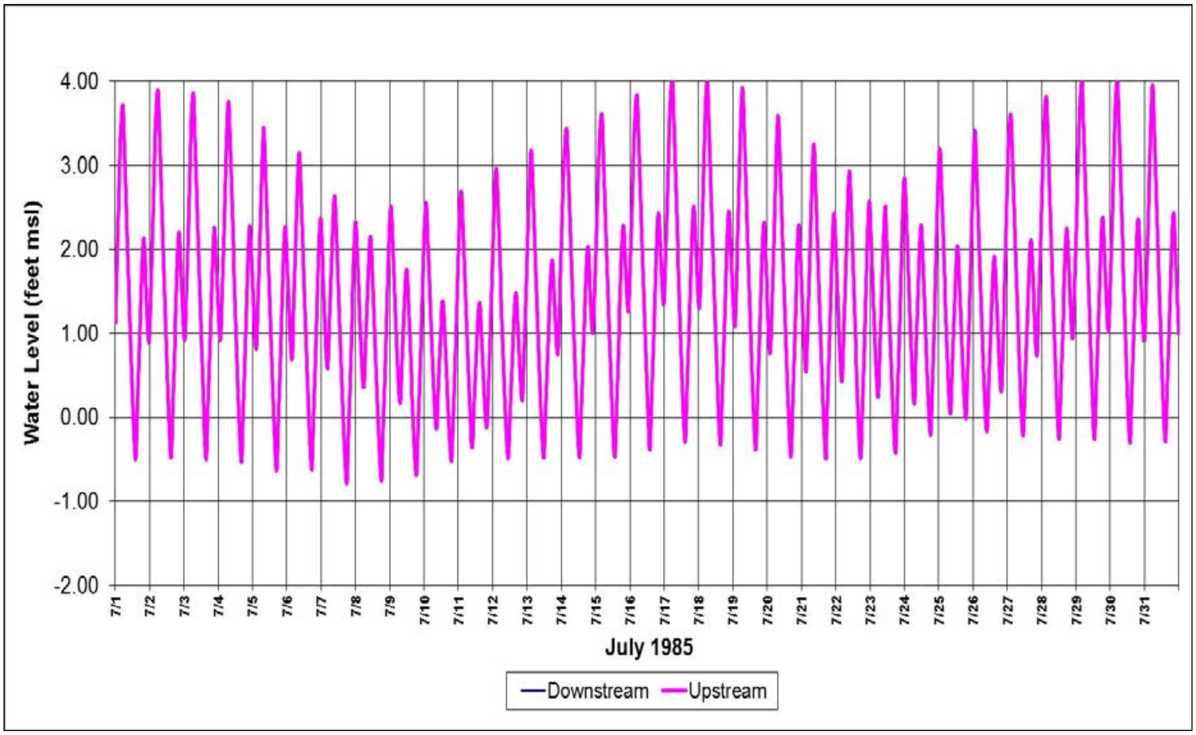

Figure 5-3a. DSM2-Simulated Tidal Elevations for Old River at the DMC Temporary Barrier Location with No CVP or SWP Pumping and No Barrier for July 1985 (Source: DWR and USBR 2005 Figure 5.2-29) (msl = mean sea level)

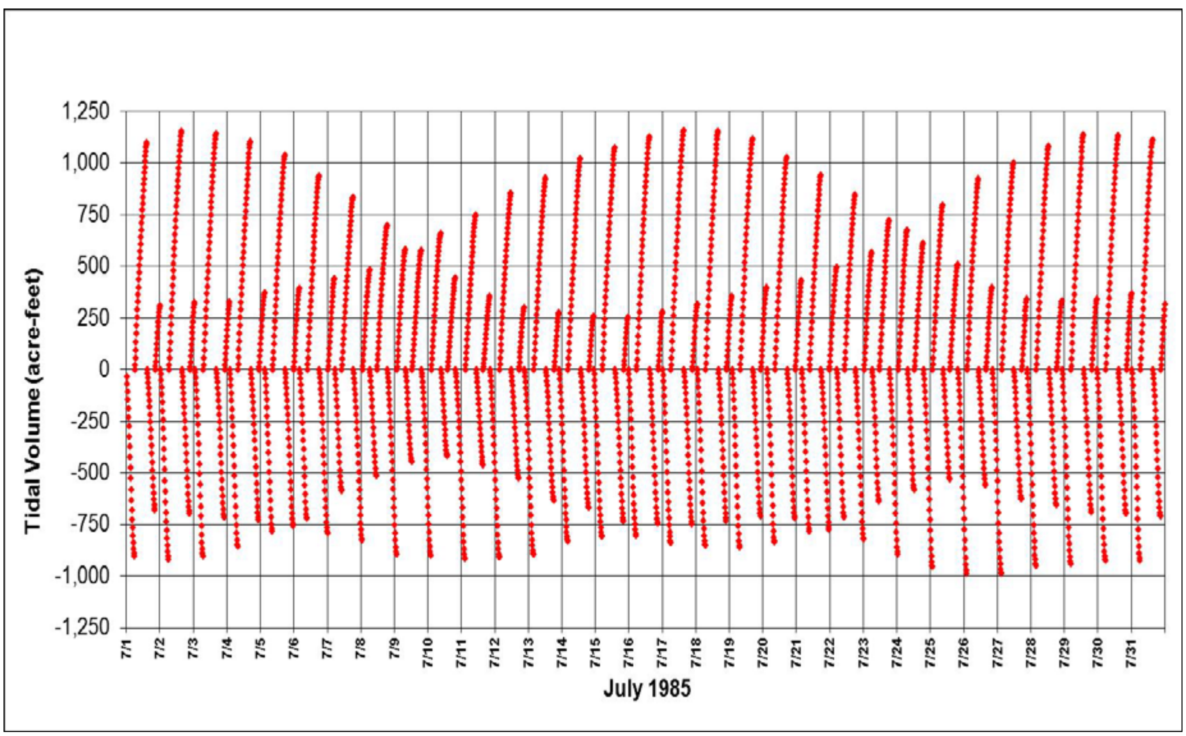

Figure 5-3b. DSM2-Simulated Tidal Flow Volumes (acre-feet) for Old River at the DMC Temporary Barrier Location with No CVP or SWP Pumping and No Barrier for July 1985 (Source: DWR and USBR 2005 Figure 5.2-29)

Figures 5-4a and 5-4b show the DSM2-simulated tidal level and tidal flow volumes at the Old River DMC barrier location with CVP and SWP pumping (but no temporary barrier). The DSM2-simulated average downstream tidal flow was 680 cfs, and the average upstream tidal flow was −712 cfs, with a net (upstream) flow of −17 cfs. The tidal flows in Old River at the DMC barrier location were about half of the tidal flows without any CVP or SWP pumping, but the net flow was slightly increased as a result of the pumping (i.e., less negative). The simulated SJR diversion to Old River was 1,470 cfs (increased to 90 percent of the SJR flow as a result of the pumping) and the Grant Line Canal net flow was 1,017 cfs (increased because of higher SJR diversion to Old River). The CVP and SWP pumping reduced the tidal flows but increased the SJR diversion to Old River and the net flows in these southern Delta channels.

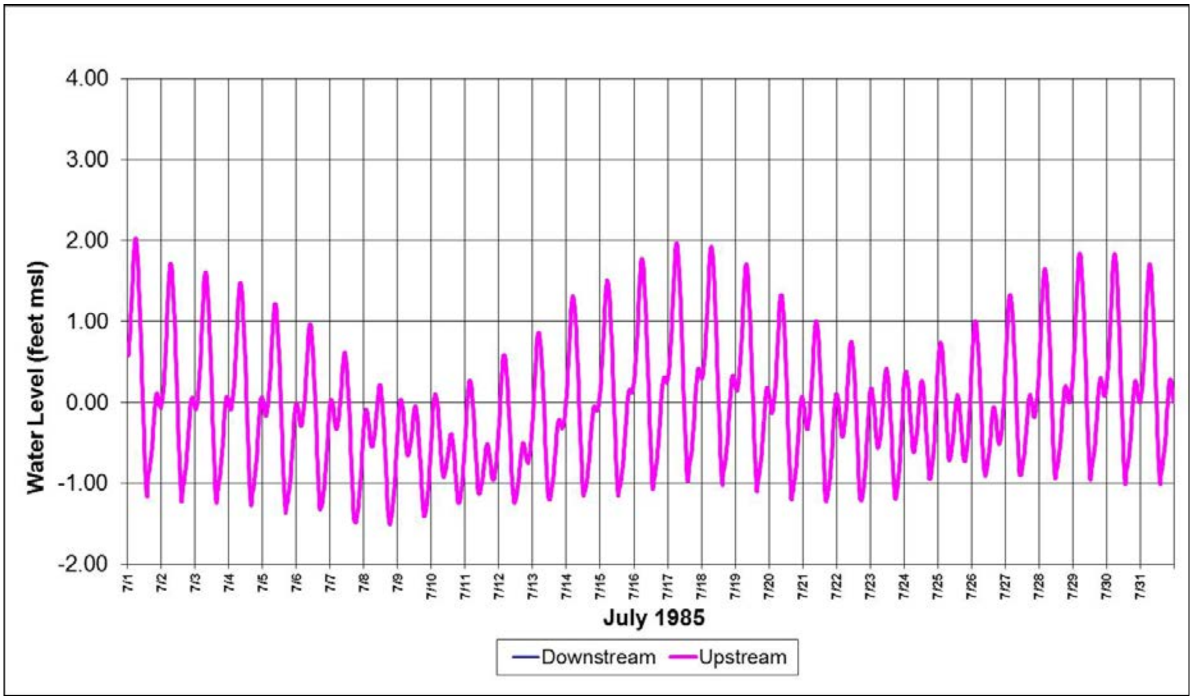

Figure 5-4a. DSM2-Simulated Tidal Elevations for Old River at the DMC Temporary Barrier Location with CVP Pumping (4,533 cfs) and SWP Pumping (7,180 cfs) with No Barriers for July 1985 (Source: DWR and USBR 2005 Figure 5.2-33) (msl = mean sea level)

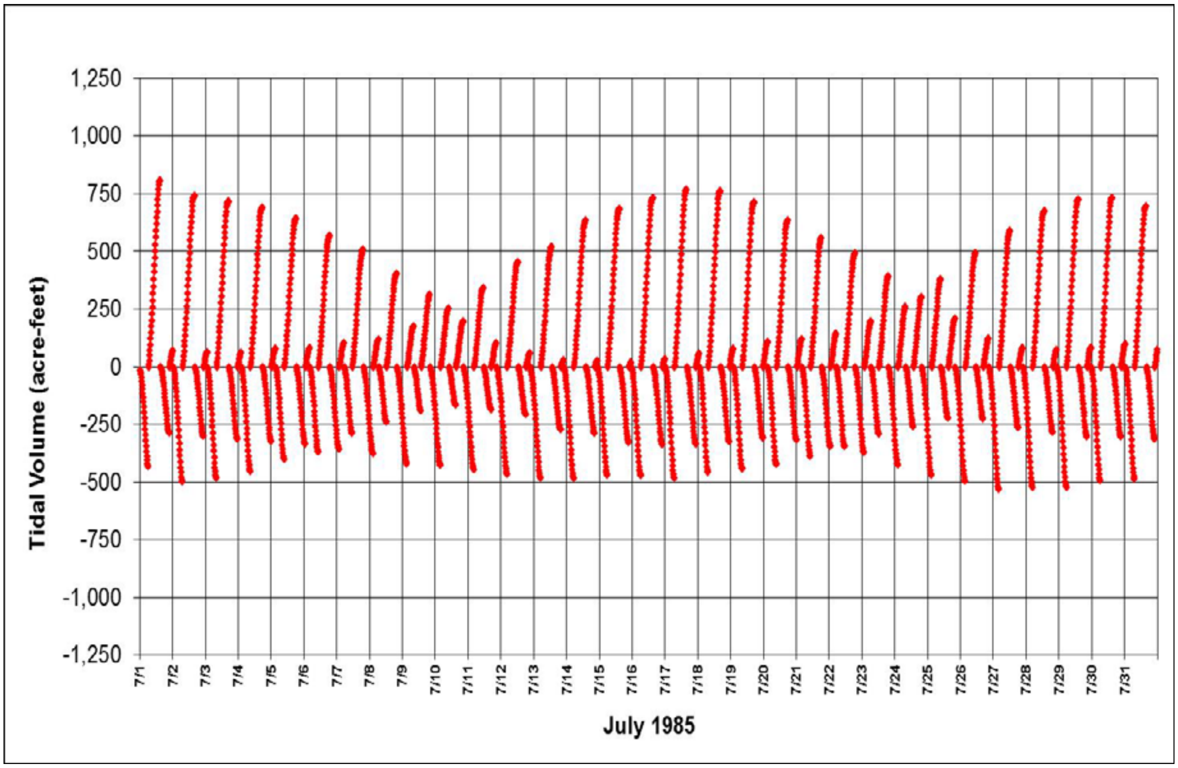

Figure 5-4b. DSM2-Simulated Tidal Flow Volumes (acre-feet) for Old River at the DMC Temporary Barrier Location with CVP and SWP Pumping with No Barriers for July 1985 (Source: DWR and USBR 2005 Figure 5.2-33)

Figures 5-5a and 5-5b show the DSM2-simulated tidal level and tidal flow volumes at the Old River temporary barrier location near the DMC with CVP and SWP pumping and with the TBP barriers. The downstream tidal level ranged from -1.8 ft. MSL to approximately 3.6 ft. MSL, with a median of 0.0 ft. MSL. The upstream water level during low tide was maintained by the temporary barrier weir, which had a simulated crest elevation of approximately 2.0 ft. The upstream tidal level varied from approximately 0.8 ft. to approximately 2.7 ft, with a median of 1.3 ft MSL. Upstream flow through the weir culverts can begin with the flood tide, although the greatest upstream flow occurs when the tidal elevation downstream of the weir rises above the weir height. The downstream tide reached a maximum of 3.5 ft MSL on many days, but the flow over the weir (of approximately 1,000 cfs) was not sustained for long and was not sufficient to raise the upstream level to more than 2.5 ft MSL. Upstream flow over the barrier did not begin until the downstream level reached the weir crest at 2.0 ft MSL. This did not occur during the neap-tide periods July 7–July 11 and again July 23–July 25. Downstream flow was blocked once the upstream level dropped to 2.0 ft MSL. The tidal flow at the Old River at DMC barrier was very restricted compared to conditions without the temporary barrier. The DSM2-simulated average downstream tidal flow was 24 cfs, and the average upstream tidal flow was -171 cfs, with a net (upstream) flow of -73 cfs. The upstream tidal flows in Old River at the DMC barrier location were approximately 25 percent of the tidal flows with CVP and SWP pumping but without the temporary barriers, but the net flow was about the same as without pumping and without barriers. The simulated SJR diversion to Old River was 930 cfs (reduced compared to without the barriers) and the Grant Line Canal net flow was 460 cfs (reduced because of less SJR diversion to Old River). The TBP barriers greatly reduced the tidal flows and also reduced the DSM2-simulated SJR diversion and net flows in these southern Delta channels. Recent tidal flow measurements at the head of Old River indicate that the effects of the temporary barriers on reducing the SJR diversions are not as large as the DSM2 model indicated; the temporary barriers may not change the net flows in the southern Delta channels, but they reduce the tidal flows upstream of the temporary barriers by approximately 50 percent. The TBP does increase the low tidal levels (MLW) by approximately 1–2 ft, but the TBP may also cause increased salinity in portions of the channels upstream of the barriers, because of reduced tidal flow mixing (dilution).

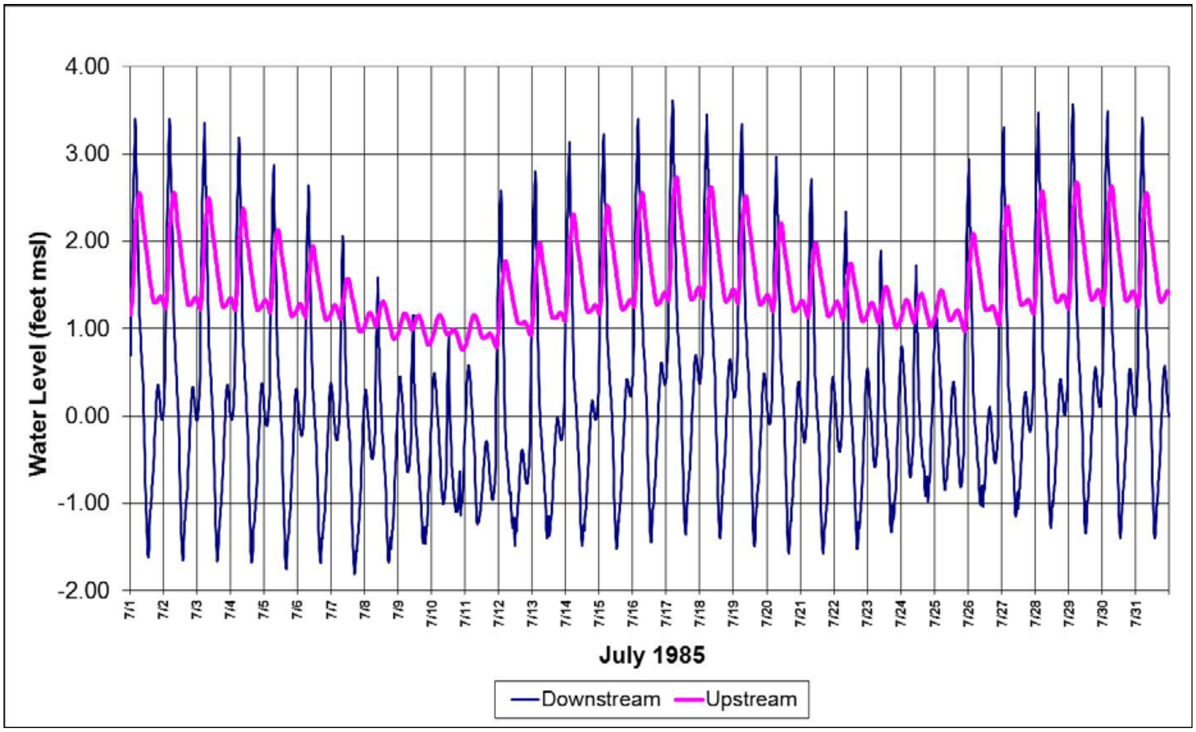

Figure 5-5a. DSM2-Simulated Tidal Elevations for Old River at the DMC Temporary Barrier with Full CVP and SWP Pumping with the Barrier Installed for July 1985 (Source: DWR and USBR 2005 Figure 5.2-37) (msl = mean sea level)

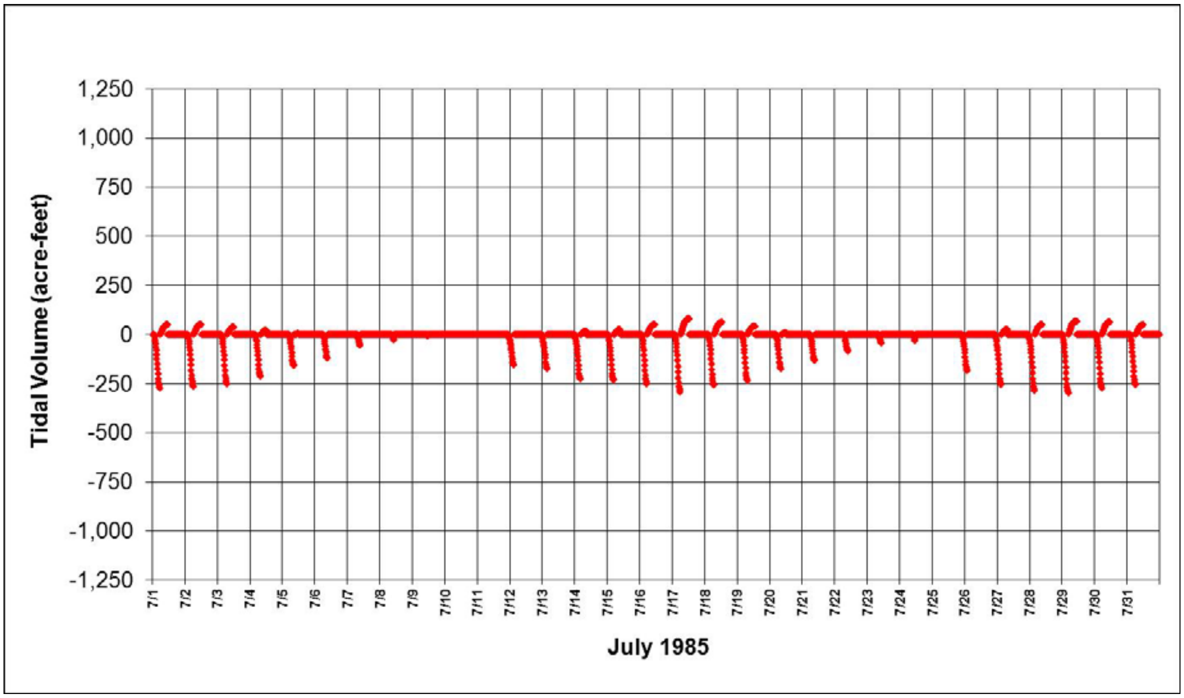

Figure 5-5b. DSM2-Simulated Tidal Flow Volumes (acre-feet) for Old River at the DMC Temporary Barrier with Full CVP and SWP Pumping with the Barrier Installed for July 1985 (Source: DWR and USBR 2005 Figure 5.2-37)

Water Quality and Salinity

The range of salinity conditions that exist across the large majority of the Delta are sufficiently low that the SJR Watershed and southern Delta channels are subject to freshwater regulatory water quality objectives. Salinity conditions in the southern Delta and SJR Watershed fall within the range of values that are adequate for freshwater aquatic life. Consequently, potential impacts on agricultural beneficial uses are the primary focus in the discussion of salinity changes in this chapter since EC values in the study area are sometimes exceed the EC objectives for the protection of agriculture beneficial uses.

A synopsis of the current Bay-Delta plan water quality objectives for the protection of agricultural water use is presented here. Further detail regarding the regulatory background with respect to water quality and other legal requirements is provided below in Section 5.3. Tables 2 and 3 of the 2006 Bay-Delta Plan include objectives for flow and EC for the southern Delta and Lower SJR to protect the beneficial uses of fish and wildlife and agriculture, respectively. The water quality objectives include the following.

> Under all water year types, the three interior southern Delta compliance stations (i.e., Old River near Middle River, Old River at Tracy Rd. Bridge, and SJR at Brandt Bridge) and the SJR at Airport Way Bridge, Vernalis station have a maximum 30-day running average of mean daily EC (dS/m) of 0.7 April–August and 1.0 September–March.[11]

[11] Although the 0.700 dS/m salinity objective was included in the 1978 and the 1995 Bay-Delta Plans, implementation of the objective was postponed. Water Right Decision 1641 assigned responsibility to DWR and USBR to meet the 1.0/0.7 dS/m EC objective at the three southern Delta locations, and this requirement became effective on April 1, 2005. The 1.0/0.7 dS/m EC objectives at Vernalis have been implemented since 1995 when

Under all water year types, the Stockton Deepwater Ship Channel section of the SJR between Turner Cut and the City of Stockton maintains DO levels that are above 6.0 mg/l during the months of September, October, and November for the protection migrating adult salmon.

EC values in the southern Delta are affected primarily by the salinity of water flowing into the southern Delta from the SJR at Vernalis, salt discharged back into southern Delta channels that was previously diverted for irrigation, the combined CVP and SWP pumping influencing salinity in the southern Delta, and tidal mixing of inflow from the Pacific Ocean. Municipal treated wastewater discharges have some effect on the southern Delta salinity. The SJR flow at Vernalis has a large effect on the SJR salinity at Vernalis. Higher flows will generally reduce the salinity, following a dilution relationship in which salinity is inversely proportional to the flow. Higher CVP and SWP pumping also has an effect on southern Delta salinity by bringing more low-salinity Sacramento River water across the Delta to the export pumps. However, periods of low Delta outflow (in the fall months) causes increased seawater intrusion and higher EC at the southern Delta export and CCWD intakes.

EC at the three southern Delta compliance stations downstream of Vernalis (SJR at Brandt Bridge, Old River at Middle River [Union Island], and Old River at Tracy Boulevard) are generally higher than the Vernalis EC because of agricultural drainage and municipal discharges. All of the agricultural land in the southern Delta diverts irrigation and salt leaching water (during winter months) from the southern Delta channels. The total amount of diverted water can generally be estimated from the irrigated acreage, with approximately 3–4 AF per acre applied. The withdrawal of water from channels for use on agricultural fields (i.e., agricultural diversions) does not change the salinity of the channel water. But because agricultural drainage (i.e., runoff from agricultural fields) eventually returns the diverted salt that is applied to the soils back to the channels (often during rainfall runoff and salt leaching periods in the winter), there is an indirect and/or delayed increase in southern Delta salinity. In some channel locations (e.g., Old River at Tracy Boulevard) there can be an increase in the channel salinity during the irrigation season as a result of the agricultural drainage returning to the channels (Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*).

There are several treated wastewater discharges in the southern Delta. Figure 2-12 identifies their locations. The effects of the wastewater discharges depend on the difference between the discharge EC and the river EC. All of the salt from agricultural drainage and wastewater discharges, as well as from the SJR at Vernalis, is generally exported at the CVP and SWP export pumping plants. Because CVP and SWP export pumping draws a majority of the exported water from the Sacramento River, thereby reducing the salinity in the channels near the pumping plants, it is difficult to detect the effects of agricultural drainage or treated municipal wastewater discharged in the southern Delta. Table 5-14 lists the major wastewater dischargers (greater than 1 million gallons per day) and their effect on existing EC concentrations in the southern Delta.

Water Right Order 95-6 assigned responsibility to USBR to meet the Vernalis EC objectives. D-1641 continued the requirement for USBR to meet the Vernalis EC objectives.

Table 5-14. Effect of Wastewater Dischargers on Existing Salinity Concentrations in the Southern Delta

Wastewater Discharger	Permitted Discharge (cfs)	2014 Annual Average EC (dS/m)	Daily Salt Load (Tons)	Annual Salt Load (Tons)	Effects on SJR
Manteca	27.1	0.7	33	12,140	The effect of the Manteca discharge on EC of the SJR is minimal because the average discharge EC of 0.7 dS/m is not above the irrigation season salinity objective.
Stockton	85.1	1.0	149	54,460	The effects of the Stockton discharge on EC of the SJR can be estimated for any river flow and EC value. For example, with a river flow past Stockton of 750 cfs with an EC of 0.7 dS/m (irrigation season), the Stockton discharge would increase the river EC by about 0.031 dS/m (i.e., [1.0 -0.7] x 85 / [750+85]).
Tracy	24.8	1.3	57	20,630	If the Old River flow was 750 cfs with an EC of 0.7 dS/m, the City of Tracy discharge would increase the Old River EC by about 0.019 dS/m (i.e., [1.3-0.7] x 25 / [750+25]).
Mountain House	8.4	1.0	15	5,380	The effects of the Mountain House treated wastewater discharge on EC are more difficult to estimate because the flows in this section of Old River are tidal, so water may enter and leave this Old River channel section from both ends. The net summer flows at the upstream end (near Tracy Boulevard Bridge) tend to be positive (i.e., downstream) but less than 100 cfs, because the agricultural diversions in Old River of about 100–250 cfs are drawing water from both ends of the Old River channel.
Discovery Bay	3.2	2.0	11	4,100	Because the pumping at the CVP and SWP pumps is generally greater than the Old River flow from the SJR, net flows are generally upstream and the wastewater discharge is mixed with the southern Delta exports, just like the other southern Delta discharges.

Source: Chapter 13, *Service Providers*, Tables 13-4 and 13-5.
Note: Only discharges of greater than 1 million gallons per day (1.5 cfs) are included in this table.
1 dS/m = 1000 microSiemens per centimeter (1000 µS/cm)
cfs = cubic feet per second
EC = salinity (electrical conductivity)
dS/m = deciSiemens per meter

Historical Salinity (EC) Measurements

The measured EC values throughout the southern Delta indicate that the monthly patterns of EC are generally below the existing Bay-Delta Plan EC objectives. There have been periodic exceedances of the objectives in recent dry years at one or more of these stations, but high salinity is not the general pattern. High salinity that exceeds the existing EC objectives in about half of the years in the irrigation months of April–August has been routinely measured only at Tracy Boulevard Bridge. The monthly salinity is controlled by the Vernalis EC and is then slightly increased by agricultural drainage and treated municipal wastewater. Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, describes the salinity conditions in the Lower SJR and southern Delta using the available flow, EC, and salt load data.

Baseline salinity conditions in the SJR and southern Delta channels can be summarized with the USGS and DWR monitoring data from the period 1985–2011. Tables 5-15a through 5-15d show the distribution of monthly average EC values that have been measured during that period at Vernalis, the SJR at Brandt Bridge, Old River at Middle River (Union Island), and Old River at Tracy Boulevard, respectively. The lowest values have only occasionally been below 0.200 dS/m. The highest 90th percentile value was 1.174 dS/m (in Old River at Tracy Boulevard in February). Maximum monthly values have rarely been greater than 1.200 dS/m, with the highest monthly value of 1.326 dS/m again occurring in Old River at Tracy Boulevard during February. These data show that the EC values in the southern Delta rarely fall outside of a range of 0.200–1.200 dS/m.

Table 5-15a shows the historical EC data from Vernalis for 1985–2011 (27 years), presented in the monthly cumulative distribution format. The monthly median values provide the general seasonal pattern. The highest monthly median values were in December–March, when the salinity objective in the 2006 Bay-Delta Plan is 1.000 dS/m. The lowest monthly median EC values were measured in the irrigation season of April–August, when the salinity objective in the Bay-Delta Plan is 0.700 dS/m. The average Vernalis EC was lower in months with higher flows and higher in months with lower flows. The lowest EC (10 percent cumulative values) were 0.200–0.400 dS/m during the April–August irrigation season and were 0.250–0.500 dS/m September–March.

The January and February EC values were greater than 1.000 dS/m, the current 2006 Bay-Delta Plan salinity objective, in approximately 10 percent of the years. The March and April EC values were greater than 1.000 dS/m in just a few years. The measured EC values were greater than 0.700 dS/m April–August, the current 2006 Bay-Delta Plan salinity objective, in approximately 10 percent to 30 percent of the years depending on the month (e.g., less than 10 percent for May and almost 30 percent for July). The Vernalis EC approached the 1.000 dS/m objective in January–March 2003 and January–March 2009. The Vernalis EC has been above 0.650 dS/m in only approximately 6 months during the April–August period since 1996 because New Melones releases water to meet the EC objective at Vernalis.

Table 5-15a. Monthly Average Measured SJR at Vernalis EC (µS/cm) for 1985–2011

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Minimum	262	452	210	128	144	163	128	95	110	152	214	239
10	310	504	336	338	250	230	200	166	184	320	432	332
20	398	579	587	490	338	314	276	230	264	473	498	410
30	414	616	728	534	553	412	351	296	452	541	525	475
40	476	657	752	639	630	672	470	352	500	586	570	550
50	507	673	771	752	750	747	535	380	575	611	608	591
60	524	692	782	778	784	800	570	438	627	633	629	626
70	584	705	836	815	873	835	643	501	686	693	651	687
80	696	755	853	945	940	904	695	644	731	758	758	762
90	768	807	880	1,047	1,104	962	743	692	827	766	797	798
Maximum	866	819	926	1,137	1,299	1,095	1,144	718	871	846	873	898
Average	520	661	699	694	695	647	506	413	534	583	600	578

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-15b shows the historical EC data from Brandt Bridge for 1985–2009 (25 years), presented in the monthly cumulative distribution format. The monthly median EC values at Brandt Bridge show the same seasonal pattern as Mossdale and Vernalis. There is some agricultural drainage between Vernalis and Brandt Bridge, but the monthly EC at Brandt Bridge was similar to the EC at Vernalis and at Mossdale. The median monthly EC values were approximately 0.025–0.050 dS/m greater than the median monthly Vernalis EC values during the non-irrigation season of September–March and were 0.050–0.100 dS/m higher than the median Vernalis EC values during the irrigation season of April–August. The monthly EC values were greater than the 0.700 dS/m objective in approximately 30 percent of the years during April; in approximately 20 percent of the years during May, in approximately 40 percent of the years during June, in approximately 40 percent of the years during July, and in approximately 30 percent of the years during August. Most of the EC values greater than 0.700 dS/m were in years prior to 1995, when the salinity objective in effect at the time was 1.0 dS/m as a 30-day running average.

Table 5-15b. Monthly Average Measured SJR at Brandt Bridge EC (µS/cm) for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Minimum	240	436	252	150	168	215	154	115	156	243	314	291
10	337	560	392	424	299	253	228	199	228	356	488	399
20	401	596	611	526	433	345	335	304	413	548	524	477
30	467	621	742	574	617	428	397	333	508	609	580	528
40	504	668	755	672	696	620	562	404	590	676	620	605
50	530	699	777	772	778	719	636	427	613	695	653	652
60	601	708	823	800	803	801	659	497	680	709	681	701
70	659	747	837	863	875	868	686	517	773	739	694	751
80	722	775	881	968	936	932	733	684	787	777	764	780
90	808	845	929	1,011	1,047	969	787	734	823	851	801	833
Maximum	941	961	955	1,063	1,213	1,108	827	840	961	888	872	959
Average	560	694	734	719	715	662	548	459	593	648	639	631

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-15c shows the monthly cumulative distribution of historical EC data from Old River at Middle River (Union Island), located just upstream of the city of Tracy discharge. The monthly median EC values were similar to Vernalis, Mossdale, and Brandt Bridge. The median EC values for 1993–2009 (17 years) were 0.588 dS/m in September, 0.510 dS/m in October, 0.711 dS/m in November, 0.818 dS/m) in December, 0.761 dS/m in January, 0.695 dS/m in February, and 0.682 dS/m in March. The monthly median EC values were 0.543 dS/m in April, 0.402 dS/m in May, 0.565 dS/m in June, 0.634 dS/m in July, and 0.630 dS/m in August. The median EC values at Union Island were sometimes greater and sometimes less than the Vernalis EC values, and were generally lower than the median EC values at Mossdale. Because the SJR water at Mossdale flows past both Brandt Bridge and Union Island, the EC values at these two stations are similar.

Table 5-15c. Monthly Average Measured Old River at Middle River (Union Island) EC (µS/cm) for 1993–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Minimum	245	567	271	191	184	225	150	111	123	183	365	282
10	300	588	536	391	280	278	257	179	195	360	457	396
20	451	617	661	546	317	324	305	253	367	457	516	432
30	472	653	759	591	439	402	354	338	514	617	566	503
40	494	679	795	623	610	455	472	375	537	629	609	555
50	510	711	818	761	695	682	543	402	565	634	630	588
60	530	721	839	778	780	802	586	425	570	684	639	606
70	541	731	864	808	918	873	616	439	639	713	704	650
80	595	768	876	819	958	947	665	476	675	721	726	693
90	616	787	890	948	971	1,016	711	517	750	779	732	722
Maximum	660	853	907	1,008	979	1,043	855	649	899	853	918	913
Average	491	696	754	679	651	639	501	376	530	610	619	574

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-15d shows the historical EC data from Old River at Tracy Boulevard Bridge, located downstream of the City of Tracy discharge and downstream of Doughty Cut, which diverts most of the Old River flow to Grant Line Canal. This section of Old River has less tidal movement and less net flow but is influenced by several agricultural drainage pumps that discharge into Old River. The monthly median EC values for 1985–2009 (25 years) were 0.761 dS/m (170 higher than Vernalis) in September, 0.730 dS/m (223 higher than Vernalis) in October, 0.801 dS/m (128 higher) in November, 0.870 dS/m (99 higher) in December, 0.872 dS/m (120 higher) in January, 0.877 dS/m (127 higher) in February, and 0.906 dS/m (159 higher) in March. The monthly median EC values were 0.721 dS/m (186 higher) in April, 0.591 dS/m (211 higher) in May, 0.697 dS/m (122 higher) in June, 0.815 dS/m (204 higher) in July and 0.776 dS/m (168 higher) in August. These EC values are much higher than the Old River at Middle River (Union Island) EC values measured just a few miles upstream. The Tracy Boulevard Bridge location may not accurately indicate the salinity of the water being diverted from other sections of Old River for irrigation use.

Compliance with the 1995 Bay-Delta salinity objectives at Vernalis has been consistently achieved over the past 15 years (a subset of the data presented below in Table 5-15d). However, compliance with the interior southern Delta salinity objectives has not always been achieved. There is a strong relationship between salinity concentrations at Vernalis and salinity concentrations at Brandt Bridge and Old River at Middle River under most conditions. Salinity increases between Vernalis and Brandt Bridge averaged approximately 0.050 dS/m (Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives)*. The historical salinity increase for Old River at Tracy Boulevard has been greater, averaging approximately 0.150 dS/m, with several monthly increases of more than 0.200 dS/m. The monthly increases in downstream EC are greatest when the SJR flow is low because the dilution of the drainage EC or municipal discharge EC is less when the SJR flow is low.

Table 5-15d. Monthly Average Measured Old River at Tracy Boulevard Bridge EC (μS/cm) for 1985–2009

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Minimum	294	408	355	265	286	245	194	135	240	246	325	295
10	437	630	646	399	407	339	282	266	245	461	534	512
20	554	681	714	617	493	376	411	407	463	645	644	597
30	667	716	756	727	677	467	482	433	569	703	694	626
40	674	748	831	765	782	685	672	524	625	744	737	692
50	730	801	870	872	877	906	721	591	697	815	776	761
60	779	842	901	907	904	950	825	617	786	841	812	816
70	828	858	928	1,016	1,044	968	858	709	839	904	872	871
80	875	895	994	1,096	1,094	1,059	954	748	956	931	909	934
90	1,048	978	1,054	1,167	1,174	1,114	976	778	1,034	985	980	945
Maximum	1,094	1,136	1,246	1,233	1,326	1,174	1,206	1,008	1,210	1,186	1,194	1,541
Average	726	798	848	834	827	757	684	562	692	769	771	770

1000 μS/cm = 1 deciSiemen per meter (1 dS/m)
μS/cm = microSiemens per centimeter

5.3 Regulatory Background

5.3.1 Federal

Relevant federal programs, policies, plans, or regulations related to water supply, surface hydrology, and water quality are described below.

Clean Water Act

The federal CWA (33 U.S.C., § 1251 et seq.) places primary responsibility for developing water quality standards on the states. The CWA established the basic structure for regulating point and nonpoint discharges of pollutants into the waters of the United States and gave USEPA the authority to implement pollution control programs, such as setting wastewater standards for industry. The statute employs a variety of regulatory and non-regulatory tools to reduce pollutant discharges into waters of the United States, finance municipal wastewater treatment facilities, and manage polluted runoff.

Section 303(d)

Section 303(d) of the Clean Water Act requires states to identify waters within their jurisdiction that are not attaining water quality standards and include a priority ranking of such waters. The priority ranking takes into account the severity of the pollution and the uses to be made of such waters. The State Water Board and USEPA have approved TMDLs for several pollutants and/or stressors in the plan area (Table 5-4). The 303(d) listed waters in the study area could be affected by the LSJR alternatives.

Section 401: Water Quality Certification

Under Section 401 of the Clean Water Act, applicants for a Federal license or permit to conduct activities that might result in the discharge of a pollutant into waters of the United States must obtain certification from the state in which the discharge would originate or, if appropriate, from the interstate water pollution control agency with jurisdiction over affected waters at the point where the discharge would originate. The FERC relicensing processes that are taking place on the Merced and Tuolumne Rivers would require issuance of water quality certifications by the State Water Board, which may include conditions to implement the flow objectives adopted in the Bay-Delta Plan update.

Federal Antidegradation Policy

The federal anti-degradation policy is designed to provide the level of water quality necessary to protect existing uses and provide protection for higher quality and outstanding national resources waters (40 CFR 131.12). Federal regulations require that state water quality standards include an anti-degradation policy consistent with the federal policy. The State Water Board has interpreted State Water Board Resolution No. 68-16 to incorporate the federal anti-degradation policy (see Chapter 23, *Antidegradation Analysis*).

HR2828 (Public Law 108-361)

H.R. No. 2828, the Water Supply, Reliability, and Environmental Improvement Act (Pub. L. No. 108-361), requires the Secretary of the Interior to develop a program to meet water quality standards and objectives for which the Central Valley Project has responsibility while reducing reliance on water releases from New Melones Reservoir made for water quality purposes. USBR is also required to develop a plan to meet its obligations for water quality and is currently initiating a process to revise the operating plan of the New Melones Reservoir. While H.R. No. 2828 affords flexibility to USBR in meeting its water quality obligations, it does not relieve USBR from its responsibility to achieve those obligations as required by its water right permits. Per the 2015 Annual Work Plan, USBR continues to operate New Melones Reservoir to ensure that the D-1641 salinity standard at Vernalis is not exceeded and no other operations or actions are identified in the work plan related to these obligations (USBR 2015). The work plan includes the development of the real-time management program that would eventually (once implemented) lead to reduced salinity at Vernalis (USBR 2015).

5.3.2 State

Relevant state programs, policies, and regulations related to water supply, surface hydrology, and water quality are described below.

The State Water Board's 2006 Bay-Delta Plan and each regional water board's basin plan identifies beneficial uses, numeric and or narrative water quality objectives for the reasonable protection of the beneficial uses, a program of implementation to achieve the objectives, together with the beneficial uses assigned to water bodies and the state anti-degradation policy. Together, the beneficial uses and the water quality objectives established to reasonably protect the beneficial uses are called water quality standards under the terminology of the federal Clean Water Act.

Porter-Cologne Water Quality Control Act of 1969

Under the Porter-Cologne Water Quality Control Act (Porter-Cologne Act) (Wat. Code, § 13000 et seq.), the State Water Board has the authority to administer the CWA. USEPA retains oversight responsibilities. The State Water Board is updating the 2006 Bay-Delta Plan in accordance with the CWA and the Porter-Cologne Act.

Under the Porter-Cologne Act, water quality objectives are established for the purpose of protecting beneficial uses (e.g., agricultural beneficial uses or wildlife and fish beneficial uses). The Act requires the State Water Board and regional water boards to formulate and adopt WQCPs that designate the beneficial uses of the water to be protected, establish water quality objectives to reasonably protect these uses, and a program of implementation to meet the objectives.

California Water Plan

The California Water Plan is the state's strategic plan for managing and developing water resources statewide for current and future generations. DWR updates the California Water Plan every 5 years. The State Water Board considers the effect of its actions on the California Water Plan, looking toward the development, utilization, or conservation of water resources of the state. Once adopted, water quality control plans, such as the Bay-Delta Plan, become part of the California Water Plan. The California Water Plan identifies statewide resource management strategies that are grouped by different management objectives, including improving water quality and practicing resource stewardship. The Bay-Delta Plan complements the strategies and objectives identified in the California Water Plan by promoting multiple-benefit projects, such as matching water quality to beneficial uses, salt and salinity management, ecosystem restoration, and watershed management.

San Francisco Bay/Sacramento–San Joaquin Delta Estuary Water Quality Control Plan

The State Water Board's 2006 Bay-Delta Plan identifies beneficial uses of water in the Bay-Delta to be reasonably protected, water quality objectives for the reasonable protection of beneficial uses, and an implementation program to achieve the water quality objectives. The beneficial uses designated in the Bay-Delta plan are provided in Table 5-3. For additional information on the 2006 Bay-Delta Plan, see Chapter 1, *Introduction*.

Sacramento River and San Joaquin River Basins Water Quality Control Plan

The Central Valley Water Board's Basin Plan covers the entire Sacramento and SJR Basins, including an area bounded by the crests of the Sierra Nevada on the east and the Coast Range and Klamath Mountains on the west, and extending some 400 miles, from the California-Oregon border southward to the headwaters of the SJR.

The Basin Plan identifies the beneficial uses to be reasonably protected in the Sacramento and SJR Basin waterbodies, water quality objectives, implementation programs, and surveillance and monitoring programs. The Basin Plan contains specific numeric water quality objectives that are applicable to certain water bodies or portions of water bodies. Numerical objectives have been established for bacteria, DO, pH, pesticides, EC, TDS, temperature, turbidity, and trace metals. The Basin Plan also contains narrative water quality objectives for certain parameters that must be attained through pollutant control measures and watershed management. The Basin Plan includes TMDLs and the associated implementation plans adopted by the State and Regional Board and approved by USEPA pursuant to Clean Water Act Section 303(d), including those required for impairments that occur in the plan area (see Table 5-4). The State Water Board's Bay-Delta Plan supersedes the Central Valley Water Board's Basin Plan to the extent of any conflict and the Central Valley Water Board actions must conform to the Bay-Delta Plan.

State Antidegradation Policy

The goal of State Water Board Resolution No. 68-16 (Statement of Policy with Respect to Maintaining High Quality Waters in California), which applies to surface water and groundwater, is to maintain high quality waters of the State to the maximum extent possible. The State Water Board has interpreted Resolution No. 68-16 to incorporate the federal antidegradation policy (see Chapter 23, *Antidegradation Analysis*).

State Water Board Water Right Decision 1641

The Bay-Delta Plan (discussed previously) establishes water quality objectives for the Bay-Delta. State Water Board D-1641 contains the current water right requirements, applicable to DWR and USBR's operations of the SWP and CVP facilities, respectively to implement the Bay-Delta water quality objectives. D-1641 requirements pertaining to flow at Vernalis are discussed above in Section 5.2.6, *Lower San Joaquin River.*

5.4 Impact Analysis

This section identifies the thresholds or significance criteria used to evaluate the significance of potential impacts on surface hydrology and water quality resulting from the proposed alternatives. It describes the methods used to analyze changes in the environment and to evaluate the significance of those changes. Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant impacts to less than significant accompany the impact discussion, if any significant impacts are identified. This section also summarizes results of hydrologic modeling for river flow, water supply, reservoir storage, and water temperature, under the LSJR alternatives relative to baseline to demonstrate the magnitude and timing of the effects and describe the interrelationship between flow and temperature. While these effects are summarized here, related impacts are described in other resource chapters.

5.4.1 Thresholds of Significance

The thresholds for determining the significance of impacts for this analysis are based on the State Water Board's Environmental Checklist in Appendix A of the Board's CEQA regulations. (Cal. Code Regs, tit. 23, §§ 3720–3781.) The thresholds derived from the checklist(s) have been modified, as appropriate, to meet the circumstances of the alternatives. (Cal. Code Regs., tit. 23, § 3777, subd. (a)(2).) Hydrology and water quality impacts were determined to be potentially significant in the State Water Board's Environmental Checklist (see Appendix B, *State Water Boards Environmental Checklist*) and therefore are discussed in this analysis as to whether the alternatives could result in the following:

- Violate water quality standards by increasing the number of months with EC above the water quality objectives for salinity at Vernalis or the southern Delta compliance stations.

- Substantially degrade water quality by increasing Vernalis or southern Delta EC such that agricultural beneficial uses are impaired.
- Substantially degrade water quality by increasing pollutant concentrations caused by reduced river flows.

Where appropriate, specific quantitative or qualitative criteria are described in Section 5.4.2, *Methods and Approach* for evaluating these thresholds.

As described in Appendix B, *State Water Board's Environmental Checklist,* the LSJR and SDWQ alternatives would result in either no impact or less-than-significant impacts on the following related to surface hydrology, and water quality and, therefore, are not discussed within this chapter.

- Create or contribute runoff water which would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff.

5.4.2 Methods and Approach

The effects of the LSJR alternatives on reservoir operations, flood control releases, water supply diversions, and water quality in the SJR at Vernalis and in the southern Delta were analyzed using the State Water Board's Water Supply Effects (WSE) model. Because flows are not expected to change in response to the SDWQ alternatives, the WSE model was not needed to assess effects of the SDWQ alternatives. The scientific basis for the WSE model is described in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*, and the detailed methods and results for the LSJR alternatives are presented in Appendix F.1, *Hydrologic and Water Quality Modeling*.

Water Supply Effects Model

This section describes development of the WSE spreadsheet model and the assumptions used to model baseline and alternative conditions. General comparisons of the baseline and alternative results are presented in Section 5.4.3, *Hydrologic and River Temperature Modeling Results*. The initial scientific basis and methodologies for the WSE model are described in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The methodologies, with additions and refinements to the WSE model, are summarized below. Appendix F.1, *Hydrologic and Water Quality Modeling* fully describes the development and calculation methodologies for specified unimpaired flow targets, diversions, river and reservoir water balances, and the results of the WSE model.

The WSE model is a monthly spreadsheet model that calculates monthly streamflow, reservoir storage levels, and water supply diversions for each eastside tributary based upon user-specified target flows, other user defined inputs, input from CALSIM II, flood storage rules, and an allocation of available water. The general approach is to calculate available water for diversion in each water year based on inflows, net available water from storage after carryover guidelines, and after streamflow targets are met.

The WSE model was developed because SWRCB staff determined that CALSIM II does not easily allow for the setting of monthly downstream flow targets as a fraction of unimpaired flows. Also, it is difficult to change operations and assess these changes rapidly in CALSIM. Furthermore, CALSIM and its data output are not readily understood by a wide variety of users. By utilizing a spreadsheet as the platform for the WSE model, changes in reservoir operations and the effects of changes to flow requirements can be rapidly assessed, and the model and its results are more understandable to users overall. Since the WSE model uses a similar mass balance and assumptions as CALSIM, and utilizes many of the same inputs, it produces similar results as CALSIM. The WSE model is considered a reasonably equivalent tool to CALSIM for the purposes of this analysis, and is sufficiently representative of baseline and potential alternative conditions to assess impacts. As with any model, the WSE model does not precisely re-create historic conditions, and it also does not precisely predict the potential future operations of the system. However, it can accurately depict baseline and alternative conditions such that relative comparisons can be made to analyze potential environmental impacts.

The WSE model baseline condition scenario was developed such that it would agree with CALSIM II SJR Module results when both models are subject to a similar set of assumptions and rules. The State Water Board conducted CALSIM II modeling using the CALSIM II SJR Module supplied by USBR (USBR 2013a, 2013b). This version of the model contained many of the same assumptions and inputs as the CALSIM II "Current Conditions" case used in the DWR 2009 Delivery Reliability Report (DWR 2010), a version of CALSIM II which closely represents the baseline conditions over 82 years of historic climate. The State Water Board used the USBR SJR Module, USBR Base, and made minor adjustments to operations on the Stanislaus River and Vernalis pulse flow requirements as described in Appendix F.1, *Hydrologic and Water Quality Modeling,* in order to make the CALSIM SJR Module most appropriately represent the baseline condition for this analysis. The results from this CALSIM run (SWRCB–CALSIM) can be compared to the WSE model results. Figure 5-6 contains an example of the WSE model to State Water Board-CALSIM comparison contained in Appendix F.1 for baseline regulatory conditions (the final WSE model baseline simulation contained some further modifications described in Appendix F.1, Section F.1.2.4, that resulted in divergence from CALSIM).

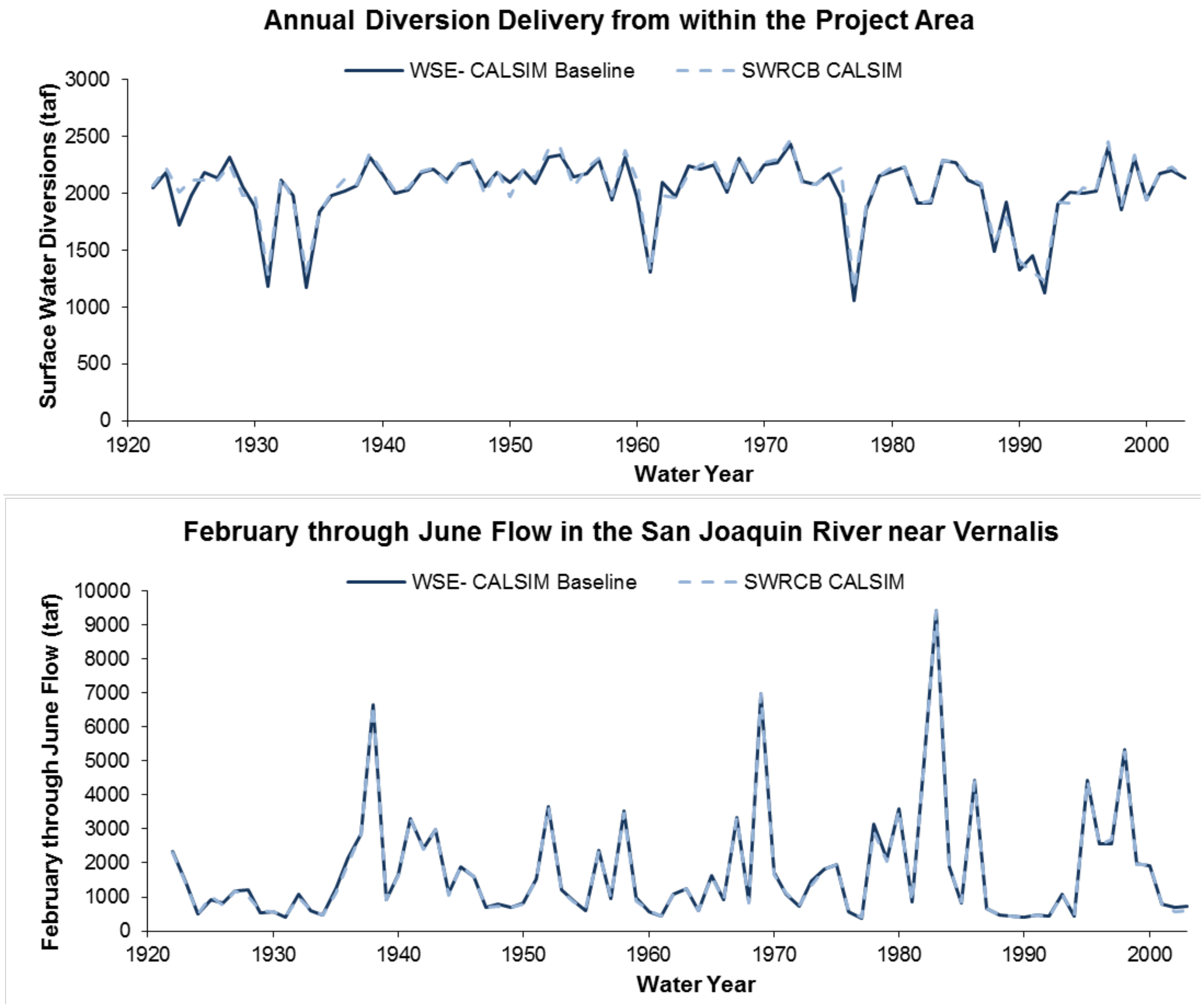

Figure 5-6. Annual WSE Model Baseline[12] SJR Flow at Vernalis and Three Tributary Total Diversion Compared to SWRCB CALSIM Results

The WSE model incorporates 82 years of hydrology that results in the monthly flows, reservoir storage levels, and water supply diversions for each eastside tributary based upon user-specified target flows, other user defined inputs, CALSIM data inputs and outputs, and flood storage rules. User defined inputs to the WSE model include those listed below.

- Months for which flow targets are to be set.
- Monthly flow targets as a percentage of unimpaired monthly flow for each eastside tributary.
- Monthly minimum flows for each eastside tributary.

[12] This example illustrates the close match between "SWRCB–CALSIM"—i.e., the SWRCB-modified version of USBR SJR Module, compared to WSE model results, prior to further modification of assumptions for surface water demand for the CEQA baseline described in Appendix F.1, *Hydrologic and Water Quality Modeling,* Section F.1.2.4, *Calculation of Monthly Surface Water Demand*.

- Maximum annual surface water diversion for each eastside tributary.
- Minimum annual surface water diversion (may supersede end-of-September storage guidelines).
- Minimum annual end-of-September storage guidelines.
- Maximum annual allowable draw from reservoirs as a percentage of the available storage.

Many CALSIM values used by the WSE model were adapted directly from the USBR CALSIM model run (USBR 2013a, 2013b). Some WSE model inputs not defined by the user include those listed below.

- Monthly surface water demand based on Consumptive Use of Applied Water (CUAW) estimates from CALSIM.
- CALSIM inflows to each major reservoir (New Melones, New Don Pedro, and Lake McClure), and SJR inflow from upstream of the Merced River confluence near Newman.
- CALSIM evaporation rates from each major reservoir.
- CALSIM accretions/depletions and return flows downstream from each major reservoir.
- Flood storage rule curves at each major reservoir.

Calculation of annual diversions for major irrigation districts depends on the amount of surface water available for diversion, which is based on: (1) reservoir storage (March 1 storage minus September 30 storage guideline); (2) projected reservoir inflow (for March 1–September 30); (3) water expected to be lost through evaporation; and (4) water required for instream flow. Surface water demand and minimum diversion requirements control the upper and lower limits of diversions. The available water for diversion is calculated annually using CALSIM hydrologic conditions (inflows) for water years 1922–2003. This methodology allows for maximizing annual diversions based on climate variations; reservoirs can be re-operated to allow additional draw-down relative to baseline and ensure a portion of storage is retained for maintaining river temperatures downstream. To distribute the calculated available seasonal diversion throughout the year, an allocation was determined as a fraction of surface water demands for each of the major irrigation district diversions, then applied to the each month of the irrigation year. More information regarding this calculation is provided in Appendix F.1, *Hydrologic and Water Quality Modeling*.

The following flow requirements are included in the baseline: NMFS BO flows on the Stanislaus River; FERC flows on the Tuolumne and Merced Rivers; and Davis-Grunsky and Cowell Agreement requirements on the Merced River. For the LSJR alternatives, the WSE model uses the maximum of these flow requirements or the percent of unimpaired flow specified for each LSJR alternative.

The modeled baseline is the basis for comparison and determination of water supply and water quality impacts under the LSJR alternatives described in this chapter (Impacts WQ-1–WQ-3).

Adaptive Implementation

Each LSJR alternative includes a February–June unimpaired flow requirement (i.e., 20, 40, or 60 percent) and methods for adaptive implementation to reasonably protect fish and wildlife beneficial uses, as described in Chapter 3, *Alternatives Description*. In addition, a minimum base flow is required at Vernalis at all times during this period. This base flow may be adaptively implemented as described below and in Chapter 3. State Water Board approval is required before any method can be implemented, as described in Appendix K, *Revised Water Quality Control Plan*. All methods may be implemented individually or in combination with other methods, may be applied differently to each tributary, and could be in effect for varying lengths of time, so long as the flows are coordinated to achieve beneficial results in the LSJR related to the protection of fish and wildlife beneficial uses.

The Stanislaus, Tuolumne, and Merced Working Group (STM Working Group) will assist with implementation, monitoring, and assessment activities for the flow objectives and with developing biological goals to help evaluate the effectiveness of the flow requirements and adaptive implementation actions. Further details describing the methods, the STM Working Group, and the approval process are included in Chapter 3 and Appendix K. Without adaptive implementation, flow must be managed such that it tracks the daily unimpaired flow percentage based on a running average of no more than 7 days. The four methods of adaptive implementation are described briefly below.

- Based on best available scientific information indicating that more flow is needed or less flow is adequate to reasonably protect fish and wildlife beneficial uses, the specified annual February–June minimum unimpaired flow requirement may be increased or decreased to a percentage within the ranges listed below. For LSJR Alternative 2 (20 percent unimpaired flow), the percent of unimpaired flow may be increased to a maximum of 30 percent. For LSJR Alternative 3 (40 percent unimpaired flow), the percent of unimpaired flow may be decreased to a minimum of 30 percent or increased to a maximum of 50 percent. For LSJR Alternative 4 (60 percent unimpaired flow), the percent of unimpaired flow may be decreased to a minimum of 50 percent.
- Based on best available scientific information indicating a flow pattern different from that which would occur by tracking the unimpaired flow percentage would better protect fish and wildlife beneficial uses, water may be released at varying rates during February–June. The total volume of water released under this adaptive method must be at least equal to the volume of water that would be released by tracking the unimpaired flow percentage from February–June.
- Based on best available scientific information, release of a portion of the February–June unimpaired flow may be delayed until after June to prevent adverse effects to fisheries, including temperature, that would otherwise result from implementation of the February–June flow requirements. The ability to delay release of flow until after June is only allowed when the unimpaired flow requirement is greater than 30 percent. If the requirement is greater than 30 percent but less than 40 percent, the amount of flow that may be released after June is limited to the portion of the unimpaired flow requirement over 30 percent. For example, if the flow requirement is 35 percent, 5 percent may be released after June. If the requirement is 40 percent or greater, then 25 percent of the total volume of the flow requirement may be released after June. As an example, if the requirement is 50 percent, at least 37.5 percent unimpaired flow must be released in February–June and up to 12.5 percent unimpaired flow may be released after June. ~~If after June the STM Working Group determines that conditions have changed such that water held for release after June should not be released by the fall of that year, the water may be held until the following year.~~ See Chapter 3 and Appendix K for further details.
- Based on best available scientific information indicating that more flow is needed or less flow is adequate to reasonably protect fish and wildlife beneficial uses, the February–June Vernalis base flow requirement of 1,000 cfs may be modified to a rate between 800 and 1,200 cfs.

The operational changes made using the adaptive implementation methods above may be approved if the best available scientific information indicates that the changes will be sufficient to support and maintain the natural production of viable native SJR Watershed fish populations migrating through the Delta and meet any biological goals. The changes may take place on either a short-term (for example monthly or annually) or longer-term basis. Adaptive implementation is intended to foster coordinated and adaptive management of flows based on best available scientific information in order to protect fish and wildlife beneficial uses. Adaptive implementation could also optimize flows to achieve the objective, while allowing for consideration of other beneficial uses, provided that these other considerations do not reduce intended benefits to fish and wildlife.

The quantitative results presented in the figures, tables, and text of this chapter present WSE modeling of the specified unimpaired flow requirement of each LSJR alternative (i.e., 20, 40, or 60 percent). This chapter also incorporates a qualitative discussion of adaptive implementation under each of the LSJR alternatives that includes the potential environmental effects associated with adaptive implementation. To inform the qualitative discussion and account for the variability allowed by adaptive implementation, modeling was performed to predict conditions at 30 percent and 50 percent of unimpaired flow (as reported in Appendix F.1, *Hydrologic and Water Quality Modeling*). The modeling also allows some inflows to be retained in the reservoirs until after June, as could occur under method 3, to prevent adverse temperature effects. This variety of modeling scenarios provides information to support the analysis and evaluation of the effects of the alternatives and adaptive implementation. This chapter incorporates a qualitative discussion of the potential water quality impacts of adaptive implementation under each of the LSJR alternatives. For more information regarding the modeling methodology and quantitative flow and temperature modeling results, see Appendix F.1. Because flow modification is not part of the SDWQ alternatives, there is no adaptive implementation component of the SDWQ alternatives and adaptive implementation does not have the potential to affect the impact determinations of the SDWQ alternatives.

Water Temperature Model

This section describes the development of the temperature model and the assumptions used to model baseline and LSJR alternative conditions. Comparisons of the baseline and LSJR alternative temperature results are presented in Section 5.4.3, *Hydrologic and River Temperature Modeling Results.* More details of the model development and results are described in Appendix F.1, *Hydrologic and Water Quality Modeling.* To model effects on temperature in the LSJR and three eastside tributaries, the State Water Board modified the *San Joaquin River Basin-Wide Water Temperature and EC Model* (SJR HEC-5Q model, or temperature model) developed by a group of consultants between 2003 and 2008 through a series of CALFED contracts that included peer review and refinement (CALFED 2009). The temperature model was most recently updated by the California Department of Fish and Wildlife (CDFW) and released in June of 2013 (CDFW 2013).

The SJR HEC-5Q temperature model uses the Hydrologic Water Quality Modeling System (HWMS-HEC5Q) to model reservoir and river temperatures subject to historical climate conditions and user-defined operations. The HWMS-HEC5Q is a graphical user interface that employs HEC-5Q, the USACE Hydrologic Engineering Center (HEC) flow and water quality simulation model. The temperature model was designed to provide a SJR basin-wide evaluation of temperature response at 6-hour intervals for alternative conditions, such as operational changes, physical changes, and combinations of the two. The extent of the model includes the Stanislaus, Tuolumne, and Merced River systems from their LSJR confluences to the upstream end of their major reservoirs (i.e., New

Melones, New Don Pedro, and Lake McClure, respectively). The upstream extent of the model is the Merced River confluence. The downstream extent of the model is the LSJR at Mossdale (which is downstream of Vernalis). The model simulates the reservoir stratification, release temperatures, and downstream river temperatures as a function of the inflow temperatures, reservoir geometry and outlets, flow, meteorology, and river geometry. Calibration data was used to accurately simulate temperatures for a range of reservoir operations, river flows, and meteorology.

The temperature model interfaces with CALSIM or monthly data formatted similarly to CALSIM output. A pre-processing routine converts the monthly output to a format compatible with the SJR HEC-5Q model. This routine serves two purposes: (1) to allow the temperature model to perform a long-term simulation compatible with the period used in CALSIM; and (2) to convert monthly output to daily values used in the temperature model.

The State Water Board used the CALSIM-to-HEC-5Q temperature model pre-processor, using the monthly output from the WSE model, and ran the temperature model to determine the river temperature effects of the LSJR alternatives within the Stanislaus, Tuolumne, and Merced Rivers and the LSJR. The temperature model was run for the years 1970–2003, a period with sufficient length and climatic variation to determine the effects of the LSJR alternatives on river temperatures.

Exports and Outflow

The LSJR alternatives have the potential to change the CVP and SWP exports and Delta outflow. Appendix F.1, *Hydrologic and Water Quality Modeling*, details the methodology used to estimate the change in southern Delta exports and Delta outflow. SJR at Vernalis flow changes primarily during the months of February–June. Changes in SJR flow at Vernalis either change exports or change outflow. Based on the existing Delta objectives and NMFS BO rules, the most likely changes in exports for each month were estimated based on the change in flow at Vernalis simulated by the WSE model and the most likely regulation to be controlling Delta exports for a given month (see Table F.1.7-1). To estimate the possible effects on exports, analysis related to exports and outflow assumes the State Water Board will not change the export constraints to protect any increased flows downstream of Vernalis because the LSJR Alternatives as described in Chapter 3, *Alternatives Description*, would not affect export regulations. Results of this analysis are summarized here in Chapter 5, but potential impacts on aquatic resources are discussed in Chapter 7, *Aquatic Biological Resources*, and potential impacts on service providers are discussed in Chapter 13, *Service Providers*. The State Water Board is currently in the process of reviewing the export restrictions included in the 2006 Bay-Delta Plan as part of its periodic review of the plan. Through that process, the State Water Board will determine what changes, if any, should be made to the export restrictions. The State Water Board will then determine what actions are needed to implement changes to the flow and export objectives.

Salinity Analysis

This section describes the methods used to analyze salinity in the southern Delta as a result of implementing the LSJR and SDWQ alternatives. Two potential mechanisms for salinity impacts are described: (1) changes to flow at Vernalis; and (2) changes to circulation, water levels, and tidal flow in the southern Delta.

The SDWQ alternatives would amend the southern Delta salinity objectives identified in the 2006 Bay-Delta Plan. The purpose of the salinity objective in the 2006 Bay-Delta Plan as well as the purpose of the SDWQ alternatives is to protect beneficial uses, specifically agricultural uses in the southern Delta. Currently, the attainment of the objective in the southern Delta is assessed by monitoring EC in the SJR at Vernalis and Brandt Bridge, and in Old River at Middle River (Union Island) and Tracy Boulevard. Under SDWQ Alternatives 2 and 3, the EC objective would be modified. In addition, under the program of implementation, the monitoring locations for assessing attainment of the objective could also be modified, except at Vernalis, to better assess salinity conditions attainment of the water quality objective.

While the monitoring locations could change under SDWQ Alternatives 2 and 3, the historic monitoring locations specified in the 2006 Bay-Delta Plan were used to assess water quality impacts. These historic monitoring locations were used because much data has been collected at these locations, which allows for a quantitative assessment of how the LSJR alternatives may affect water quality at these locations. Estimated changes in water quality at these locations are indicative of how water quality may change at other southern Delta locations.

The potential for changes in salinity to affect the beneficial use of water for aquatic resources, agricultural supply, and drinking water supply are discussed in Chapter 7, *Aquatic Biological Resources*, Chapter 11, *Agricultural Resources*, and Chapter 13, *Service Providers*, respectively.

Vernalis Flow Effects on Salinity

Potential southern Delta salinity impacts associated with LSJR Alternatives 2, 3, and 4 and SDWQ Alternatives 2 and 3 were assessed in two ways.

- By assessing whether the alternatives would increase the number of months with EC above the water quality objectives for salinity at Vernalis or southern Delta compliance stations (impact WQ-1).
- By assessing whether the alternatives would substantially increase southern Delta EC such that agricultural beneficial uses are impaired. The potential overall change in southern Delta salinity for agriculture was evaluated using the long term cumulative distribution for EC during the irrigation season (April–September)(Impact WQ-2).

Salinity at SJR at Vernalis was calculated within the WSE model using a flow-to-salinity ratio based on the CALSIM results. Increases in salinity within the southern Delta were empirically derived based on historic data at Vernalis and the interior southern Delta stations. These methods are summarized here and further discussed in Appendix F.1, *Hydrologic and Water Quality Modeling*.

The WSE model estimated Vernalis EC based on the assumption that the salt load at Vernalis is the same as that modelled by CALSIM using the following equation.

$$\textit{Adjusted Vernalis EC} = \textit{CALSIM EC} * (\textit{CALSIM Flow}/\ \textit{Adjusted Flow}) \qquad (\textit{Eqn. 5-1})$$

Using this equation, EC decreases under high flow conditions and increases under reduced flow conditions. The Vernalis EC values were calculated in this manner for both baseline conditions and each of the LSJR alternatives. As necessary, the WSE model adjusted the flow releases from New Melones Reservoir on the Stanislaus River to ensure that the Vernalis EC objectives were met.

Appendix F.1, *Hydrologic and Water Quality Modeling,* shows the comparison of measured monthly average SJR at Vernalis EC values and the CALSIM EC results for water years 1994–2003 in Section F.1.42.1, *Salinity Modeling Methods*. This covers a period during which actual operations in the watershed(s) were relatively similar to those modeled in CALSIM.

Simple calculations of the southern Delta EC values were made based on the historical EC increases between Vernalis and the southern Delta stations for 1985–2009 (see Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*). A review of the historical EC data indicated that the EC increment from Vernalis to Brandt Bridge or Old River at Middle River (Union Island) can be estimated with the following flow dilution relationship.

EC increase from Vernalis (dS/m) = 100/ SJR flow at Vernalis (cfs) *(Eqn. 5-2)*

Accordingly, for a flow of 1,000 cfs, the EC increase would be 0.10 dS/m. For a flow of 2,000 cfs, the EC increase would be 0.050 dS/m, and for a flow of 5,000 cfs, the EC increase would be 0.020 dS/m. The EC increase at Old River at Tracy Boulevard was assumed to be 3 times the EC increase at Brandt Bridge.

EC increase from Vernalis (dS/m) = 300/ SJR flow at Vernalis (cfs) *(Eqn. 5-3)*

The quantitative water quality impact analysis focusses on salinity because: (1) salinity is the main water quality constituent likely to be affected by the LSJR and SDWQ alternatives, (2) there is sufficient EC data available to evaluate effects quantitatively, and (3) it is a constituent of great concern in the southern Delta. Other water quality constituents are also included in the impact assessment below, but the analysis is less quantitative. Other water quality constituents are expected to respond to changes in flow in a manner similar to that which is estimated for salinity.

Circulation, Water Levels, and Tidal Flows Effects on Salinity

Salinity conditions in the southern Delta water bodies are affected by their capacity to assimilate upstream and local salt loading. This assimilative capacity is potentially affected by hydrodynamic conditions, such as ~~water levels and~~ the direction and magnitude of flow in the various channels of the southern Delta. CVP and SWP pumping operations in the southern Delta have the potential to affect water level and flow conditions there. To address these impacts, the temporary barriers are currently installed during the irrigation season in Old River near the DMC, in Grant Line Canal at Tracy Boulevard Bridge, and in Middle River at Victoria Canal. The temporary barriers block the tidal flows during ebb tide (falling water elevations, water moving downstream towards the estuary), and thereby maintain higher elevations during ebb tides. The Grant Line barrier is placed each year at a lower elevation than the other two barriers.

The SDWQ alternatives call for continuation of the temporary barriers, followed by special studies and development of a ~~coordinated~~ <u>comprehensive</u> operations plan. The existing water levels in the southern Delta channels, therefore, would not change with the LSJR or SDWQ alternatives evaluated in this SED. As a result, barrier operations and associated effects on circulation, water level, and tidal flows would have either no impact or provide a slight improvement in salinity conditions in the southern Delta (due to the ~~coordinated~~ <u>comprehensive</u> operations plan) and are not discussed further.

303(d) Pollutant Analysis

Pollutants identified by the 303(d) list for the various receiving waters in the study area (Table 5-4) are more likely to approach criteria levels when river flows are relatively low because concentrations of pollutants generally increase when flows are low. An increase in flows would not likely cause concentrations to exceed criteria levels. Although some data are available for these pollutants, there was not a sufficient number of water quality measurements for each month over the range of baseline flows to be able to calculate concentrations or loads; therefore, a generalized more qualitative evaluation of changes in pollutant concentrations, based on changes in flows expected for each of the LSJR alternatives, was used to evaluate whether the LSJR alternatives would result in an increase in 303(d) pollutant concentrations. The impact assessment for general pollutant concentrations is based on the changes in the monthly cumulative distributions of flows. The likely changes in pollutant concentration were assessed using the percent change in the 10th percentile and median flows (Impact WQ-3). The evaluation is conservative because it assumes that baseline concentrations of 303(d) pollutants would approach or exceed water quality criteria limits.

Plan Area and Water Supply Effects Model

The water supply effects analysis, WSE model, and overall analysis of impacts on other resources in the SED focus on the plan area downstream of the rim dams (New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure), where the flow objectives attain the greatest benefits on the Stanislaus, Tuolumne, and Merced Rivers. The assessment of water supply effects in the plan area downstream of the rim dams provides an adequate means of identifying and evaluating effects for the overall analysis because the effects below the rim dams largely represent the potential effects of the LSJR alternatives overall. Upstream areas above the rim dam reservoirs are not included in the WSE model because upstream water rights are relatively small compared to the downstream rights and, thus, any changes in operations due to the project alternatives are assumed not to significantly affect inflows into New Melones Reservoir, New Don Pedro Reservoir, or Lake McClure. Although water rights in the extended plan area above the rim dams could also be affected by implementation of the flow objectives, the effect would be small compared to the effect downstream of the rim dams. The impact analysis therefore addresses those potential effects in less detail than for downstream areas.

An illustration of the proportion of water use below the rim dams compared to the proportion in the extended plan area can be shown using the face value of post-1914 water rights for consumptive use in each region. The allocation of responsibility to implement the objectives would generally follow water right priority and other applicable law. In general, the rule of priority requires junior water right holders to reduce water diversions when water is not available for diversion by all water right holders. The face-value of non-hydropower post-1914 water rights upstream of the rim dams in the extended plan area account for approximately 2 percent, 1 percent, and 6 percent of the post-1914, non-hydropower water in the Stanislaus, Tuolumne, and Merced River Watersheds, respectively.[13] Large post-1914 rights downstream of the rim dams, in the plan area, include the following.

- Three non-power water rights held by the Merced ID for water diverted at or downstream of Lake McClure account for approximately 98 percent of the post-1914 water authorized for diversion in the Merced River Watershed.
- Five non-power water rights held by TID and MID for water diverted at or downstream of New Don Pedro Reservoir account for approximately 99 percent of the post-1914 water authorized for diversion in the Tuolumne River Watershed (not including CCSF diversions at Hetch Hetchy authorized by the Raker Act of 1913).

[13] These numbers do not include upstream water rights that are owned and operated by major irrigation districts, e.g., Donnells and Beardsley Reservoirs operated by the Tri-Dam Project, to be used consumptively within the plan area downstream of the rim dams, and assessed as a portion of the rim dam inflows.

- 16 non-power water rights held by OID, SSJID, USBR, McMullin Reclamation District #2075, and River Junction Reclamation District #2064 for water to be consumptively used downstream of New Melones Reservoir account for 94 percent of the post-1914 water authorized for diversion in the Stanislaus River Watershed.

These and other water users downstream of the rim dams also rely on significant pre-1914 water rights. Given the small volume of water held in non-hydropower post-1914 rights for consumptive use in the extended plan area compared to the volume held in non-hydropower post-1914 water rights used below the rim dams, most of the effect of implementing LSJR alternatives would occur at, or downstream of, the major rim dams in the Stanislaus, Tuolumne, and Merced Rivers.

The Tuolumne River has a significant upstream diversion (e.g., CCSF, Hetch Hetchy aqueduct). The water rights and operating agreement for New Don Pedro Reservoir includes requirements for seasonal storage in the CCSF upstream reservoirs and water banking in New Don Pedro Reservoir allocated between TID, MID, and CCSF, as described above in Section 5.2.4, *Tuolumne River*. The water accounting for New Don Pedro Reservoir could be modified by the LSJR alternatives, but the upstream CCSF operations (storage, hydropower, and water diversion volume) are assumed to be mostly unchanged and therefore would not significantly affect the release of the flows required for the alternatives from New Don Pedro and, therefore, is not part of the WSE model. Depending on the operating agreements between MID, TID, and CCSF, there is some potential that CCSF water supply and operations could be affected during dry conditions. This potential effect is evaluated in Chapter 13, *Service Providers*, Chapter 20, *Economic Analyses*, and Appendix L, *City and County of San Francisco Analyses*.

Extended Plan Area

The primary means by which the extended plan area reservoirs and rivers might be affected is if water is bypassed by junior water rights holders, in accordance with the rules of priority and applicable law, to achieve the required flows in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR.

Under baseline, junior water rights holders who divert water to storage, including February through June, must cease diversion to storage if there is not enough water to satisfy the water rights of more senior water rights downstream. The frequency with which these junior water rights holders must cease diversion to storage would increase during some months of some years under LSJR Alternatives 2, 3, and 4 if water needed to meet the February–June flow requirements reduces the amount of water that can be diverted. A reduction in diversion to storage in the upstream reservoirs can result in reduced reservoir levels, which already occur in the baseline condition. The increased frequency with which reservoirs in the extended plan area are drawn down to lower storage levels would depend on seniority of water rights and how water rights are conditioned to implement the flow objectives in a future water right proceeding. While the effects may be greatest in critically dry and dry years, there may be some effects in below normal, above normal, and wet years. Table 5-19b shows the distribution of changes to annual average diversions under each of the LSJR alternatives.

The increased frequency of lower reservoir levels and the related physical changes, however, would be limited by the program of implementation, which states that the State Water Board will include minimum reservoir carryover storage targets or other requirements to help ensure that providing flows to meet the flow objectives will not have adverse temperature or other impacts on fish and wildlife or, if feasible, on other beneficial uses. It also states that the State Water Board will also take actions as necessary to ensure that implementation of the flow objectives does not impact supplies of water for minimum health and safety needs, particularly during drought periods. Accordingly, when the State Water Board implements the flow requirements, it will consider impacts on fish, wildlife and other beneficial uses and health and safety needs, along with water right priority. Any project-level proceeding would require compliance with CEQA, and the State Water Board would consider project-specific impacts associated with lower reservoir levels, and mitigate any significant impacts. This could, for example, result in establishing bypass limitations for reservoirs that store water for non-consumptive uses or providing flexibility, such as shifting the timing of release, in meeting such requirements for those reservoirs. Water required to satisfy senior rights could be temporarily retained in upstream reservoirs as long as it is released later when the water is needed for use under senior rights downstream. This approach is consistent with the physical solution doctrine, which allows for measures such as alternative supplies—in this case storage under upstream, junior water rights instead of bypassing that water for storage under downstream, senior water rights, while still making that water available when needed under the downstream, senior rights—that serve to maximize beneficial use while avoiding injury to water right holders.

The LSJR alternatives could temporarily increase river flows in the extended plan area relative to baseline as a result of bypassing direct diversions or reducing diversions to storage. The increases in flows could occur more frequently and be a larger volume of water under the higher unimpaired flow alternatives (e.g., LSJR Alternative 4). Later in the year, flows potentially could be reduced if reservoir storage is too low; however, as described in the program of implementation, there would be limits on, or shifting of the timing of, bypass requirements, which would reduce this effect.

In this chapter, the analysis of the extended plan area generally identifies how the impacts may be similar to or different from the impacts in the plan area (i.e., downstream of the rim dams) depending on the similarity of the impact mechanism (e.g., changes in reservoir levels, reduced water diversions, and additional flow in the rivers) or location of potential impacts in the extended plan area. Where appropriate, the program of implementation is discussed to help contextualize the potential impacts in the extended plan area.

Hydrologic and River Temperature Modeling Results

This section includes a summary of the hydrologic and river temperature modeling results, including an evaluation of the changes in flow, diversions, reservoir storage, and water temperature estimated to occur under LSJR Alternatives 2, 3, and 4 relative to baseline. These four hydrologic parameters are the primary parameters used to evaluate the impacts of many of the resources analyzed in this SED, but impacts on many of the resources are not evaluated based solely on these parameters. These parameters are discussed below to describe how they may change in response to the LSJR alternatives. The impacts driven by these parameters are discussed in the appropriate resource chapters of the SED. Water quality, however, is evaluated within specific impacts in this chapter in Section 5.4.4, *Impact and Mitigation Measures* (Impacts WQ-1, WQ-2, and WQ-3), and thus a summary and evaluation of those results are contained within those impact discussions.

Detailed hydrologic and river temperature results for the baseline and each of the LSJR alternatives can be found in Appendix F.1, *Hydrologic and Water Quality Modeling*. In later chapters, the analysis of the hydrologic conditions is tailored to the specific resource and the potential impact being evaluated. These later chapters either make use of the model result summaries provided here or evaluate the modeling results in a manner to focus on the resource of concern.

Potential project-related changes in river flow, surface water diversions, reservoir storage, and water temperature are summarized in this chapter, but their potential impacts are described in other resource chapters. These include, but are not limited to the following.

- Potential effects associated with changes in river flow are discussed in Chapter 6, *Flooding, Sediment, and Erosion*; Chapter 7, *Aquatic Biological Resources*; Chapter 8, *Terrestrial Biological Resources*; Chapter 10, *Recreational Resources and Aesthetics*; and Chapter 12, *Cultural Resources*.
- Potential effects associated with changes in diversions from the rivers and the southern Delta are discussed in Chapter 7, *Aquatic Biological Resources*; Chapter 9, *Groundwater Resources*; Chapter 11, *Agricultural Resources*; Chapter 13, *Service Providers*; and Chapter 14, *Energy and Greenhouse Gases*.
- Potential effects associated with changes in reservoir storage are discussed in Chapter 7, *Aquatic Biological Resources*; Chapter 8, *Terrestrial Biological Resources*; Chapter 10, *Recreational Resources and Aesthetics*; and Chapter 12, *Cultural Resources.* The changes in reservoir elevation described here also can produce impacts associated with changes in hydropower, which are discussed in Chapter 14, *Energy and Greenhouse Gases*.
- Potential effects associated with changes in water temperature are discussed in Chapter 7, *Aquatic Biological Resources*.

In addition, a description of potential aquatic resource benefits associated with modeled changes are described in Chapter 19, *Analyses of Benefits to Native Fish Populations from Increased Flow Between February 1 and June 30,* and a description of potential economic effects associated with the modeled changes are described in Chapter 20, *Economic Analyses.*

Presentation of Results

The WSE model was used to simulate monthly hydrologic parameters for baseline and each LSJR alternative. A time series of the New Melones Reservoir storage (Figure 5-7) is shown as an example of the monthly model output of storage generated for the 82-year modeling period. The annual February–June flow at Ripon is shown in Figure 5-8, and annual diversions from the Stanislaus River in Figure 5-9. Similar results for the Tuolumne and Merced Rivers and for the SJR at Vernalis are shown in Appendix F.1, *Hydrologic and Water Quality Modeling*.

The evaluation of change in hydrologic parameters in this chapter and other chapters of this SED was based on the monthly cumulative distribution of values rather than individual changes in monthly values. As discussed previously in Section 5.2.2, *Upper San Joaquin River*, the cumulative distribution of monthly values is a better metric to describe the overall effects of the LSJR alternatives.

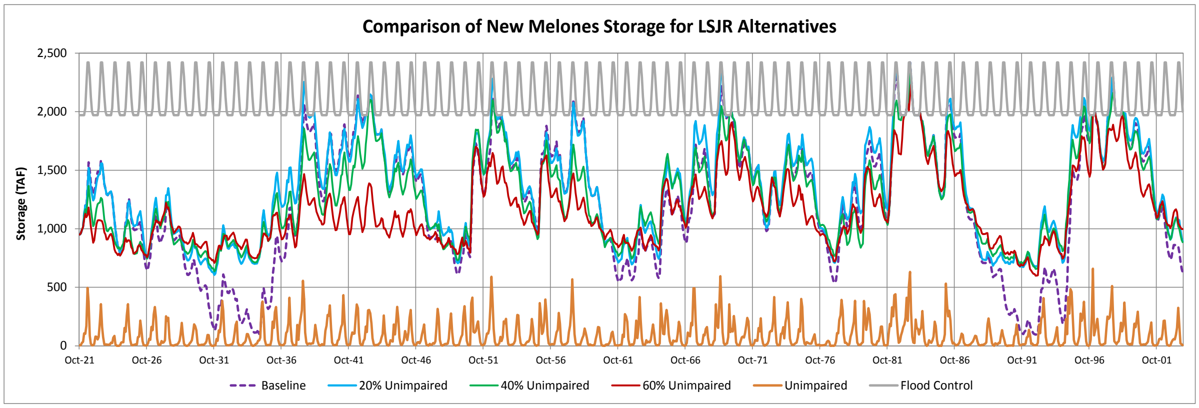

Figure 5-7. Comparison of WSE Model Results for Baseline and LSJR Alternatives: New Melones Reservoir Storage for 1922–2003 (TAF = thousand acre-feet)

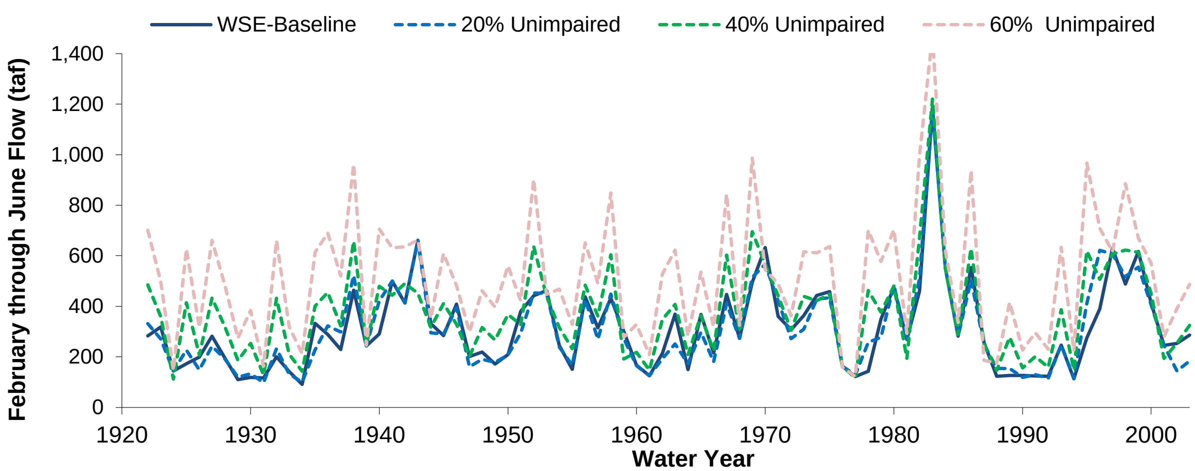

Figure 5-8. Comparison of WSE Model Results for Baseline and LSJR Alternatives: Stanislaus River Total February–June Flows for 1922–2003

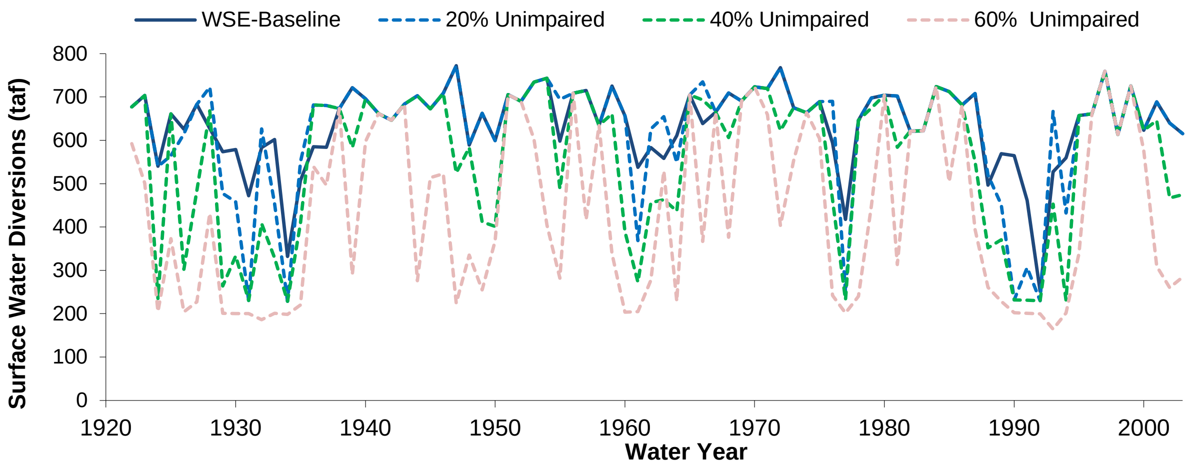

Figure 5-9. Comparison of WSE Model Results for Baseline and LSJR Alternatives: Stanislaus River Diversions for 1922–2003 (TAF = thousand acre-feet)

River Flow

As a general comparison of the LSJR alternatives, the baseline February–June flow volumes (TAF) and average changes to the February–June flow volumes are presented in Table 5-16 for the three eastside tributaries at their confluence with the LSJR and SJR at Vernalis. Average February – June flows increased under each of the LSJR alternatives for all rivers, with the exception of the Stanislaus River under LSJR Alternative 2, which experienced a decrease of 1 percent relative to baseline.

Table 5-16. Average February–June Baseline Flow and Differences from Baseline in the Eastside Tributaries and the SJR at Vernalis for the LSJR Alternatives for the 82-year Modeling Period

	Stanislaus River at Ripon TAF/ (%)	Tuolumne River at Modesto TAF / (%)	Merced River at Stevinson TAF / (%)	SJR at Vernalis TAF/ (%)
Baseline	312 / (100)	562/ (100)	242/ (100)	1,742/ (100)
LSJR Alternative 2 Difference from Baseline	-3 / (-1)	32 / (6)	27 / (11)	56 / (3)
LSJR Alternative 3 Difference from Baseline	62 / (20)	135 / (24)	91 / (38)	288 / (17)
LSJR Alternative 4 Difference from Baseline	203 / (65)	332 / (59)	193 / (80)	728 / (42)

Note: Resulting flow effects on the tributaries are as calculated near the confluence with the LSJR, specifically at Ripon, Modesto, and Stevinson.
TAF = thousand acre-feet

Tables 5-17a through 5-17d show the 10, 50, and 90 percent cumulative distributions (i.e., 10^{th}, 50^{th}, 90^{th} percentiles) under the LSJR alternatives. These tables summarize the modeled effects of the LSJR alternatives at low, median, and high flows and show the variations from month-to-month and the magnitude of some of the largest percent increases. In general, during the objective months of February–June, the LSJR alternatives caused an increase in flows on all the rivers. There were also smaller changes to flow outside of these months on all the rivers, especially under LSJR Alternatives 3 and 4. Some river specific changes under the LSJR alternatives are noted below.

- On the Merced River, the percent increases in flow from the LSJR alternatives were smaller in February–March than in April–June (Table 5-17a). This occurred because from February–March, under baseline conditions, often there was already a relatively high percent of unimpaired flow released. The largest percent increase in both low and median flows was for the Merced River in May and June under LSJR Alternative 4. Under low (10th percentile) flow conditions in May, modeled flow for LSJR Alternative 4 were more than seven times the baseline flow. Large percent increases at low flow can be helpful to biological resources during periods of water stress. Percent increases in the median flows indicate a substantial change in the frequency of higher flows.
- On the Tuolumne River, the percent increases in flow from the LSJR alternatives were smaller in February–April than in May and June (Table 5-17b). This occurred because from February–April, under baseline conditions, often there was already a relatively high percent of unimpaired flow released.
- On the Stanislaus River (Table 5-17c), LSJR Alternative 2 had little effect on river flow, whereas LSJR Alternatives 3 and 4 generally produced increases in flow. The percentages of increase from April–June on the Stanislaus River were generally less than the percentages of increase on the Merced and Tuolumne Rivers because the baseline releases were already relatively high.

As shown in Tables 5-17a through 5-17d, the LSJR alternatives can also affect flows from July–January. This is due to changes in the flow requirements and diversions, which in turn affect reservoir storage relative to baseline. Two specific reasons for changes in July–January flow under the LSJR alternatives are: (1) changes to the flood control releases, and (2) adaptive implementation to shift some of the additional February–June flow to later in the year.

First, when the LSJR flow alternatives require more flow to be released February–June, in many years the storage by the end of June may end up lower than it did under baseline. If this occurs, the potential for flood control releases from July–January is also reduced, especially for the reservoirs that are small relative to watershed runoff volume (i.e., Lake McClure and New Don Pedro Reservoir), and thus flow in July through the following January can be reduced relative to baseline. In the modeling results, this occurred many times during years of high inflows and led to a change in the cumulative distribution during these months. For example, under LSJR Alternative 4, increased flood control space caused a 57 percent reduction in the 90th percentile flows in the Merced River in December and July, and a 64 percent reduction in the 90th percentile flows in the Tuolumne River in July. The reduced flood control releases can also occur during February–June if carryover storage has been reduced relative to baseline, leaving more space to retain flood waters.

Second, as described in the program of implementation, with adaptive implementation, some of the February–June flow can be retained in storage and released later in the year to reduce potential increases in river temperature. This typically occurs under LSJR Alternatives 3 and 4 and was modeled by shifting a portion of the additional February–June water to be released from July–November in wet years for all three rivers, from July–September in above normal years in the Merced River only, and during October for all year types in the Stanislaus River (for more specific details regarding flow shifting, see Appendix F.1, *Hydrologic and Water Quality Modeling,* Section F.1.2.7, *Calculation of River and Reservoir Water Balance*). This adaptive implementation maintains the colder temperatures generally experienced in wet water years due to flood control releases and maintains similar temperatures as baseline conditions for these year types by increasing flow during these months. Due to the increased flows of LSJR Alternatives 3 and 4, there is a reduced potential for flood control releases that causes flows to occasionally be reduced relative to baseline. Without adaptive implementation, these two alternatives may otherwise reduce the flows, resulting in temperature increases relative to baseline. The adaptive implementation, in part, leads to the changes in the cumulative distributions of flow from July–January, with increases in flows most apparent in September–November.

- There are several additional reasons why the LSJR alternatives may cause flow to change on the Stanislaus River, which explain some of the results presented in Table 5-17c.VAMP—Under baseline conditions, VAMP pulse flow requirements at Vernalis for April 15–May 15 resulted in additional releases from the rivers; however, VAMP is not part of the LSJR alternatives.
- D-1641 flow requirements—Under baseline conditions, water from the Stanislaus River was used to meet D-1641 flow requirements for flow at Vernalis from February 1–April 14 and May 16–June 30; however, these flow requirements are not part of the LSJR alternatives.
- Vernalis EC objectives—The Vernalis EC objectives are met under baseline conditions and in all LSJR alternatives. Water from the Stanislaus River is sometimes released to attain the Vernalis EC objective. The need for this release is dependent on flows from the other rivers, which varies with the alternatives.
- NMFS BO flows—Under baseline conditions and the LSJR alternatives, flows in the Stanislaus River must be at least as high as the NMFS BO flows. However, the NMFS BO flows vary depending on reservoir storage, so the baseline and alternative NMFS BO flows are not always the same.

Table 5-17a. Flow Summary for the Merced River at Stevinson—Monthly Cumulative Distributions of Baseline Flow and Differences from Baseline for the LSJR Alternatives for the 82-year Modeling Period

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Merced Flow at Stevinson (cfs)—Baseline												
10	325	266	277	280	312	283	150	117	88	55	32	55
50	423	338	348	385	450	384	508	473	225	155	163	170
90	548	419	991	1,621	2,556	1,728	973	2,478	2,981	2,113	1,150	544
Alternative 2—Percent difference from Baseline												
10	0	2	1	0	0	5	89	182	96	0	-7	-4
50	0	1	0	-2	4	4	-6	67	118	-1	-5	-2
90	3	4	5	6	12	0	-6	-1	-11	0	1	0
Alternative 3—Percent difference from Baseline												
10	5	2	-3	-5	4	18	259	465	230	0	10	1
50	1	4	-2	-2	1	34	69	201	304	29	22	18
90	46	91	-56	6	-16	0	36	2	-12	-13	0	10
Alternative 4—Percent difference from Baseline												
10	5	2	-2	-7	6	38	438	747	396	0	10	1
50	1	4	-2	-4	29	100	157	364	511	29	22	18
90	46	91	-57	-6	-7	0	101	29	-9	-57	-7	10

cfs = cubic feet per second

Table 5-17b. Flow Summary for the Tuolumne River at Modesto—Monthly Cumulative Distributions of Baseline Flow and Differences from Baseline for the LSJR Alternatives for the 82-year Modeling Period

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Tuolumne Flow at Modesto (cfs) —Baseline												
10	290	246	257	316	312	349	546	546	270	262	277	256
50	550	464	470	570	647	1,568	1,414	1,238	499	448	426	422
90	813	756	1,152	3,424	5,084	5,097	4,591	4,810	4,387	3,331	652	691
Alternative 2—Percent difference from Baseline												
10	0	0	0	0	11	24	16	27	38	0	0	0
50	0	-1	0	-3	24	-7	-6	19	130	0	0	0
90	0	0	-20	0	-10	-1	0	5	0	0	0	0
Alternative 3—Percent difference from Baseline												
10	0	0	0	0	42	74	104	154	123	0	0	0
50	0	2	-4	-5	39	-25	41	132	335	8	0	1
90	23	32	-41	-30	-20	-1	0	0	1	-6	0	45
Alternative 4—Percent difference from Baseline												
10	0	0	0	0	68	136	194	281	235	0	0	0
50	0	2	-4	-4	100	3	88	252	559	8	0	1
90	23	32	-41	-36	-22	-13	-11	32	29	-64	0	45

cfs = cubic feet per second

Table 5-17c. Flow Summary for the Stanislaus River at Ripon—Monthly Cumulative Distributions of Baseline Flow and Differences from Baseline for the LSJR Alternatives for the 82-year Modeling Period

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Stanislaus Flow at Ripon (cfs)—Baseline												
10	729	248	224	270	230	308	573	525	292	293	302	311
50	889	319	288	337	385	486	1,556	1,422	629	437	416	419
90	1,116	454	421	576	1,285	1,911	1,997	2,107	1,655	705	632	667
Alternative 2—Percent difference from Baseline												
10	4	0	1	0	4	2	5	5	8	1	3	0
50	2	0	1	2	1	-15	-4	-3	24	0	2	2
90	1	0	0	5	2	0	-7	-3	-7	3	0	3
Alternative 3—Percent difference from Baseline												
10	10	0	1	-1	16	21	21	44	8	5	3	-4
50	26	0	1	0	35	42	-1	25	77	0	2	0
90	25	-2	0	-6	40	-1	-3	29	24	13	-12	20
Alternative 4—Percent difference from Baseline												
10	10	0	1	-1	41	50	75	76	33	2	-8	-6
50	25	0	0	1	99	106	22	85	146	-3	-1	0
90	25	-3	-3	-9	75	16	33	97	90	17	-8	20

cfs = cubic feet per second

Table 5-17d. Flow Summary for the SJR at Vernalis—Monthly Cumulative Distributions of Baseline Flow and Differences from Baseline for the LSJR Alternatives for the 82-year Modeling Period

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
San Joaquin River Flow at Vernalis (cfs)—Baseline												
10	2,000	1,566	1,513	1,481	1,856	1,614	1,616	1,543	1,009	959	1,055	1,488
50	2,598	1,981	1,941	2,200	3,489	3,502	4,640	4,600	2,280	1,620	1,544	2,024
90	3,331	2,724	4,264	10,926	15,228	13,821	12,538	13,327	11,586	6,902	2,983	2,940
Alternative 2—Percent difference from Baseline												
10	0	0	0	0	-4	0	16	43	10	0	0	0
50	0	0	0	1	4	3	-8	-2	46	1	1	0
90	0	2	-9	2	-2	0	5	8	1	0	2	9
Alternative 3—Percent difference from Baseline												
10	0	0	0	0	0	8	73	109	52	0	0	-2
50	9	1	0	-2	-12	13	16	59	122	1	2	0
90	20	23	-29	-14	-20	-1	7	19	3	-8	0	21
Alternative 4—Percent difference from Baseline												
10	0	0	0	0	5	42	137	181	104	0	0	-2
50	9	1	0	-2	7	38	55	121	209	0	0	-1
90	21	26	-29	-29	-3	-2	11	45	23	-36	-1	21

cfs = cubic feet per second

Adaptive implementation method 4 would allow an adjustment of the Vernalis February–June minimum flow requirement. Table 5-18 provides an evaluation of the Vernalis flow requirement using the WSE model. It indicates that changes due to method 4 under all alternatives would rarely alter the flows in the three eastside tributaries or the LSJR. The 1,000 cfs requirement is included in the WSE model simulations of the LSJR alternatives as evaluated in the SED. Increasing this requirement to 1,200 cfs or reducing it to 800 cfs would affect very few months because the Vernalis flows under the LSJR alternatives are generally greater than 1,200 cfs during February–June. For example, under LSJR Alternative 4, if the minimum Vernalis flow requirement were increased as part of adaptive implementation from 1,000 cfs to 1,200 cfs, then the number of months affected by the Vernalis flow requirement would increase from 1 month to 3 months out of the 410 that were simulated.

Table 5-18. Number and Percent of Months Affected by February–June Minimum Vernalis Flow Requirements Based on the 82 Years Simulated by the WSE Model

	800 cfs		1,000 cfs		1,200 cfs	
	Number	Percent	Number	Percent	Number	Percent
LSJR Alternative 2	2	0.5	3	0.7	11	2.7
LSJR Alternative 3	1	0.2	1	0.2	5	1.2
LSJR Alternative 4	0	0.0	1	0.2	3	0.7

cfs = cubic feet per second

Water Diversions

The LSJR alternatives could require higher river flows in the three eastside tributaries and would potentially result in a change in surface water diversions. The runoff to the eastside tributary reservoirs is determined by rainfall and snowmelt conditions and the reservoir storage capacity is fixed. Accordingly, there is no possibility of increasing the total surface water supply to provide more water for surface water diversions. More water released to the rivers under the LSJR alternatives means, generally, there would be less water available for water supply diversions. The WSE model was used to predict the change in annual surface water diversions expected under each LSJR alternative and the results are presented here to provide a description of the magnitude of change under each of the alternatives.

Additionally, as discussed above in Section 5.4.2, *Methods and Approach*, the CVP and SWP exports could be modified based on the inflow from the LSJR. Because the WSE model does not simulate Delta exports, changes in exports were estimated from changes in flow at Vernalis and the Delta regulations that affect exports for each month. These changes were compared to the average historic exports for 1995–2013 (years since the Bay-Delta Plan was introduced).

Table 5-19a shows the simulated average differences in water supply diversions between baseline and the LSJR alternatives. The results indicate that there would be small reductions in water supply under LSJR Alternative 2, moderate water supply reductions under LSJR Alternative 3, and greater water supply reductions under LSJR Alternative 4. Table 5-19b shows the percentiles of these diversions in baseline and the LSJR alternatives, showing that the differences are greatest in drought years, e.g., 10th percentile.

Table 5-19a. Average Annual Baseline Water Supply and Differences from Baseline (Changes in Diversions) in the Eastside Tributaries and Plan Area for the LSJR Alternatives for 1922–2003

	Stanislaus (TAF) / (%)	Tuolumne (TAF) / (%)	Merced (TAF) / (%)	LSJR Plan Area (TAF) / (%)
Baseline	637 / 100	851 / 100	580 / 100	2,068 / 100
LSJR Alternative 2	-12 / -2	-20 / -2	-33 / -6	-65 / -3
LSJR Alternative 2 or LSJR Alternative 3 with Adaptive Implementation (30 percent unimpaired flow)[a]	-33/-5	-56/-7	-60/-10	-149/-7
LSJR Alternative 3	-79 / -12	-119 / -14	-95/ -16	-293 / -14
LSJR Alternative 4	-206 / -32	-298 / -35	-185 / -32	-689 / -33

TAF = thousand acre-feet
TAF/y = thousand acre-feet per year
[a] WSE model results for 30 percent unimpaired flow are included in this table because they are relevant to impact determination in Chapter 13, *Service Providers,* under LSJR Alternatives 2 or 3.

Table 5-19b. Distribution of Changes in Average Annual Diversions Associated with the LSJR Alternatives

Percentile	Baseline Annual Diversions (TAF)	Percent Change			
		LSJR Alternative 2	LSJR Alternative 2 with AI (30 percent unimpaired flow)	LSJR Alternative 3	LSJR Alternative 4
Stanislaus River					
10	538	-16.0%	-40.6%	-50.8%	-62.6%
50	661	1.8%	0.5%	-3.2%	-39.7%
90	723	0.1%	0.1%	-1.5%	-4.5%
Tuolumne River					
10	685	-4.8%	-20.7%	-40.4%	-66.6%
50	878	-1.0%	-3.0%	-8.6%	-38.8%
90	960	-0.3%	-2.3%	-5.4%	-11.1%
Merced River					
10	441	-13.7%	-30.2%	-41.1%	-50.0%
50	617	-4.8%	-9.2%	-10.6%	-38.3%
90	669	-1.6%	-4.0%	-5.6%	-13.4%
Total					
10	1,783	-16.1%	-33.4%	-44.9%	-63.4%
50	2,135	-0.7%	-2.5%	-8.3%	-38.4%
90	2,341	-0.7%	-2.5%	-4.9%	-10.2%

Tables 5-20a and 5-20b show the annual cumulative distribution for the WSE model simulated water supply diversions and the percentage of full demand for diversion that is met for the Stanislaus, Tuolumne, and Merced Rivers. These cumulative distribution values are based on the 82-years simulated by the WSE model and capture the historic range of hydrologic conditions. The annual values are calculated by irrigation year, which runs from March–February. Shortages typically are greater during drier conditions and are represented by low values for the percentage of demand for diversion that is met.

Diversions are reduced in dry years when the reservoir storage is not sufficient to supply the total demands. On the Stanislaus River, the baseline average annual diversion of 637 TAF was reduced by 12 TAF/y (2 percent), 79 TAF/y (12 percent), and 206 TAF/y (32 percent) for LSJR Alternative 2, LSJR Alternative 3, and LSJR Alternative 4, respectively. On the Tuolumne River, the baseline average annual diversion of 851 TAF was reduced by 20 TAF/y (2 percent), 119 TAF/y (14 percent), and 298 TAF/y (35 percent) for LSJR Alternative 2, LSJR Alternative 3, and LSJR Alternative 4, respectively.

On the Merced River, the baseline average annual diversion of 580 TAF was reduced by 33 TAF/y (6 percent), 95 TAF/y (16 percent), and 185 TAF/y (32 percent) for LSJR Alternative 2, LSJR Alternative 3, and LSJR Alternative 4, respectively. The percent change in diversions associated with each alternative was similar for all three rivers, with the biggest difference only being 4 percent.

Reductions in diversions were mirrored by decreases in the ability to meet full demands. For all three rivers, baseline demand for diversion was fully met in more than half the years and, on average, more than 90 percent of the demand for diversion was met, with the Stanislaus River meeting full demands less often than the Merced River, and the Merced River meeting full demands less often than the Tuolumne River. Under LSJR Alternative 2, there were slight (2–5 percent) decreases in the average percentage of demand that was met. Under LSJR Alternative 3, the average percentage of demand met decreased to approximately 80 percent for all three rivers, and under LSJR Alternative 4, the average percentage of demand met decreased further to 62 percent, 63 percent, and 64 percent for the Stanislaus, Tuolumne, and Merced Rivers, respectively.

Table 5-20a. Annual Cumulative Distributions of Unimpaired Runoff and Water Supply Diversions[14] for Baseline and LSJR Alternatives 2, 3, and 4 (20, 40, and 60 Percent Unimpaired Flow) for Irrigation Years 1922–2003 (TAF)

	Stanislaus					Tuolumne					Merced				
Percentile	Unimpaired Flow	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Unimpaired Flow	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Unimpaired Flow	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4
Minimum	155	252	228	228	164	384	557	371	341	214	151	136	203	203	202
10	456	538	452	265	201	836	685	652	408	229	408	441	380	259	220
20	592	583	570	403	221	1,055	796	781	563	287	489	558	472	353	243
30	680	605	624	464	260	1,166	828	822	641	378	560	578	551	408	284
40	891	630	657	584	322	1,413	855	852	763	460	669	602	565	467	323
50	1,095	661	673	640	399	1,783	878	869	802	538	895	617	587	551	380
60	1,264	676	687	663	510	2,036	891	889	828	673	1,086	630	603	564	442
70	1,368	694	701	679	601	2,198	915	910	859	763	1,169	643	619	582	494
80	1,563	708	709	695	661	2,490	932	930	887	820	1,399	653	632	607	557
90	1,910	723	724	712	690	3,090	960	957	908	853	1,706	669	659	632	580
Maximum	2,954	772	772	759	759	4,630	1,034	1,034	1,004	907	2,790	680	673	673	648
Average	1,118	637	624	558	431	1,851	851	831	732	553	958	580	547	485	395

TAF = thousand acre-feet

[14] Diversions include major district diversions, CVP contractor diversions on the Stanislaus River, and riparian diversion totals from all three rivers.

Table 5-20b. Annual Cumulative Distributions of Percentage of Demand for Diversion Met for Baseline and LSJR Alternatives 2, 3, and 4 (20, 40, and 60 Percent Unimpaired Flow) for Irrigation Years 1922–2003

	Stanislaus				Tuolumne				Merced			
Percentile	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4	Baseline	LSJR Alt 2	LSJR Alt 3	LSJR Alt 4
Minimum	36	32	31	25	57	38	35	23	19	30	30	30
10	77	62	37	28	76	71	46	25	70	57	40	33
20	81	85	55	29	100	93	59	29	94	71	54	37
30	86	87	67	36	100	100	69	38	100	87	61	44
40	92	100	82	46	100	100	83	50	100	96	73	50
50	100	100	98	55	100	100	98	57	100	100	89	59
60	100	100	100	73	100	100	100	76	100	100	100	69
70	100	100	100	88	100	100	100	84	100	100	100	77
80	100	100	100	100	100	100	100	100	100	100	100	100
90	100	100	100	100	100	100	100	100	100	100	100	100
Maximum	100	100	100	100	100	100	100	100	100	100	100	100
Average	91	89	80	62	95	93	82	63	92	87	78	64

Table 5-21 gives a summary of the CVP and SWP export calculations from Appendix F.1, *Hydrologic and Water Quality Modeling*. This table shows the expected changes in exports that would likely be caused by monthly SJR flow changes as a result of the LSJR alternatives.

Table 5-21. Cumulative Distribution of Estimated Changes in CVP and SWP Exports Caused by Changes in SJR Flow at Vernalis for the LSJR Alternatives (TAF)

	Historical 1995–2013[a]		LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
	Annual Exports	Feb–June Exports	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change
Minimum	3,520	890	-74	-61	-190	-140	-376	-36
Median	5,081	1,484	9	8	69	58	187	196
Maximum	6,573	2,277	158	134	329	301	592	579
Average	5,185	1,525	18	16	76	67	194	211

TAF = thousand acre-feet
[a] based on DAYFLOW data

The calculated annual changes in CVP and SWP southern Delta exports were minimal. The estimated average annual change for Alternative 2 was an increase of 18 TAF/y and the estimated average annual change for LSJR Alternative 3 was an increase of 76 TAF/y. Both of these numbers are small compared to the historic annual average export of 5,185 TAF (data for water years 1995–2013).

The estimated annual changes in CVP and SWP southern Delta exports for LSJR Alternative 4 averaged 194 TAF/y. This small increase is approximately 4 percent of the historic average annual export of 5,185 TAF/y. On a year-by-year basis, the changes compared to baseline were often larger than the average change, but still small compared to total exports, and years with decreases in exports were balanced by years with increases in exports.

Reservoir Storage

In many years, modeling results showed storage in New Melones, New Don Pedro, and Lake McClure reservoirs was altered when compared to baseline. Reasons why reservoir storage changed include the following.

- Under the LSJR alternatives, the combination of higher river flows and demand for diversions sometimes resulted in lower carryover storage compared to baseline.
- The LSJR alternatives have minimum carryover storage guidelines to avoid adverse temperature impacts on fish and wildlife beneficial uses, and thus there were some dry years when the carryover storage was larger than under baseline conditions.
- The LSJR alternatives (particularly LSJR Alternatives 3 and 4) may retain water in the reservoirs beyond June for adaptive implementation purposes; this was modeled to occur during wet years and, for the Merced River, in above normal years.
- The LSJR alternatives caused variations in the frequency and timing of flood control releases (particularly for New Don Pedro Reservoir and Lake McClure).

Reservoir storage is of most concern during the fall when storage is at its lowest point. Table 5-22a shows average carryover storage (end of September) for each reservoir and alternative. The changes in average carryover storage were 13 percent or less. Under LSJR Alternative 2, all three reservoirs had an increase or no change in average carryover storage relative to baseline. Average carryover storage under LSJR Alternative 3 was less than for LSJR Alternative 2, and average carryover storage under LSJR Alternative 4 was less than for LSJR Alternative 3.

During critical years, LSJR alternative carryover storage was greater than baseline carryover storage under all LSJR alternatives for all reservoirs (Table 5-22b) because the carryover storage targets are part of the LSJR alternatives and not baseline. For both New Melones Reservoir and Lake McClure, the increase in critical-year carryover storage was substantial (47–113 percent)

Table 5-22a. Average Carryover Storage and Differences from Baseline in the Eastside Tributary Reservoirs for the LSJR Alternatives for the 82-Year Modeling Period

	New Melones TAF / (%)	New Don Pedro TAF / (%)	Lake McClure TAF / (%)
Baseline	1,125 / (100)	1,348 / (100)	453 / (100)
LSJR Alternative 2 Difference from Baseline	136/(12)	-6/ (0)	58/ (13)
LSJR Alternative 3 Difference from Baseline	63/ (6)	-99/ (-7)	26/ (6)
LSJR Alternative 4 Difference from Baseline	-38/ (-3)	-125/ (-9)	9/ (2)

TAF = thousand acre-feet

Table 5-22b. Average Carryover Storage and Differences from Baseline in the Eastside Tributary Reservoirs for the LSJR Alternatives for Critical Years during the 82-Year Modeling Period

	New Melones TAF / (%)	New Don Pedro TAF / (%)	Lake McClure TAF / (%)
Baseline	540 / (100)	880 / (100)	154 / (100)
LSJR Alternative 2 Difference from Baseline	254/ (47)	65/ (7)	161/ (104)
LSJR Alternative 3 Difference from Baseline	290/ (54)	60/ (7)	174/ (113)
LSJR Alternative 4 Difference from Baseline	306/ (57)	88/ (10)	113/ (73)

TAF = thousand acre-feet

Hydropower

The rim dams release water through the hydroelectric turbines at their maximum efficiency capacity in order to generate energy. Typically, water is released for a specified number of hours each day. The number of hours of releases is a function of daily average release flow and the turbine capacity flow.

Downstream of the rim dams are regulating reservoirs on each of the three eastside tributaries (e.g., McSwain Dam on the Merced River; the hydroelectric power plant at TID canal on the

Tuolumne River; and Tulloch Dam on the Stanislaus River). These regulating reservoirs operate with a seasonal storage elevation and a daily fluctuating elevation that depends on the number of peaking hours to flatten the peaking from the hydropower facilities and release more steady flows downstream.

The normal peaking-energy operation of the rim dams would continue under the LSJR alternatives. The only changes to the peaking energy operation would be slightly different hours with peaking energy releases each day during the month according to the monthly changes in the simulated WSE model river flows and diversion flows under the LSJR alternatives.

Because hydropower generation is dependent on reservoir elevation (head), a reduction in storage has the potential to affect hydropower generation. In addition, there is the potential for hydropower generation to be reduced as a result of the extent to which reservoir releases exceed the capacity of the hydropower turbines. The economic value of hydropower generation is somewhat dependent on time of year, with a greater demand for electricity in the summer than in the winter and spring. The change in reservoir releases associated with the LSJR alternatives affects the distribution of power generation between these seasons.

Water Temperature

A summary of modeled water temperature results for baseline and under each LSJR alternative are presented below for each tributary (Tables 5-23a through 5-23c). These temperature results are fully described in Appendix F.1, *Hydrologic and Water Quality Modeling*.

Due to the dynamics of heat exchange, river temperatures generally increase if river flow is reduced and decrease if river flow is increased. A change in flow can cause a corresponding change in the water temperature downstream. However, if the existing flow is relatively high, a change in flow would likely cause a smaller change in temperature than would the same change in flow if the existing flows were lower. Furthermore, a change in flow during colder months causes a smaller change in water temperature than during warmer months. This is because during colder months the reservoir release temperatures are more similar to the average ambient air temperatures. Appendix F.1 provides more detail about the relationship between flow and water temperature.

Changes in relatively low flows during warm months are likely to have a substantial effect on water temperatures. The biggest changes in water temperature are expected to occur from April–June. The LSJR alternatives also affected water temperature from February–March, but to a lesser degree than during the warmer months.

Although the LSJR alternatives apply to February–June, there are several reasons why modeled results show water temperatures changing outside of this period. One reason temperatures could change relative to baseline from July–January is that there are occasionally changes in flow during these months due to reduced spills in wet years, and shifting of flows to the fall as a part of adaptive implementation (for more specific details regarding flow shifting, see Appendix F.1, Section F.1.2.7, *Calculation of River and Reservoir Water Balance*). Water temperatures also are affected by changes in reservoir storage, which could occur during any month, but low storage in the fall is of most concern because the cold water at the bottom of the reservoirs could be depleted in the fall. Appendix F.1 provides more detail about the relationship between reservoir storage and water temperature.

The average monthly temperatures were compared between baseline and the LSJR alternatives (Table 5-23a through 5-23c). This temperature evaluation was performed at a single location for each tributary: at RM 27.1 on the Merced River; at RM 28.1 on the Tuolumne River; and at RM 28.2 on the Stanislaus River (Appendix F.1). These are approximately the halfway points between the river mouths and the upstream regulating reservoirs and were selected because they are good locations for capturing the effect of flow on water temperature. Water temperature effects at Lake McClure, New Don Pedro Reservoir, and New Melones Reservoir releases are driven only by changes in the storage.

The 10^{th}, 50^{th} (median), and 90^{th} percentiles show the general range of temperatures modeled for baseline conditions and the LSJR alternatives. Baseline temperatures are shown followed by the differences between the LSJR alternatives and baseline. The 90^{th} percentile results present the warmest temperatures, which generally are of more concern to the harming of fish and wildlife than cooler temperatures.

At the halfway locations, the baseline January to July seasonal warming of median temperatures ranged from 27°F on the Merced River to 19°F on the Stanislaus and Tuolumne Rivers (Table 5-23a through 5-23c). The spread of temperatures for any given month (90^{th} percentile minus 10^{th} percentile) varies by month, with June or July generally having the largest spread. The largest spread occurred on the Tuolumne River (23°F in July).

On the Merced River (Table 5-23a), LSJR Alternatives 2, 3, and 4 produced progressively cooler water temperatures in many months, with the effect being largest in May or June. Median June temperatures were 6.0°F cooler for LSJR Alternative 2, 8.7°F cooler for LSJR Alternative 3, and 10.3°F cooler for LSJR Alternative 4. Temperature reductions for the June 90^{th} percentile values were 5-6°F smaller than the reduction in median temperatures.

Similarly, on the Tuolumne River (Table 5-23b), LSJR Alternatives 2, 3, and 4 produced progressively cooler water temperatures in many months, with the effect being largest in June. However, temperature reductions in the Tuolumne River were larger than on the Merced or Stanislaus Rivers. Median June temperatures were 8.3°F cooler for LSJR Alternative 2, 11.4°F cooler for LSJR Alternative 3, and 12.5°F cooler for LSJR Alternative 4. Temperature reductions for the June 90^{th} percentile values were 1-6°F smaller than the reductions in median temperatures.

On the Stanislaus River (Table 5-23c), temperature effects for LSJR Alternative 2 were relatively small, with some values being a little higher than baseline and some being a little lower. This is a reflection of the effect of LSJR Alternative 2 on Stanislaus River flows, the effect of which was relatively small and variable relative to baseline. On the Stanislaus River, LSJR Alternatives 3 and 4 produced cooler water temperatures in many months, but the effect was smaller than on the Tuolumne or Merced Rivers. Median June temperatures were 1.1°F cooler for LSJR Alternative 3 and 3.0°F cooler for LSJR Alternative 4.

Table 5-23a. Monthly Cumulative Distributions of Simulated Merced River Water Temperatures (Fahrenheit) at River Mile 27.1 for Baseline and Differences from Baseline for the LSJR Alternatives for 1970–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Baseline												
10	60.9	55.1	49.7	48.6	50.2	51.2	56.4	57.9	56.4	60.3	63.8	64.1
50	62.6	57.1	51.2	50.0	52.9	57.1	61.9	66.4	73.9	76.7	75.4	72.1
90	68.6	61.1	53.4	52.3	55.5	59.9	65.8	70.9	76.1	80.1	79.0	76.8
LSJR Alternative 2 Minus Baseline												
10	-0.4	0.0	0.0	0.0	-0.3	-0.2	-0.1	-0.5	0.4	0.0	0.0	0.1
50	0.0	-0.1	0.0	0.3	0.5	0.4	-0.7	-4.2	-6.0	-0.4	0.0	-0.3
90	-2.9	-1.9	-0.4	0.0	0.2	0.2	-2.3	-3.7	-1.4	-0.8	-0.4	-0.2
LSJR Alternative 3 Minus Baseline												
10	-1.1	0.1	0.1	0.0	-0.7	-0.1	-0.5	-1.8	0.9	0.1	0.1	-0.1
50	-0.6	-0.4	0.0	0.2	0.1	-0.5	-3.1	-6.8	-8.7	-1.0	-0.3	-0.7
90	-2.7	-1.9	-0.5	0.0	-0.1	-0.9	-4.7	-6.4	-3.6	-1.0	-0.3	-0.1
LSJR Alternative 4 Minus Baseline												
10	-0.5	0.4	0.0	-0.1	-1.5	-0.3	-3.0	-3.3	1.2	5.5	1.4	0.3
50	-0.5	-0.5	0.2	0.1	0.2	-1.5	-4.5	-8.4	-10.3	-1.1	-0.1	-0.4
90	-1.5	-1.3	-0.4	0.0	-0.4	-1.5	-5.7	-7.5	-4.6	-0.8	0.0	0.1

Table 5-23b. Monthly Cumulative Distributions of Simulated Tuolumne River Water Temperatures (Fahrenheit) at River Mile 28.1 for Baseline and Differences from Baseline for the LSJR Alternatives for 1970–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Baseline												
10	58.1	54.2	50.5	49.7	49.4	49.6	51.0	52.2	54.0	56.5	67.7	63.2
50	60.5	55.4	51.5	51.4	53.6	52.5	54.0	56.3	68.2	70.8	70.3	67.2
90	65.8	57.8	53.4	53.0	56.5	60.9	61.5	63.8	75.5	79.2	77.8	74.5
LSJR Alternative 2 Minus Baseline												
10	0.2	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	0.1	0.0	0.0
50	0.1	0.1	0.0	0.2	-0.6	0.2	0.0	-0.2	-8.3	-0.5	0.0	0.1
90	-0.3	-0.2	-0.2	0.0	-0.1	-2.1	-2.8	-1.3	-2.4	-1.1	0.0	0.0
LSJR Alternative 3 Minus Baseline												
10	-0.9	0.3	-0.1	0.2	-0.1	0.0	-0.1	-0.1	0.0	0.5	-1.7	-3.3
50	-0.4	0.0	0.4	0.2	-1.2	-0.5	-0.4	-2.6	-11.4	-0.7	-0.3	0.3
90	-0.2	-0.4	-0.1	0.1	-1.6	-4.9	-6.1	-6.4	-8.9	-1.5	0.0	0.0
LSJR Alternative 4 Minus Baseline												
10	-0.3	0.6	-0.3	0.0	-0.1	0.0	-0.4	-0.2	-0.3	3.8	-1.5	-2.6
50	-0.5	0.4	0.4	0.2	-1.9	-0.9	-1.2	-2.9	-12.5	-0.7	-0.1	0.5
90	-0.2	-0.5	0.0	0.2	-2.1	-6.3	-7.2	-7.9	-11.6	-1.7	0.0	0.0

Table 5-23c. Monthly Cumulative Distributions of Simulated Stanislaus River Water Temperatures (Fahrenheit) at River Mile 28.2 for Baseline and Differences from Baseline for the LSJR Alternatives for 1970–2003

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Baseline												
10	55.6	53.6	48.6	47.2	49.5	51.0	52.7	54.7	57.8	64.7	64.5	61.1
50	57.4	55.0	50.5	49.3	51.2	54.7	55.1	57.1	62.3	68.7	68.5	65.6
90	65.3	57.5	51.7	50.9	53.8	57.3	59.4	62.1	69.4	73.0	72.8	70.8
LSJR Alternative 2 Minus Baseline												
10	0.0	0.0	0.0	0.1	-0.2	0.0	0.4	0.3	-0.2	1.4	1.1	1.1
50	-0.1	-0.5	-0.3	0.0	-0.3	-0.9	0.0	0.1	0.8	-0.1	-0.5	-0.1
90	-4.5	-0.6	-0.3	-0.2	-0.6	0.6	-0.6	-0.8	-0.5	-0.3	-0.7	-1.4
LSJR Alternative 3 Minus Baseline												
10	-0.2	0.0	0.1	0.0	-1.0	0.1	0.3	0.0	-1.0	-1.9	1.2	-0.4
50	-0.1	-0.1	-0.3	0.0	-0.6	-1.9	-0.1	-0.3	-1.1	-0.5	-0.6	-0.7
90	-5.4	-0.6	-0.2	-0.2	-0.9	-0.8	-1.4	-1.6	-0.7	-0.4	-0.6	-1.3
LSJR Alternative 4 Minus Baseline												
10	0.0	0.1	0.2	-0.2	-1.2	-0.4	0.1	-1.0	-2.6	-2.3	0.5	-0.1
50	0.2	-0.1	-0.3	0.1	-1.2	-2.0	-0.4	-1.2	-3.0	-0.1	-0.1	0.0
90	-5.4	-0.4	-0.1	-0.2	-1.4	-1.8	-2.7	-2.2	-1.4	-0.3	-0.5	-1.3

5.4.3 Impacts and Mitigation Measures

Impact WQ-1: Violate water quality standards by increasing the number of months with EC above the water quality objectives for salinity at Vernalis or southern Delta compliance stations

No Project Alternative (LSJR/SDWQ Alternative 1)

The No Project Alternative would result in implementation of flow objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative impact discussion and Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative technical analysis.

LSJR Alternatives

The impact associated with each LSJR alternative was assessed using the existing water quality objectives. The impact WQ-1 analysis focuses on the objectives at the southern Delta compliance stations because these objectives are the most likely to be exceeded as a result of changes in LSJR flows. Water quality at locations farther downstream is less affected by changes in LSJR flow and is more likely to be affected by the presence of relatively clean water from the Sacramento River.

The monthly EC values at Vernalis, corresponding to the monthly flows and assumed LSJR salt loads, were calculated for the 1922–2003 time period with the WSE model. The modeling incorporated additional releases from New Melones Reservoir in some months to satisfy the baseline Vernalis EC objectives because USBR is required to maintain salinity at Vernalis in accordance with its water rights. Under the LSJR alternatives, the Vernalis objectives would be the same as the baseline objectives. Under the SDWQ alternatives, the Vernalis objectives would change, but the program of implementation would still require that USBR ensure the Vernalis EC values remain less than or equal to 0.700 dS/m for April–August and 1.000 dS/m for September–March as a 30-day running average.

The number of months when the estimated EC at the southern Delta compliance stations would exceed the existing water quality objectives for each LSJR alternative was compared to the number of months that the estimated EC would exceed the existing water quality objectives under baseline flow and EC conditions. The impact associated with each SDWQ alternative was assessed by evaluating how the number of months with EC greater than the objectives would change in response to the change in objectives under the SDWQ alternatives. The number of months the EC exceeded the existing EC objective was compared to the number of months the EC exceeded the objectives for each of the SDWQ alternatives.

Described below are baseline conditions at the Vernalis and the southern Delta compliance stations. Note that the baseline EC values described here are different from the historic measured EC values described in the environmental setting section above; the baseline values cover a longer period of record as simulated by the WSE model and they represent recent operating procedures unlike the historic values, which represent variable regulations for system operations. The baseline EC values are a better representation of EC under existing regulations than the historical EC values. The calculated monthly EC values for the SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard for baseline are given in Appendix F.1, *Hydrologic and Water Quality Modeling,* (Tables F.1-14b, e, and g).

Table 5-24a shows a summary of monthly Vernalis EC values for baseline as simulated with the WSE model for 1922–2003, sorted by the number of years with values greater than 0.400–1.200 dS/m (400 μS/cm–1,200 μS/cm) in 0.100 dS/m (100 μS/cm) increments.[15] The table indicates the number of years with a calculated monthly EC value greater than the EC values given in the first column. For example, the Vernalis EC values in October for baseline were above 0.400 dS/m (400 μS/cm) in 78 years (out of 82 years); above 0.500 dS/m (500 μS/cm) in 36 years; and above 0.600 dS/m (600 μS/cm) in 0 years. Other months with an EC objective of 1.000 dS/m (1,000 μS/cm) show no violations at Vernalis. There were 20 years with an EC of greater than 0.900 dS/m (900 μS/cm) in February and 16 years with a March EC of greater than 0.900 dS/m (900 μS/cm), suggesting that the EC values for baseline were often approaching the EC objective in these months. Many of the simulated Vernalis EC values in April–August were above 0.600 dS/m (600 μS/cm), suggesting that EC was approaching the EC objectives in many years during this period.

[15] These EC objective values have a line under them in the table; the number of months with calculated EC above the EC objective is in this row.

Table 5-24a. Monthly Distribution of SJR at Vernalis EC Values (100 µS/cm increments) for Baseline for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	78	80	79	73	62	51	45	39	66	78	77	79	77
500	36	75	78	69	56	47	28	21	43	69	57	55	56
600	0	46	74	64	49	43	15	12	22	40	21	7	34
700	0	5	67	54	37	28	0	0	0	0	0	0	13
800	0	0	54	23	31	22	0	0	0	0	0	0	0
900	0	0	3	0	20	16	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-24b shows the baseline monthly distribution of calculated EC values at Brandt Bridge. There were 16 years in February and 15 years in March that exceeded the 1.000 dS/m (1,000 µS/cm) objective (a total of 31 months out of 574). There were 12 years in April, 8 years in May, 17 years in June, 26 years in July, and 16 years in August that exceeded the 0.700 dS/m (700 µS/cm) objective (a total of 79 months out of 410). The baseline EC values at Brandt Bridge exceeded the EC objectives in a total of 110 months out of the 984 months from 1922–2003.

Table 5-24b. Monthly Distribution of SJR at Brandt Bridge EC Values (100 µS/cm increments) for Baseline for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	73	62	52	47	40	67	78	79	79	80
500	68	77	78	72	57	48	30	25	48	69	62	70	62
600	8	62	76	65	52	44	19	18	39	63	48	30	46
700	0	25	69	56	43	30	12	8	17	26	16	4	20
800	0	2	61	47	34	26	0	0	3	4	4	0	9
900	0	0	19	10	26	17	0	0	0	0	0	0	0
1,000	0	0	0	0	16	15	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-24c shows the baseline monthly distribution of calculated EC in Old River at Tracy Boulevard. There was a total of 81 months with EC values higher than the EC objective of 1.000 dS/m (1,000 µS/cm) (September–March) and a total of 186 months with EC values higher than the EC objective of 0.700 dS/m (700 µS/cm) (April–August). The baseline EC values at Tracy Boulevard exceeded the existing EC objectives in a total of 267 months (out of 984), approximately 27 percent of the months in the 82-year modeled simulation. This percent of time with exceedances is greater than the percent of time of measured EC exceedances reported at Old River at Tracy during the past 25 years.[16]

Table 5-24c. Monthly Distribution of Old River at Tracy Boulevard EC Values (100 µS/cm Increments) for Baseline for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	74	62	55	57	58	71	78	79	79	81
500	75	79	78	72	57	50	38	36	60	73	77	79	73
600	50	77	76	66	55	46	26	21	44	67	60	63	56
700	8	61	72	63	46	43	18	17	39	61	51	32	43
800	1	27	67	55	36	29	12	9	22	39	26	8	20
900	0	5	59	44	33	26	5	3	13	19	10	4	12
1,000	0	1	24	16	24	16	0	0	6	7	7	0	2
1,100	0	0	5	2	16	15	0	0	0	3	3	0	0
1,200	0	0	0	0	0	6	0	0	0	2	1	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-25 summarizes the number of months with EC higher than the objectives at the two representative compliance stations for baseline and for each LSJR alternative. As described in Section 5.2.7, *Southern Delta*, Union Island (Old River near Middle River) has EC similar to Brandt Bridge. The number of months with EC higher than the objectives would be reduced for SDWQ Alternatives 2 and 3.

Table 5-25. Number of Months when Estimated EC Values would be Greater than EC Objectives at Southern Delta Compliance Stations 1922–2003 (984 months)

Compliance Station	Baseline	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
Baseline EC Objectives (700 µS/cm April–August and 1,000 µS/cm September–March)				
Brandt Bridge	110	93	74	68
Tracy Boulevard	267	248	202	196
SDWQ Alternative 2 (1,000 µS/cm January–December)				
Brandt Bridge	31	40	28	17
Tracy Boulevard	101	107	95	86
SDWQ Alternative 3 (1,400 µS/cm January–December)				
Brandt Bridge	0	0	0	0
Tracy Boulevard	0	0	0	0

Note: The WSE modeling includes releases of additional water from New Melones Reservoir necessary to meet the existing Vernalis EC objectives of 0.700 dS/m (700 µS/cm) for April–August and 1.000 dS/m (1000 µS/cm) for September–March, which would be required as part of the program of implementation.
1000 µS/cm = 1 deciSiemen per meter (1 dS/m)

[16] The values predicted by the modeled simulation are more than the actual measured data because the method used to calculate the EC increment between Vernalis and Old River at Tracy Boulevard provides a conservative estimate of the effect of any potential decreases in flow at Vernalis on the EC increment (Appendix F.1, *Hydrologic and Water Quality Modeling*).

μS/cm = microSiemens per centimeter

LSJR Alternative 2 (Less than significant/Less than significant with adaptive implementation)

The calculated monthly EC values for the SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard for LSJR Alternative 2 are given in Appendix F.1, *Hydrologic and Water Quality Modeling* (Tables F.1-15a through 15c). Table 5-26a shows the monthly Vernalis EC values for LSJR Alternative 2. There were no months with EC values greater than the objectives at Vernalis because the WSE modeling for the LSJR alternatives included the requirement from the program of implementation that USBR continue to meet the existing Vernalis EC objectives by releasing water from the New Melones Reservoir.

Table 5-26b shows that Brandt Bridge EC values for LSJR Alternative 2 were higher than the 1.000 dS/m (1,000 μS/cm) objective in the months of September–March in a total of 40 months (out of 574 months) and were higher than the 0.700 (700 μS/cm) objective in the months of April–August in a total of 53 months (out of 410 months), for a total of 93 exceedances of the existing objectives. The EC was higher than the EC objective for LSJR Alternative 2 in 17 months fewer than for baseline because some of the estimated Vernalis flows were higher compared to baseline, and the corresponding Vernalis EC values were slightly lower. The calculated EC values in Old River at Middle River (Union Island) are assumed to be the same as at Brandt Bridge. Because of the overall reduced incidence of EC values that would be above the EC objective (93 months for LSJR Alternative 2 versus 110 months for baseline), impacts would be less than significant at Brandt Bridge and Union Island.

Table 5-26a. Monthly Distribution of SJR at Vernalis EC Values (100 μS/cm increments) for LSJR Alternative 2 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	78	80	79	73	61	53	48	26	44	77	75	76	76
500	34	74	78	68	56	47	22	9	21	70	57	56	54
600	0	46	75	64	46	42	7	2	5	42	19	6	32
700	0	5	70	57	37	33	0	0	0	0	0	0	5
800	0	0	56	26	35	29	0	0	0	0	0	0	0
900	0	0	3	0	29	20	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 μS/cm = 1 deciSiemen per meter (1 dS/m)
μS/cm = microSiemens per centimeter

Table 5-26b. Monthly Distribution of SJR at Brandt Bridge EC Values (100 µS/cm increments) for LSJR Alternative 2 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	73	61	53	51	31	52	77	77	76	79
500	67	77	78	71	58	48	32	12	25	70	63	69	64
600	8	60	78	64	48	43	15	5	16	65	47	27	47
700	0	25	71	59	38	34	5	2	4	27	15	4	18
800	0	2	64	48	36	30	0	0	0	4	4	0	2
900	0	0	19	10	33	23	0	0	0	0	0	0	0
1,000	0	0	0	0	22	18	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-26c shows that the Old River at Tracy Boulevard EC values for LSJR Alternative 2 were higher than the 1.000 dS/m (1,000 µS/cm) objective in the months of September–March in a total of 95 months and were higher than the 0.700 (700 µS/cm) objective in the months of April–August in a total of 153 months (out of 410 months), for a total of 248 exceedances of the existing objectives. Because of the reduced incidence of EC values that were above the EC objective at Tracy Boulevard (248 months for LSJR Alternative 2 versus 267 months for baseline), impacts would be less than significant at Tracy Boulevard.

Table 5-26c. Monthly Distribution of Old River at Tracy Boulevard EC Values (100 µS/cm increments) for LSJR Alternative 2 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	74	61	54	58	40	62	78	77	79	80
500	75	79	78	71	59	51	42	25	42	73	75	76	73
600	46	76	78	65	55	44	23	10	24	68	61	64	53
700	8	59	72	63	43	42	13	6	18	65	51	29	41
800	1	27	70	56	37	33	5	2	9	40	25	7	23
900	0	5	61	46	35	30	2	1	3	18	10	4	8
1,000	0	1	24	16	31	23	0	0	0	6	6	0	0
1,100	0	0	5	2	21	18	0	0	0	3	3	0	0
1,200	0	0	0	0	0	6	0	0	0	2	1	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Adaptive Implementation

Based on best available scientific information indicating that a change in the percent of unimpaired flow is needed to reasonably protect fish and wildlife, adaptive implementation method 1 would allow an increase of up to 10 percent over the 20-percent February–June unimpaired flow requirement (to a maximum of 30 percent of unimpaired flow). A change to the percent of unimpaired flow would take place based on required evaluation of current scientific information and would need to be approved as described in Appendix K, *Revised Water Quality Control Plan*. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. However, an increase of up to 30 percent of unimpaired flow would potentially result in different effects as compared to 20-percent unimpaired flow, depending upon flow conditions and frequency of the adjustment. Under LSJR Alternative 2, this adaptive implementation approach would increase flows in the three eastside tributaries. As a result, it is anticipated the EC values presented above for SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard would not be substantially different or would actually be reduced because any additional flow in the LSJR potentially required under adaptive implementation would likely result in a decrease in EC in the southern Delta and at compliance points because increases in flow from the relatively low salinity eastside tributaries would dilute salt load. Therefore, method 1 would not result in an increase in EC.

Based on best available scientific information indicating that a change in the timing or rate of unimpaired flow is needed to reasonably protect fish and wildlife, adaptive implementation method 2 would allow changing the timing of the release of the volume of water within the February–June time frame. While the total volume of water released February–June would be the same as LSJR Alternative 2 without adaptive implementation, the rate could vary from the actual (7-day running average) unimpaired flow rate. Method 2 would not authorize a reduction in flows required by other agencies or through other processes, which are incorporated in the modeling of baseline conditions. During February–June, method 2 could potentially cause temporary increases in EC associated with flow dropping below 20 percent of the unimpaired flow, but increases in EC would be limited by the salinity requirements for Vernalis as specified in the program of implementation and would be offset by reductions in EC associated with flow increasing above 20 percent unimpaired flow at other times during February–June. Although changes in the timing of flows released from February–June under adaptive implementation method 2 would cause flow to temporarily go below 20 percent of the unimpaired flow, EC at Vernalis would still be maintained at or below a running 30-day average of 0.7 dS/m April–August and 1.0 dS/m September–March through the program of implementation, as it is under the current objectives and, furthermore, flows would not be permitted to go below what is required by other agencies and processes. As such, it is unlikely that there would be more exceedances than would occur under baseline. Method 3 would not be authorized under LSJR Alternative 2 since the unimpaired flow percentage would not exceed 30 percent; therefore, method 3 would not affect EC.

Adaptive implementation method 4 would allow an adjustment of the Vernalis February–June flow requirement. WSE model results show that under LSJR Alternative 2 the 1,200-cfs February–June base flow requirement at Vernalis would require a flow augmentation in the three eastside tributaries and LSJR only 2.7 percent of the time in the 82-year record analyzed. Similarly, flow augmentation would be required 0.7 percent of the time to meet a 1,000-cfs requirement and 0.5 percent of the time for an 800-cfs Vernalis base flow requirement. These results indicate that changes due to method 4 under this alternative would rarely alter the flows in the three eastside tributaries or the LSJR.

Impacts associated with adaptive implementation method 1 may be slightly different from those associated with methods 2 and 3. With method 1, if the specified percent of unimpaired flow were changed from 20 percent to 30 percent on a long-term basis, the conditions and impacts could become more similar to those described under LSJR Alternative 3. It is anticipated that over time the unimpaired flow requirement could increase or not change at all within a year or between years, depending on fish and wildlife conditions and hydrology. If method 2 is implemented, the total annual volume of water associated with LJSR Alternative 2 (i.e., 20 percent of the February–June unimpaired flow) would not change, but the timing or magnitude of flows might change. Implementing method 4 would have little effect on conditions in the three eastside tributary rivers and LSJR because it rarely would cause a change in flow and the volume of water involved would be relatively small. As described above, adaptive implementation method 1 could cause a reduction in EC and methods 2 and 4 would cause little to no change in EC. Consequently, adaptive implementation would not affect the impact determination for the potential effect of LSJR Alternative 2 on attainment of EC objectives at Vernalis and southern Delta compliance locations, and impacts would be less than significant.

LSJR Alternative 3 (Less than significant/Less than significant with adaptive implementation)

The calculated monthly EC values for the SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard for LSJR Alternative 3 are given in Appendix F.1, *Hydrologic and Water Quality Modeling,* (Tables F.1-16a through 16c). Table 5-27a shows the monthly Vernalis EC values for LSJR Alternative 3, with adjusted Stanislaus River flows to meet the Vernalis EC objectives. There were no months with EC violations at Vernalis. Table 5-27b shows that Brandt Bridge EC values for LSJR Alternative 3 were higher than the 1.000 dS/m (1,000 µS/cm) objective in the months of September–March in a total of 28 months. The Brandt Bridge EC values were higher than the EC objective of 0.700 dS/m (700 µS/cm) in a total of 46 months during the April–August period. In total, at Brandt Bridge there were fewer months with EC values greater than the objective under LSJR Alternative 3 than there were for baseline (74 months for LSJR Alternative 3 versus 110 months for baseline). As described in Section 5.2.7, *Southern Delta*, Union Island (Old River near Middle River) has EC similar to Brandt Bridge.

Table 5-27a. Monthly Distribution of SJR at Vernalis EC Values (100 µS/cm increments) for LSJR Alternative 3 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	59	76	78	76	64	54	21	2	19	77	77	60	77
500	15	57	78	72	49	43	5	1	6	66	60	50	51
600	0	45	78	72	43	35	1	0	4	38	22	6	17
700	0	6	77	63	42	23	0	0	0	0	0	0	1
800	0	0	63	31	32	13	0	0	0	0	0	0	0
900	0	0	8	2	23	9	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-27b. Monthly Distribution of SJR at Brandt Bridge EC Values (100 µS/cm increments) for LSJR Alternative 3 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	63	79	79	76	65	56	28	5	29	77	80	69	79
500	42	58	78	72	50	47	8	1	11	68	63	57	58
600	0	55	78	72	44	39	2	1	4	60	46	30	32
700	0	26	77	65	43	25	1	0	3	27	15	4	4
800	0	3	72	56	38	17	0	0	0	4	4	0	0
900	0	0	25	13	25	11	0	0	0	0	0	0	0
1,000	0	0	4	0	16	8	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-27c shows that the Old River at Tracy Boulevard EC values for LSJR Alternative 3 were higher than the 1.000 dS/m (1,000 µS/cm) objective in the months of September–March in a total of 83 months.[17] The Tracy Boulevard calculated EC values for LSJR Alternative 3 were higher than the EC objective of 0.700 dS/m (700 µS/cm) in a total of 119 months during the April–August period. The total number of months with EC values above the EC objective for Old River at Tracy Boulevard would be reduced compared to baseline (202 months for LSJR Alternative 3 versus 267 months for baseline). Because LSJR Alternative 3 would likely reduce the number of months with EC above the existing EC objectives at Brandt Bridge, Union Island, and Tracy Boulevard, impacts would be less than significant.

Table 5-27c. Monthly Distribution of Old River at Tracy Boulevard EC Values (100 µS/cm increments) for LSJR Alternative 3 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	76	66	61	38	10	34	78	80	79	79
500	57	73	78	72	56	49	16	2	24	72	77	58	69
600	24	58	78	72	45	42	5	1	10	64	62	56	51
700	3	55	77	69	43	34	2	1	5	60	51	33	27
800	0	28	77	63	42	23	1	0	4	38	25	8	10
900	0	6	69	53	35	15	1	0	2	19	11	4	1
1,000	0	1	29	18	24	11	0	0	0	6	6	0	0
1,100	0	0	8	2	16	8	0	0	0	3	3	0	0
1,200	0	0	0	0	0	3	0	0	0	2	1	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

[17] As described above, the calculated EC values in Old River at Tracy Boulevard are generally greater than the EC values measured during the past 25 years.

Adaptive Implementation

Under LSJR Alternative 3, impacts associated with adaptive implementation method 1 may be slightly different from those associated with adaptive implementation methods 2 and 3.

Implementing method 1 would allow an increase or decrease of up to 10 percent in the February–June, 40-percent unimpaired flow requirement (with a minimum of 30 percent and maximum of 50 percent). Adaptive implementation must be approved using the process described in Appendix K, *Revised Water Quality Control Plan*. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. Adaptive implementation method 1 could affect the amount of water available for water supply and the volume of water and level of flow in the LSJR and its tributaries. However, the frequency and duration of such a change is unknown. If the specified percent of unimpaired flow were changed from 40 percent to 30 percent or 40 percent to 50 percent on a long-term basis, the conditions and impacts could become more similar to LSJR Alternatives 2 or 4, respectively. It is anticipated that over time the unimpaired flow requirement could increase, decrease, or not change at all within a year or between years, depending on fish and wildlife conditions and hydrology. If February–June flow is reduced as a result of adaptive implementation method 1, the reduction could cause an increase in EC relative to LSJR Alternative 3 without adaptive implementation. However, flow would not be reduced below 30 percent of unimpaired flow. Because LSJR Alternative 2 at 20 percent of unimpaired flow would not significantly impact the attainment of EC objectives in the southern Delta, 30 percent of unimpaired flow, as allowed by adaptive implementation method 1, would also not significantly impact the attainment of EC objectives.

Under adaptive implementation methods 2 or 3, the overall volume of water from the February–June time period or after June would be the same as LSJR Alternative 3 without adaptive implementation, but the volume within each month could vary. These two methods would not allow flows to go below what is required by existing requirements on the three tributaries and the SJR. EC, which can be dependent on the timing or magnitude of flow, could potentially be affected by method 2 or 3. Under adaptive implementation methods 2 or 3, flows could temporarily be reduced and EC increased in comparison to the 40 percent unimpaired flows. However, flows would be unlikely to go below baseline flows and flow reductions would be offset by increases in flows during other months.

Implementing method 4 would have little effect on conditions in the three eastside tributary rivers. WSE model results show that under Alternative 3 the 1,200-cfs February–June base flow requirement at Vernalis would require a flow augmentation in the three eastside tributaries and LSJR only 1.2 percent of the time in the 82-year record analyzed. Similarly, flow augmentation would be required only 0.2 percent of the time to meet either a 1,000-cfs or 800-cfs Vernalis base flow requirement. These results indicate that method 4 would rarely alter the flows in the three eastside tributaries or the LSJR under this alternative and, thus, would not influence EC.

Because adaptive implementation method 1 would not allow flows to go below those of LSJR Alternative 2 and because increases in EC resulting from methods 2–4 would cause little to no change in EC, adaptive implementation would not affect the impact determination for the effect of LSJR Alternative 3 on attainment of EC objectives at Vernalis and southern Delta compliance locations. Impacts would remain less than significant.

LSJR Alternative 4 (Less than significant/Less than significant with adaptive implementation)

Table 5-28a shows the monthly Vernalis EC values for LSJR Alternative 4, with adjusted Stanislaus River flows to meet the Vernalis EC objectives. There were no months with EC violations at Vernalis. Table 5-28b shows that Brandt Bridge, EC values for LSJR Alternative 4 were higher than the 1.000 dS/m (1,000 μS/cm) objective in the months of September–March in a total of 17 months. The Brandt Bridge EC values were higher than the EC objective of 0.700 dS/cm (700 μS/cm) in a total of 51 months during the April–August period. In total, there were fewer months with Brandt Bridge and Union Island EC values greater than the EC objective under LSJR Alternative 4 (68 months for LSJR Alternative 4 versus 110 months for baseline).

Table 5-28a. Monthly Distribution of SJR at Vernalis EC Values (100 μS/cm increments) for LSJR Alternative 4 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	59	75	79	75	54	46	6	1	6	77	77	60	76
500	15	57	79	73	45	30	2	0	4	72	63	50	42
600	0	45	77	72	40	17	0	0	1	52	22	6	5
700	0	6	77	66	29	11	0	0	0	0	0	0	0
800	0	0	64	35	24	8	0	0	0	0	0	0	0
900	0	0	8	4	14	3	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 μS/cm = 1 deciSiemen per meter (1 dS/m)
μS/cm = microSiemens per centimeter

Table 5-28b. Monthly Distribution of SJR at Brandt Bridge EC Values (100 μS/cm increments) for LSJR Alternative 4 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	63	79	79	75	56	48	7	1	9	77	80	69	79
500	43	58	79	73	45	32	2	0	5	74	71	57	55
600	0	55	79	72	41	21	1	0	3	69	47	31	17
700	0	26	77	67	31	13	0	0	1	35	15	4	3
800	0	3	73	59	27	9	0	0	0	4	4	0	0
900	0	0	25	17	16	6	0	0	0	0	0	0	0
1,000	0	0	4	2	9	2	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0

1000 μS/cm = 1 deciSiemen per meter (1 dS/m)
μS/cm = microSiemens per centimeter

Table 5-28c shows that the Old River at Tracy Boulevard EC values for LSJR Alternative 4 were higher than the 1.000 dS/m (1,000 µS/cm) objective in the months of September–March in a total of 74 months. The Tracy Boulevard calculated EC values were higher than the EC objective of 0.700 dS/m (700 µS/cm) in a total of 122 months during the April–August period. The total incidence of monthly EC values that were above the EC objective at Tracy Boulevard would be reduced compared to baseline (196 months for LSJR Alternative 4 versus 267 months for baseline). Because LSJR Alternative 4 would likely reduce the number of months with EC values above the EC objectives at Brandt Bridge, Union Island, and Tracy Boulevard, impacts would be less than significant.

Table 5-28c. Monthly Distribution of Old River at Tracy Boulevard EC Values (100 µS/cm increments) for LSJR Alternative 4 for 1922–2003

EC Value	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
400	80	80	79	75	62	54	14	2	13	79	80	80	79
500	57	70	79	75	47	41	4	1	9	77	77	58	70
600	24	58	79	72	44	29	2	0	6	71	70	56	46
700	3	55	77	70	36	16	1	0	3	68	50	35	17
800	0	28	77	66	29	12	0	0	2	39	28	8	4
900	0	6	71	57	25	8	0	0	1	19	11	4	1
1,000	0	1	30	21	16	6	0	0	0	6	6	0	0
1,100	0	0	8	2	10	2	0	0	0	3	3	0	0
1,200	0	0	0	0	0	1	0	0	0	2	1	0	0

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Adaptive Implementation

As discussed under LSJR Alternatives 2 and 3, adaptive implementation methods 2, 3, and 4 would not result in substantial increases in EC. Adaptive implementation method 1 would allow a decrease of up to 10 percent in the February–June, 60-percent unimpaired flow requirement (to 50 percent). Adaptive implementation must be approved using the process described in Appendix K, *Revised Water Quality Control Plan*. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. If the specified percent of unimpaired flow were changed from 60 percent to 50 percent on a long-term basis, the conditions and impacts could become more similar to LSJR Alternative 3, with adaptive implementation. Because LSJR Alternative 3 would have a less-than-significant effect on attainment of EC objectives, the impact of LSJR Alternative 4 with adaptive implementation would also be less than significant.

SDWQ Alternatives

SDWQ Alternative 2 (Less than significant)

Under SDWQ Alternative 2, the Vernalis and southern Delta salinity objectives would be changed to a year-round value of 1.0 dS/m. However, EC at Vernalis would be maintained at or below 0.7 dS/m April – August and 1.0 dS/m September–March through the program of implementation, as it is under the current objectives. This would provide some assimilative capacity downstream of Vernalis and protect beneficial agricultural uses. Because EC at Vernalis would be maintained under the program of implementation, as it is under the current objectives, SDWQ Alternative 2 would not change the Vernalis flow or EC values, regardless of whether the baseline flows or one of the LSJR alternatives were selected and implemented. SDWQ Alternative 2 would not lead to a deterioration of water quality at either Vernalis or the southern Delta.

The number of months with calculated EC values above the SDWQ Alternative 2 EC objective (1.0 dS/m in all months) would be different because most EC violations in the months of April–August at Brandt Bridge and Tracy Boulevard would be eliminated with the higher EC objective, but the calculated number of months with EC violations in the months of September–March would remain the same (because the EC objective would be the same). SDWQ Alternative 2 would generally reduce the number of months with EC values above the existing EC objectives (baseline) for the baseline flows and all LSJR alternatives (flows) in the following manner and as shown in Table 5-25.

- If SDWQ Alternative 2 is adopted, the number of calculated EC exceedances at Brandt Bridge would decrease from 110 months (out of 984) to 31 months if the flow and EC at Vernalis remain at baseline levels. The number of calculated EC violations at Tracy Boulevard would decrease from 267 months to 101 months. This reduces the incidence of EC values that were above the EC objective when compared to baseline.
- If LSJR Alternative 2 is implemented and SDWQ Alternative 2 is adopted, the number of EC violations at Brandt Bridge would decrease from a baseline of 110 months to 40 months. The Tracy Boulevard EC exceedance would decrease from 267 to 107.
- If LSJR Alternative 3 is implemented and SDWQ Alternative 2 is adopted, the number of EC violations at Brandt Bridge would decrease from a baseline of 110 months to 28 months. The number of EC violations at Tracy Boulevard would decrease from 267 months for existing EC objectives to 95 months with SDWQ Alternative 2.
- If LSJR Alternative 4 is implemented and SDWQ Alternative 2 is adopted, the number of EC violations at Brandt Bridge would decrease from a baseline of 110 months to 17 months. The number of EC violations at Tracy Boulevard would decrease from 267 months to 86 months.

Under SDWQ Alternative 2, the water quality objectives would be met in more months when compared to baseline conditions. Impacts would be less than significant.

SDWQ Alternative 3 (Less than significant)

Under SDWQ Alternative 3, the Vernalis and southern Delta salinity objectives would be changed to a year-round value of 1.4 dS/m. However, EC at Vernalis would be maintained at or below 0.7 dS/m April–August and 1.0 dS/m September–March through the program of implementation, as it is under the current objectives. This would provide some assimilative capacity downstream of Vernalis and protect beneficial agricultural uses.

SDWQ Alternative 3 would not change the Vernalis flow or EC values, regardless of whether the baseline flows or one of the LSJR alternatives were selected and implemented. The number of months with calculated EC values above the SDWQ Alternative 3 EC objectives (1.4 dS/m in all months) would be reduced to 0 months because there are no calculated EC values of greater than 1.4 dS/m for baseline or for any of the LSJR alternatives. The reduced incidence of EC values that were above the EC objective is considered beneficial, and because there has never been a calculated EC value greater than 1.4 dS/m for the southern Delta, impacts would be less than significant.

Impact WQ-2: Substantially degrade water quality by increasing Vernalis or southern Delta EC such that agricultural beneficial uses are impaired

No Project Alternative (LSJR/SDWQ Alternative 1)

The No Project Alternative would result in implementation of flow objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative impact discussion and Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative technical analysis.

LSJR Alternatives

The EC objectives are established to protect the beneficial use for agricultural water supply. The calculated monthly EC values were used to evaluate possible degradation of water quality through a substantial increase in salinity for agricultural beneficial uses at Vernalis or in the southern Delta channels when compared to baseline conditions. The approach for determining whether the LSJR alternatives could lead to an overall impact of increased salinity considers the long term cumulative distribution for EC during the irrigation season (April–September[18]).

The baseline monthly cumulative distributions of EC values at SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard are given in Appendix F.1, *Hydrologic and Water Quality Modeling,* (Tables F.1-14b, e, and g). The monthly cumulative distributions of EC values at SJR at Vernalis, SJR at Brandt Bridge, and Old River at Tracy Boulevard for the LSJR alternatives are also given in Appendix F.1 (Tables F.1-15a through 15c for LSJR Alternative 2, Tables F.1-16a through 16c for LSJR Alternative 3, and Tables F.1-17a through 17c for LSJR Alternative 4). The average April–September EC values for baseline at Vernalis ranged from 198 µS/cm to 678 µS/cm, with an average of 497 µS/cm. The calculated April–September average EC values for baseline at Brandt Bridge ranged from 205 µS/cm to 791 µS/cm, with an average of 545 µS/cm (48 µS/cm higher than Vernalis EC). The calculated April–September average EC values for baseline at Tracy Boulevard ranged from 218 µS/cm to 1,038 µS/cm, with an average of 640 µS/cm (143 µS/cm higher than Vernalis EC).

Tables 5-29a through 5-29c show the average April-September EC values expected under LSJR Alternatives 2, 3, and 4.

[18] September is included in the analysis because most agriculture still needs irrigation due to high air temperatures, high solar radiation, and little to no rain.

Table 5-29a. Cumulative Distributions of April–September Average EC values at Vernalis Baseline and LSJR Alternatives for 1922–2003

Percentile	Baseline	LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
		Results	Change	Results	Change	Results	Change
April–September Average EC (µS/cm) at Vernalis for Baseline and LSJR Alternatives							
Minimum	198	198	0	200	2	217	19
10	346	345	-2	324	-22	327	-19
20	434	422	-12	376	-57	353	-81
30	448	443	-4	392	-56	365	-83
40	469	458	-11	404	-65	376	-93
50	503	480	-23	418	-85	384	-119
60	529	496	-33	434	-95	400	-129
70	543	518	-25	456	-87	416	-127
80	599	537	-62	471	-128	430	-168
90	640	564	-77	491	-149	452	-188
Maximum	678	658	-20	608	-70	545	-133
Average	497	471	-25	418	-78	389	-108

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-29b. Cumulative Distributions of April–September Average EC values at Brandt Bridge for Baseline and LSJR Alternatives for 1922–2003

Percentile	Baseline	LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
		Results	Change	Results	Change	Results	Change
April–September Average EC (µS/cm) at Brandt Bridge for Baseline and LSJR Alternatives							
Minimum	205	205	0	206	2	224	20
10	364	362	-2	340	-24	345	-19
20	460	453	-7	397	-64	374	-86
30	484	477	-7	424	-60	392	-92
40	505	493	-12	441	-64	409	-96
50	548	524	-24	455	-93	418	-130
60	581	547	-34	474	-107	437	-144
70	595	571	-23	505	-89	460	-135
80	665	601	-64	525	-140	478	-187
90	736	656	-79	568	-167	518	-217
Maximum	791	755	-36	713	-78	641	-150
Average	545	516	-28	459	-86	427	-117

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

Table 5-29c. Cumulative Distributions of April–September Average EC values at Old River at Tracy Boulevard for Baseline and LSJR Alternatives for 1922–2003

Percentile	Baseline	LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
		Results	Change	Results	Change	Results	Change
April–September Average EC (µS/cm) at Tracy Boulevard for Baseline and LSJR Alternatives							
Minimum	218	218	0	220	2	239	21
10	400	398	-2	373	-27	383	-17
20	513	514	1	445	-68	423	-90
30	555	542	-14	476	-79	445	-110
40	580	570	-10	510	-70	474	-106
50	630	605	-25	530	-99	491	-139
60	677	646	-31	561	-116	521	-156
70	707	680	-27	598	-109	544	-163
80	794	720	-74	632	-162	573	-221
90	907	814	-92	710	-197	650	-257
Maximum	1,038	977	-62	923	-116	833	-205
Average	640	607	-34	540	-100	504	-137

1000 µS/cm = 1 deciSiemen per meter (1 dS/m)
µS/cm = microSiemens per centimeter

LSJR Alternative 2 (Less than significant/Less than significant with adaptive implementation)

Table 5-29a indicates that the average April–September EC values at Vernalis ranged from 0.198 dS/m (198 µS/cm) to 0.658 dS/m (658 µS/cm), with an average of 0.471 dS/m (471 µS/cm) under LSJR Alternative 2. The decrease in the distribution of EC at Vernalis was greater at the higher EC values, with an average reduction of 0.025 dS/m (25 µS/cm). This slight decrease in Vernalis EC was caused by the general increase in the monthly flows compared to the baseline flows at Vernalis. Because the baseline EC objectives at Vernalis are also expected to be met under the LSJR alternatives (due to the continuing responsibility of USBR to meet Delta water quality objectives identified in their water rights), the maximum EC values at Vernalis did not increase above the objectives under LSJR Alternative 2.

Table 5-29b indicates that the average April–September EC values at Brandt Bridge ranged from 0.205 dS/m (205 µS/cm) to 0.755 dS/m (755 µS/cm), with an average EC of 0.516 dS/m (516 µS/cm) under LSJR Alternative 2. The decrease in the distribution of EC at Brandt Bridge relative to baseline was greater at the higher EC values, with an average reduction of 0.028 dS/m (28 µS/cm).

Table 5-29c indicates that the average April–September EC values at Tracy Boulevard ranged from 0.218 dS/m (218 µS/cm) to 977 dS/m (977 µS/cm), with an average of 0.607 dS/m (607 µS/cm). The decrease in the distribution of EC at Tracy Boulevard was greater at the higher EC values, with an average reduction of 0.034 dS/m (34 µS/cm).

Although the monthly EC values might increase or decrease slightly, depending on the changes in the monthly flows, the range of salinity during the irrigation season of April–September in the SJR at

Vernalis and in the southern Delta channels under LSJR Alternative 2 would generally be reduced or remain very similar to baseline. Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 2, adaptive implementation method 1 could only increase flow relative to LSJR Alternative 2; method 2 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; method 3 is not applicable to LSJR Alternative 2; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore EC, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 2 on EC for agricultural beneficial uses described above. Impacts would be less than significant.

LSJR Alternative 3 (Less than significant/Less than significant with adaptive implementation)

Table 5-29a indicates that the average April–September EC values at Vernalis ranged from 0.200 dS/m (200 µS/cm) to 0.608 dS/m (608 µS/cm), with an average of 0.418 dS/m (418 µS/cm) under LSJR Alternative 3. The decrease in the distribution of EC at Vernalis relative to baseline was greater at the higher EC values, with an average reduction of 0.078 dS/m (78 µS/cm). This reduction in Vernalis EC was caused by the general increase in the monthly flows compared to the baseline flows at Vernalis.

Table 5-29b indicates the average April–September EC values at Brandt Bridge ranged from 0.206 dS/m (206 µS/cm) to 0.713 dS/m (713 µS/cm), with an average EC of 0.459 dS/m (459 µS/cm) under LSJR Alternative 3. The decrease in the distribution of EC at Brandt Bridge relative to baseline was greater at the higher EC values, with an average reduction of 0.086 dS/m (86 µS/cm). Table 5-29c indicates that the average April–September EC values at Tracy Boulevard ranged from 0.220 dS/m (220 µS/cm) to 0.923 dS/m (923 µS/cm), with an average of 0.540 dS/m (540 µS/cm). The change in the distribution of EC at Tracy Boulevard for LSJR Alternative 3 was greatest for the higher EC values, with an average reduction of 0.100 dS/m (100 µS/cm) relative to baseline.

The range of salinity during the irrigation season of April–September in the SJR at Vernalis and in the southern Delta channels under LSJR Alternative 3 would generally be reduced when compared to baseline. Therefore, agricultural beneficial uses would not be impaired because crops are not harmed by application of water with lower salinity. Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 3, adaptive implementation method 1 would not allow flow to go below that of LSJR Alternative 2; methods 2 and 3 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore EC, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 3 on EC for agricultural beneficial uses described above. Impacts would be less than significant.

LSJR Alternative 4 (Less than significant/Less than significant with adaptive implementation)

Table 5-29a indicates that the average April–September EC values at Vernalis ranged from 0.217 dS/m (217 µS/cm) to 0.545 dS/m (545 µS/cm), with an average of 0.389 dS/m (389 µS/cm) under LSJR Alternative 4. The reductions in EC at Vernalis for LSJR Alternative 4 were greatest for the higher EC values, with an average reduction of 0.108 dS/m (108 µS/cm). This reduction in Vernalis EC was caused by the general increase in the monthly flows compared to the baseline flows at Vernalis.

Table 5-29b indicates that the average April–September EC values at Brandt Bridge ranged from 0.224 dS/m (224 µS/cm) to 0.641 dS/m (641 µS/cm), with an average EC of 0.427 dS/m (427 µS/cm) under LSJR Alternative 4. The change in the EC at Brandt Bridge relative to baseline was greatest for the higher EC values, with an average reduction of 0.117 dS/m (117 µS/cm). Table 5-29c indicates that the average April–September EC values at Tracy Boulevard ranged from 0.239 dS/m (239 µS/cm) to 0.833 dS/m (833 µS/cm), with an average of 0.504 dS/m (504 µS/cm). The change in the distribution of EC at Tracy Boulevard for LSJR 4 was greatest for the higher EC values, with an average reduction of 0.137 dS/m (137 µS/cm) relative to baseline.

The range of salinity during the irrigation season of April–September in the SJR at Vernalis and in the southern Delta channels under LSJR Alternative 4 would generally be reduced when compared to baseline. Therefore, agricultural beneficial uses would not be impaired because crops are not harmed by application of water with lower salinity. Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 4, adaptive implementation method 1 would not allow flow to go below that of LSJR Alternative 3; methods 2 and 3 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore EC, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 4 on EC for agricultural beneficial uses described above. Impacts would be less than significant.

SDWQ Alternatives

SDWQ Alternatives 2 and 3 (No impact)

Under SDWQ Alternatives 2 and 3, the Vernalis and southern Delta salinity objectives would be changed to a year-round value of 1.0 dS/m and 1.4 dS/m, respectively. However, under SDWQ 2 and 3, it is expected the program of implementation would maintain EC at Vernalis at or below 0.7 dS/m April-August and 1.0 dS/m September-March as a running 30-day average, similar to current conditions, through actions undertaken by USBR in accordance with its water rights. Changes in EC that may occur downstream of Vernalis are dependent on conditions at Vernalis and within the southern Delta. As modeled for baseline and the LSJR alternatives, additional water is not released from upstream reservoirs to meet EC objectives farther downstream in the southern Delta for the SJR at Brandt Bridge and Old River at Tracy Boulevard.

As explained above, under SDWQ Alternatives 2 and 3, there would be no change in operations affecting southern Delta salinity relative to baseline, and water quality at Vernalis would be unaffected. Merely changing the water quality objectives would not affect water quality in the southern Delta relative to baseline. Therefore, the historical range of salinity (between 0.2 and 1.2 dS/m [200 and 1,200 µS/cm]) is expected to remain unchanged under SDWQ Alternatives 2 and 3. It is not anticipated that agricultural beneficial uses would be impaired with SDWQ Alternatives 2 or 3 because salinity would not change as a result of implementing SDWQ Alternatives 2 or 3. Therefore, there would be no impacts, and implementation of SDWQ Alternatives 2 or 3 would not affect impacts associated with LSJR Alternatives 2, 3, or 4.

Impact WQ-3: Substantially degrade water quality by increasing pollutant concentrations caused by reduced river flows

No Project Alternative (LSJR/SDWQ Alternative 1)

The No Project Alternative would result in implementation of flow objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative impact discussion and Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* for the No Project Alternative technical analysis.

LSJR Alternatives

There are multiple water quality constituents that are of concern within the study area. Impact WQ-3 focuses on water quality constituents that are not covered in other locations within this document. Chemicals that are of concern for drinking water quality, such as bromide and salinity are discussed in more detail in Chapter 13, *Service Providers*. A detailed discussion of the impact of potential changes in water temperature and other water quality indicators associated with the LSJR and SDWQ alternatives on fisheries resources can be found in Chapter 7, *Aquatic Biological Resources*. In addition, potential effects on turbidity, erosion, and siltation are discussed in Chapter 6, *Flooding, Sediment, and Erosion*, and Chapter 7, *Aquatic Biological Resources.* Impacts WQ-1 and WQ-2, above, emphasize potential salinity effects because agricultural beneficial uses would be sensitive to changes in salinity extensive EC data are available, and salinity has specific water quality objectives. Potential changes in salinity indicate how other water quality constituents would change. Impact WQ-3 focuses on other water quality constituents that may be affected by changes in flow.

Changing the baseline monthly flows would change the dilution of any pollutants (e.g., 303(d) pollutants listed in Table 5-4) that enter the LSJR or its tributaries or the southern Delta as a point source or non-point source. The source loading of 303(d) pollutants would either remain constant or be caused by storm water runoff or agricultural drainage, and would be independent of the reservoir releases occurring under baseline conditions and the LSJR alternatives. Therefore, the change in concentration would be the inverse of the change in flow (flow ratio). In other words, it is reasonable to assume the concentration of a 303(d) pollutant would increase with a decrease in flow. DO is not considered to be pollutants per se, but it is a water quality indicator that can also be improved by increased flow.

Implementation of the LSJR and SDWQ alternatives would not lead to changes in the Upper SJR flow or pollutant concentrations upstream of the confluence of the LSJR with the Merced River.

Changes in flow in the Merced River associated with the LSJR alternatives would change the dilution of pollutants in the Merced River and would change flows and dilution in the LSJR downstream of the Merced River. The changes downstream would be smaller than in the tributary river because the LSJR baseline flows are greater than the flows in the tributary river. Changes in the Tuolumne River flow would change the dilution and concentrations of pollutants in the Tuolumne River, with smaller changes in the LSJR downstream of the Tuolumne. Changes in the Stanislaus River flows would change the dilution of pollutants in the Stanislaus River and in the LSJR downstream of the Stanislaus (e.g., at Vernalis).

Changes in flow at Vernalis can change water quality through many parts of the southern Delta. In general, increases in flow at Vernalis would improve water quality in the southern Delta by diluting pollutant concentrations with the addition of relatively clean water from the Stanislaus, Tuolumne, and Merced Rivers. DO within the Stockton DWSC is also generally improved (increased) by increases in flow through several different mechanisms including a reduction in the concentration of algae from reduced travel time for algal growth (Central Valley Water Board 2014; ICF International 2010). Potential effects on southern Delta EC are discussed specifically above in Impacts WQ-1 and WQ-2. However, potential effects of changes in flow on other water quality constituents in the southern Delta are captured here under Impact WQ-3.

Changes in flow at Vernalis could also affect other portions of the Delta. Increases in flow at Vernalis could either contribute to increased Delta exports or to increased Delta outflows. Delta outflow helps to prevent salinity intrusion, so increases in Vernalis flow could potentially help to prevent salinity intrusion, although the effect of the LSJR alternatives on Delta outflow are generally relatively small compared to total Delta outflow, because the SJR Watershed only contributes approximately 13 percent to total Delta inflow (based on DAYFLOW data for water years 1995–2013).

The impact assessment is based on the comparison of the baseline flows to the LSJR Alternative flows. Because water quality is generally poorest at low flows, changes in the cumulative flow distribution at the low end of the distribution are most likely to affect water quality. For this reason, the potential effect of changes in flow on changes in water quality were evaluated primarily by looking at changes in the 10^{th} percentile, but changes in median flows were also considered.

In general the LSJR Alternatives would cause flows to increase, which would reduce pollutant concentrations and improve any chronic water quality problems. However, it is possible that in some years, some months will experience flow reductions. These flow reductions would be unlikely to be detrimental because they would be of short duration. Furthermore, flows could not be reduced below levels required by other agencies or through other processes. Because a short-term reduction in flow would need to be relatively large to potentially cause water pollution problems, a threshold of a 50 percent increase in pollutant concentration was used. A 50 percent increase in pollutant concentration would occur if there was a one-third reduction in flow. Therefore, a reduction in 10^{th} percentile or median flows of more than 33 percent for a particular month was considered to be potentially significant and subject to further evaluation. In addition, smaller reductions in flow (10 percent) would also be considered to be potentially significant if they occurred for multiple months.

LSJR Alternative 2 (Less than significant/Less than significant with adaptive implementation)

For each of the three eastside tributaries and the LSJR, flows generally stayed about the same (for the Stanislaus River) or increased with LSJR Alternative 2 (Tables 5-17a through 5-17d). While only a few months showed decreases in flows on all rivers, median flows on the Stanislaus River decreased by more than 10 percent during March. However, because baseline median flows in March on the Stanislaus River were moderately high (which would generally be associated with low pollutant concentrations), this decrease in flow is unlikely to cause an exceedance of a water quality objective. None of the monthly 10th percentile or median flows decreased by more than 33 percent relative to baseline. Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 2, adaptive implementation method 1 could only increase flow relative to LSJR Alternative 2; method 2 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; method 3 is not applicable to LSJR Alternative 2; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore water quality, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 2 on pollutant concentrations as described above. Impacts would be less than significant.

LSJR Alternative 3 (Less than significant/Less than significant with adaptive implementation)

For each of the three eastside tributaries and the LSJR, low and median flows generally increased with LSJR Alternative 3 (Tables 5-17a through 5-17d). Few months showed decreases in flows and no months had 10th percentile or median flows that decreased by more than 33 percent. There were two instances of median flows decreasing by more than 10 percent (March on the Tuolumne River and February on the SJR at Vernalis). In these instances, because baseline median flows were moderately high, it is reasonable to assume that these decreases would not cause water quality problems because there would still be sufficient flow in the river to reduce concentrations of pollutants (flow would still be much higher than baseline summer median flows). Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 3, adaptive implementation method 1 would not allow flow to go below that of LSJR Alternative 2; methods 2 and 3 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore water quality, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 3 on pollutant concentrations as described above. Impacts would be less than significant.

LSJR Alternative 4 (Less than significant/Less than significant with adaptive implementation)

For each of the three eastside tributaries and the LSJR, low and median flows generally increased with LSJR Alternative 4 (Tables 5-17a through 5-17d). Few months showed decreases in flows and none of the monthly 10th percentile or median flow decreased by more than 10 percent. Impacts would be less than significant.

Adaptive Implementation

As described under Impact WQ-1 for LSJR Alternative 4, adaptive implementation method 1 would not allow flow to go below that of LSJR Alternative 3; methods 2 and 3 could cause temporary reductions in flow relative to LSJR Alternative 2, but these reductions would be offset by increases in flow at other times and flow could not go below what is required by other agencies or processes; and method 4 would rarely affect flows. Because of the limited effect of adaptive implementation on flow, and, therefore water quality, it is anticipated that adaptive implementation would not change the impact determination for the effects of LSJR Alternative 4 on pollutant concentrations as described above. Impacts would be less than significant.

SDWQ Alternatives

SDWQ Alternatives 2 and 3 (No impact)

SDWQ Alternatives 2 and 3 would not result in an increase in pollutant concentrations because the SJR at Vernalis EC would continue to be maintained as it is under baseline conditions. As a result, SDWQ Alternatives 2 and 3 would not cause a change in flow. Therefore, WQ-3 impacts would not occur.

5.4.4 Impacts and Mitigation Measures: Extended Plan Area

Similar to the plan area, changing the flows in the rivers in the extended plan area would change the dilution of any water quality constituent of concern (e.g., 303(d) pollutants identified in Section 5.2.1, *San Joaquin River Basin and Southern Delta Hydrology and Water Quality)* that enter the rivers as a point source or non-point source. The source loading would either remain constant or be caused by storm water runoff or drainage, and would be independent of the reservoir releases occurring under baseline conditions or the LSJR alternatives with or without adaptive implementation. Therefore, the change in concentration would be the inverse of the change in flow. In other words, it is reasonable to assume the concentration would decrease with an increase in flow. There is a relatively small volume of water that could be affected by the flow requirements in the extended plan area on the three rivers. In general the LSJR alternatives with or without adaptive implementation would cause flows to increase, which would reduce concentrations and improve any chronic water quality problems. Furthermore, the water quality on the rivers in the extended plan area is generally high quality (Kennedy-Jenks Consultants 2013, 2014). As such, it is expected that additional water in the rivers would not degrade the existing water quality under LSJR Alternatives 2, 3, or 4 with or without adaptive implementation. Impacts would be less than significant.

Water quality could be affected by changes in reservoir elevation (storage levels) under the LSJR alternatives with or without adaptive implementation on the Stanislaus and Tuolumne Rivers. There are no substantial reservoirs on the Merced River in the extended plan area. The frequency with which reservoirs in the extended plan area are drawn down to lower storage levels would depend on the seniority of water rights, how water rights are conditioned to implement the flow objectives, and the duration and frequency of bypass flows. While the changes in storage levels may be greatest in critically dry and dry years, particularly under LSJR Alternatives 3 and 4 with or without adaptive implementation, there may be some changes in above normal years and wet years. To the extent that water in the extended plan area is bypassed to meet the unimpaired flow requirement, instead of being diverted to storage, reservoir levels in the extended plan area would decline. Water quality in upstream reservoirs in the Stanislaus and Tuolumne Watersheds is generally high quality (Kennedy-Jenks Consultants 2013). Furthermore, reservoir volume reductions would have minimal effects on most water quality constituents (e.g., mercury) because the reduction in storage would result from water (and the constituent) flowing out of the reservoir. In other words, the concentrations of water quality constituents would not change or increase relative to baseline and it is unlikely that the water quality would be degraded. Impacts would be less than significant under LSJR Alternatives 2, 3, or 4 with or without adaptive implementation.

5.5 Cumulative Impacts

For the cumulative impact analysis, refer to Chapter 17, *Cumulative Impacts, Growth-Inducing Effects, and Irreversible Commitment of Resources.*

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5.6.2 Personal Communications

Steiner, Daniel B. Operations Modeling Consultant. Independent Consultant. (May 30, 2013)—Conversation with Lucas Sharkey during proceedings of FERC New Don Pedro Operations Model Base Case Workshop and Training Session (W&AR-02).