Appendix G Water Quality Technical Appendix

This appendix documents the water quality technical analysis to support the impact analysis in the environmental impact statement (EIS).

G.1 Background Information

This section describes surface water quality that could be potentially affected by implementing the alternatives considered in this EIS. Changes in water quality due to changes in the Central Valley Project (CVP) and State Water Project (SWP) operation may occur in the Trinity River, Sacramento River, Clear Creek, Feather River, American River, Stanislaus River, San Joaquin River, Bay-Delta, and the CVP/SWP service area (south to Diamond Valley). Given the limited changes in outflow to the Pacific Ocean, water quality in the nearshore Pacific Ocean is unlikely to be affected by this project's implementation, and therefore, this technical appendix will not analyze the nearshore Pacific Ocean. Appendix H, *Water Supply Technical Appendix* describes changes to surface water bodies and water supplies.

This appendix focuses on constituents of concern that could be affected by changes in CVP/SWP water operation. The *Final California 2014-2016 Integrated Report* (Section 303(d) List/305(b) Report) identifies constituents of concern as well as other water quality reports. This section describes constituents' sources, water quality effects, objectives, and guidelines, and plans to improve water quality.

G.1.1 State-Designated Beneficial Uses of Surface Waters in the Study Area

The Regional Water Quality Control Board (RWQCB) *Basin Plans and Integrated Reports* assessed and described water quality conditions throughout the study area. All waters of the State have specific beneficial uses specified in State or Tribal water quality standards. Each regional Water Board is charged with protecting these uses from pollution and nuisance. The use designations serve as a basis for establishing water quality objections and discharge prohibitions to protect the resource. Beneficial uses are summarized in Table G.1-1, Designated Beneficial Uses within Project Study Area. The water quality objectives established to protect these beneficial uses are found in Water Quality Control Plans, which define the limits of constituents of concern for protection of each beneficial use. Many of these water quality constituents of concern are prevalent throughout the study area. The origins and prevalence of these pollutants are discussed below.

Table G.1-1. State-Designated Beneficial Uses within Project Study Area

Surface Water Body	Municipal and Domestic Supply (MUN)	Agricultural Supply (AGR)	Industrial Service Supply (IND)	Industrial Process Supply (PRO)	Groundwater Recharge (GWR)	Fresh Water Replenishment (FRSH)	Navigation (NAV)	Hydropower Generation (POW)	Water Contact Recreation (REC-1)	Non-Contact Water Recreation (REC-2)	Commercial and Sport Fishing (COMM)	Warm Fresh Water Habitat (WARM)	Cold Fresh Water Habitat (COLD)	Wildlife Habitat (WILD)	Rare, Threatened, or Endangered Species (RARE)	Marine Habitat (MAR)	Migration of Aquatic Organisms (MIGR)	Spawning, Reproduction, and/or Early Development (SPWN)	Shellfish Harvesting (SHELL)	Estuarine Habitat (EST)	Aquaculture (AQUA)	Native American Culture (CUL)	Flood Peak Attenuation/ Flood Water Storage (FLD)	Wetland Habitat (WET)	Water Quality Enhancement (WQE)
Trinity and Lower Klamath Rivers																									
Lower Klamath River and Klamath Glen Hydrologic Subarea	E	E	P	P	E	E	E	P	E	E	E	E	E	E	E	E	E	E	E	E	P	E	–	–	–
Trinity Lake	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	–	P	E	–	–	P	–	–	–	–
Lewiston Reservoir	E	E	P	P	E	E	E	E	E	E	E	P	E	E	E	–	P	E	–	–	E	–	–	–	–
Middle Trinity River and Surrounding Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E	–	E	E	E	–	E	E	–	–	E & P	–	–	–	–
Lower Trinity River and Surrounding Hydrologic Area[1]	E	E	E	P	E	E	E	E & P	E	E	E	–	E	E	E	–	E	E	P	–	E & P	E[2]	–	–	–
Sacramento River Basin																									
Shasta Lake	E	E	–	–	–	–	–	E	E	E	–	E[4]	E[4]	E	–	–	–	E[5,6]	–	–	–	–	–	–	–
Sacramento River: Shasta Dam to Colusa Basin Drain	E	E	E	–	–	–	E	E	E[3]	E	–	E[4]	E[4]	E	–	–	E[5,6]	E[5,6]	–	–	–	–	–	–	–

Surface Water Body	Municipal and Domestic Supply (MUN)	Agricultural Supply (AGR)	Industrial Service Supply (IND)	Industrial Process Supply (PRO)	Groundwater Recharge (GWR)	Fresh Water Replenishment (FRSH)	Navigation (NAV)	Hydropower Generation (POW)	Water Contact Recreation (REC-1)	Non-Contact Water Recreation (REC-2)	Commercial and Sport Fishing (COMM)	Warm Fresh Water Habitat (WARM)	Cold Fresh Water Habitat (COLD)	Wildlife Habitat (WILD)	Rare, Threatened, or Endangered Species (RARE)	Marine Habitat (MAR)	Migration of Aquatic Organisms (MIGR)	Spawning, Reproduction, and/or Early Development (SPWN)	Shellfish Harvesting (SHELL)	Estuarine Habitat (EST)	Aquaculture (AQUA)	Native American Culture (CUL)	Flood Peak Attenuation/ Flood Water Storage (FLD)	Wetland Habitat (WET)	Water Quality Enhancement (WQE)
Colusa Basin Drain	–	E	–	–	–	–	–	–	E[3]	–	–	E[4]	P[4]	E	–	–	E[6]	E[6]	–	–	–	–	–	–	–
Sacramento River: Colusa Basin Drain to Eye (“I”) Street Bridge	E	E	–	–	–	–	E	–	E[3]	E	–	E[4]	E[4]	E	–	–	E[5,6]	E[5,6]	–	–	–	–	–	–	–
Whiskeytown Reservoir	E	E	–	–	–	–	–	E	E	E	–	E[4]	E[4]	E	–	–	–	E[6]	–	–	–	–	–	–	–
Clear Creek below Whiskeytown Reservoir	E	E	–	–	–	–	–		E[3]	E	–	E[4]	E[4]	E	–	–	E[5]	E[5,6]	–	–	–	–	–	–	–
Feather River below Lake Oroville (Fish Barrier Dam to Sacramento River)	E	E	–	–	–	–	–	–	E[3]	E	–	E[4]	E[4]	E	–	–	E[5,6]	E[5,6]	–	–	–	–	–	–	–
American River below Lake Natoma (Folsom Dam to Sacramento River)	E	E	E	–	–	–	–	E	E[3]	E	–	E[4]	E[4]	E	–	–	E[5,6]	E[5,6]	–	–	–	–	–	–	–
Yolo Bypass[7]	–	E	–	–	–	–	–	–	E	E	–	E[4]	P[4]	E	–	–	E[5,6]	E[6]	–	–	–	–	–	–	–

Surface Water Body	Municipal and Domestic Supply (MUN)	Agricultural Supply (AGR)	Industrial Service Supply (IND)	Industrial Process Supply (PRO)	Groundwater Recharge (GWR)	Fresh Water Replenishment (FRSH)	Navigation (NAV)	Hydropower Generation (POW)	Water Contact Recreation (REC-1)	Non-Contact Water Recreation (REC-2)	Commercial and Sport Fishing (COMM)	Warm Fresh Water Habitat (WARM)	Cold Fresh Water Habitat (COLD)	Wildlife Habitat (WILD)	Rare, Threatened, or Endangered Species (RARE)	Marine Habitat (MAR)	Migration of Aquatic Organisms (MIGR)	Spawning, Reproduction, and/or Early Development (SPWN)	Shellfish Harvesting (SHELL)	Estuarine Habitat (EST)	Aquaculture (AQUA)	Native American Culture (CUL)	Flood Peak Attenuation/ Flood Water Storage (FLD)	Wetland Habitat (WET)	Water Quality Enhancement (WQE)
Bay-Delta																									
Sacramento–San Joaquin Delta[7,8,9]	E	E	E	E	E	–	E	–	E	E	E	E[4]	E[4]	E	E	–	E[5,6]	E[6]	E	E	–	–	–	–	–
Suisun Bay	–	–	E	E	–	–	E	–	E	E	E	–	–	E	E	–	E	E	–	E	–	–	–	–	–
Carquinez Straight	–	–	E	–	–	–	E	–	E	E	E	–	–	E	E	–	E	E	–	–	E	–	–	–	–
San Pablo Bay	–	–	E	–	–	–	E	–	E	E	E	–	–	–	E	E	–	E	E	E	E	–	–	–	–
San Francisco Bay Central	–	–	E	E	–	–	E	–	E	E	E	–	–	E	E	–	E	E	E	E	–	–	–	–	–
San Francisco Bay Lower	–	–	E	–	–	–	E	–	E	E	E	–	–	E	E	–	E	E	E	E	–	–	–	–	–
San Francisco Bay South	–	–	E	–	–	–	E	–	E	E	E	–	–	E	E	–	E	E	E	E	–	–	–	–	–
San Joaquin River and Tulare Basin																									
San Joaquin River: Friant Dam to Mendota Pool	E	E	–	E	–	–	–	–	E[3]	E	–	E[4]	E[4]	E	–	–	E[5,6]	E[6], P[5]	–	–	–	–	–	–	–
San Joaquin River: Sack Dam to the Mouth of Merced River	P	E	–	E	–	–	–	–	E[3]	E	–	E[4]	–	E	–	–	E[5,6]	E[6], P[5]	–	–	–	–	–	–	–

Surface Water Body	Municipal and Domestic Supply (MUN)	Agricultural Supply (AGR)	Industrial Service Supply (IND)	Industrial Process Supply (PRO)	Groundwater Recharge (GWR)	Fresh Water Replenishment (FRSH)	Navigation (NAV)	Hydropower Generation (POW)	Water Contact Recreation (REC-1)	Non-Contact Water Recreation (REC-2)	Commercial and Sport Fishing (COMM)	Warm Fresh Water Habitat (WARM)	Cold Fresh Water Habitat (COLD)	Wildlife Habitat (WILD)	Rare, Threatened, or Endangered Species (RARE)	Marine Habitat (MAR)	Migration of Aquatic Organisms (MIGR)	Spawning, Reproduction, and/or Early Development (SPWN)	Shellfish Harvesting (SHELL)	Estuarine Habitat (EST)	Aquaculture (AQUA)	Native American Culture (CUL)	Flood Peak Attenuation/ Flood Water Storage (FLD)	Wetland Habitat (WET)	Water Quality Enhancement (WQE)
San Joaquin River: Mouth of Merced River to Vernalis	P	E	–	E	–	–	–	–	E[3]	E	–	E[4]	–	E	–	–	E[5,6]	E[6]	–	–	–	–	–	–	–
New Melones Reservoir	E	E	–	–	–	–	–	E	E	E	–	–	E[4]	E	–	–	–	–	–	–	–	–	–	–	–
Tulloch Reservoir	P	E	–	–	–	–	–	E	E	E	–	E[4]	–	E	–	–	–	–	–	–	–	–	–	–	–
Stanislaus River: Goodwin Dam to San Joaquin River	P	E	E	E	–	–	–	E	E[3]	E	–	E[4]	E[4]	E	–	–	E[5]	E[5,6]	–	–	–	–	–	–	–
San Luis Reservoir	E	E	E	–	–	–	–	E	E	E	–	E[4]	–	E	–	–	–	–	–	–	–	–	–	–	–
O'Neill Reservoir	E	E	–	–	–	–	–	–	E	E	–	E[4]	–	–	–	–	–	–	–	–	–	–	–	–	–
California Aqueduct	E	E	E	E	–	–	–	E	E	E	–	–	–	E	–	–	–	–	–	–	–	–	–	–	–
Delta-Mendota Canal	E	E	–	–	–	–	–	–	E	E	–	E[4]	–	E	–	–	–	–	–	–	–	–	–	–	–

Sources: State Water Resources Control Board (SWRCB) 2006; Hoopa Valley TEPA 2008; Central Valley RWQCB 2018a; North Coast RWQCB 2018; San Francisco Bay RWQCB 2017.

Notes:

E: Existing Beneficial Use; P: Potential Beneficial Use

[1] Includes beneficial uses for the Trinity River within the Hoopa Valley Indian Reservation as designated by the Hoopa Valley Indian Reservation Water Quality Control Plan, which, in addition to beneficial uses shown, also designates the Lower Trinity River as a Wild and Scenic waterway, providing for scenic, fisheries, wildlife and recreational purposes.

[2] Not all beneficial uses are present uniformly throughout this water body. They have been summarized to reflect beneficial uses present in multiple segments of the water body.

[3] Canoeing and rafting included in REC-1 designation.
[4] Resident does not include anadromous. Any Segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.
[5] Cold water protection for salmon and Steelhead.
[6] Warm water protection for Striped Bass (*Morone saxatilis*), sturgeon (*Acipenser*), and shad (*Alosa sapidissima* and *Dorosoma petenense*).
[7] Beneficial uses vary throughout the Delta and will be evaluated on a case-by-case basis. COMM is a designated beneficial use for the Sacramento San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins and not any tributaries to the listed waterways or portions of the listed waterways outside of the legal Delta boundary unless specifically designated.
[8] Delta beneficial uses are shown as designated by the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin, and the Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary.
[9] Per State Water Board Resolution No. 90-28, Marsh Creek and Marsh Creek Reservoir in Contra Costa County are assigned the following beneficial uses: REC-1 and REC-2 (potential uses), WARM, WILD and RARE. COMM is a designated beneficial use for Marsh Creek and its tributaries listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins within the legal Delta boundary.

G.1.1.1 *Salinity*

Salinity, a measure of dissolved salts in water, is a concern in the tidally-influenced Sacramento–San Joaquin Delta (Delta), as it can affect domestic supply, agriculture, industry, and wildlife (CALFED 2007a). Salinity's impacts on the Delta's domestic supply of water include aesthetic, or cosmetic effects, and increasing the need to reduce salinity for municipal and industrial uses by blending, which can lead to a reduction in the quantity of usable water. Salts in drinking water, such as bromide, can increase harmful byproducts formation. Salinity in the Delta affects agriculture by reducing crop yields and salinity in the soil can cause plant stress. Objectives for another salt ion, chloride, are intended to protect municipal and industrial uses. Residual chloride is known to cause corrosion in canned goods because of residual salts in paper boxes or linerboard.

Some fish and wildlife are also affected by salinity concentrations in the Delta because certain levels of salinity are required during different life stages to survive. One measure of salinity in the western Delta is "X2." X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where the tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs. The SWRCB established the X2 standard to improve shallow water estuarine habitat in February through June and relates to the extent of salinity movement into the Delta (California Department of Water Resources [DWR] and Reclamation 2016). The location of X2 is important to both aquatic life and water supply beneficial uses.

The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix D, *Alternatives Development*.

The California State Water Resources Control Board (SWRCB) Water Right Decision 1641 (D-1641) includes "spring X2" criteria that require CVP/SWP operation to include upstream reservoir releases from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. In addition, the 2019 United States Fish and Wildlife Service (USFWS) Biological Opinion (BO) also includes a proposed additional Delta salinity requirement of a monthly average 2 ppt isohaline (X2) at 80 km from the Golden Gate for September and October in wet and above-normal water years (USFWS 2019).

G.1.1.2 *Mercury*

Mercury is a constituent of concern throughout California, both as total mercury and as biologically-formed methylmercury, which is more available for food chain exposure and toxicity. Mercury present in the Delta, its tributaries, Suisun Marsh, and San Francisco Bay is derived from current processes as well as a result of historical deposition. Most of the mercury present in these locations is the result of historical mercury ore mining in the Coast Ranges (via Putah and Cache creeks to the Yolo Bypass) and elemental mercury's extensive use in gold extraction processes in the Sierra Nevada (via Sacramento, San Joaquin, Cosumnes, and Mokelumne rivers) (Alpers et al. 2008; Wiener et al. 2003). Elemental mercury from historical gold mining processes appears to be more bioavailable than that from mercury ore tailings because mercury used in gold mining processes was purified before use (Central Valley RWQCB 2010a). Additional mercury sources include atmospheric deposition from local and distant sources, and discharges from wastewater treatment plants (SWRCB 2018a).

Mercury methylation is an important step in the entrance of mercury into food chain (USEPA 2001a; xiv). This transformation can occur in sediment and the water column. Methylmercury is absorbed more quickly by aquatic organisms than inorganic mercury, and it biomagnifies (i.e., the concentration of methylmercury increases in predatory fish as they eat smaller contaminated fish and invertebrates). The pH of water, the length of the aquatic food chain, water temperature, and dissolved organic material and sulfate are all factors that can contribute to methylmercury's bioaccumulation in aquatic organisms. The proportion of an area that is wetlands, the soil type, and erosion can also contribute to the amount of mercury transported from soils to water bodies. These effects can be seen in the variability in bioaccumulated mercury in the Delta.

Contaminated fish consumption is the major pathway for human exposure to methylmercury (USEPA 2001a). Once consumed, methylmercury is almost completely absorbed into the blood and transported to all tissues. It is also transmitted to the fetus through the placenta. Neurotoxicity from methylmercury can result in mental retardation, cerebral palsy, deafness, blindness, and dysarthia in utero, and in sensory and motor impairments in adults. Studies have also reported cardiovascular and immunological effects from low-dose methylmercury exposure.

In an effort to protect aquatic and human health, the U.S. Environmental Protection Agency (USEPA) recommended maximum concentrations "without yielding unacceptable effects" in 2001 for acute exposure, identified as the criteria maximum concentration (CMC), and for chronic exposure, identified as the criterion continuous concentration (CCC) (USEPA 2001a, 2019). In 2000, USEPA established current state-wide water quality criteria for mercury in the California Toxics Rule (CTR) (USEPA 2000). Under these requirements, total recoverable mercury for the protection of human health was set as limits for the consumption of water and organisms, as well as the consumption of organisms only, as summarized in Table G.1-2, Water Quality Criteria for Mercury and Methylmercury (as Total Mercury). Some California RWQCB basin plans also include mercury objectives, as discussed in subsequent sections of this appendix. Where both a CTR criterion and a Basin Plan objective exist, the more stringent value applies (SWRCB 2006).

Table G.1-2. Water Quality Criteria for Mercury and Methylmercury (as Total Mercury)

NRWQC	For the protection of freshwater species		CMC = 1.4 µg/L
			CCC = 0.77 µg/L
	For the protection of saltwater species		CMC = 1.8 µg/L
			CCC = 0.94 µg/L
	For the protection of human health[1]		0.3 mg/kg [2]
CTR	For the protection of human health	Consumption of water + organism	0.050 µg/L
		Consumption of organism only	0.051 µg/L

Sources: NRWQC (National Recommended Water Quality Criteria) - USEPA 2019; CTR (California Toxic Rule) - USEPA 2000, USEPA 2001b.
Notes:
[1] For the consumption of organisms only and based on a total consumption 0.0175 kg fish and shellfish per day.
[2] Methylmercury in fish tissue (wet weight)

A review of the mercury human health criteria by USEPA in 2001 concluded that a fish tissue (including shellfish) residue water quality criterion for methylmercury is more appropriate than a water-column-based water quality criterion (USEPA 2001a).

The CTR criterion may be implemented as a fish tissue-based objective (FTO), or it may be converted into an ambient methylmercury water quality objective, the latter reflecting the USEPA's fish consumption rate of 0.0175 kilogram per fish per day (kg/fish/day), or site-specific consumption rates that more accurately reflect local consumption patterns (SWRCB 2006). A USFWS evaluation of the USEPA methylmercury criterion concluded that the FTO of 0.3 milligram (mg) methylmercury/kg fish would be insufficient to protect three species that may occur in the study area: the California least tern (*Sterna* *antillarum browni*), California clapper rail (*Rallus obsoletus*), and bald eagle (*Haliaeetus leucocephalus*) evaluated in the study.

G.1.1.3 *Selenium*

Selenium is a constituent of concern in the study area because of its potential effects on water quality and aquatic and terrestrial resources, primarily in the San Joaquin Valley and the San Francisco Bay, as well as some locations in Southern California (SWRCB 2011). Elevated selenium concentrations in soil and waterways within the San Joaquin Valley, and to some extent in the San Francisco Bay, are primarily from the erosion of uplifted selenium-enriched Cretaceous and Tertiary marine sedimentary rock located at the base of the east-facing side of the Coastal Range (Presser and Piper 1998; Presser 1994). Natural processes transport the selenium-enriched soil derived from the eroded rock to the western San Joaquin Valley; irrigation processes mobilize selenium from the soil and transported to waterways receiving agricultural drainage (Presser and Ohlendorf 1987). Other sources of selenium to the western Delta and San Francisco Bay include several oil refineries located near Carquinez Strait and San Pablo Bay (Presser and Luoma 2013; SWRCB 2011). The specific water bodies within these areas that may be affected by the project and are impaired by selenium, as specified on the California Section 303(d) list, include the Panoche Creek (from Silver Creek to Belmont Avenue), Mendota Pool, Grasslands Marshes, San Joaquin River (from Mud Slough to Merced River), San Francisco Bay, Sacramento–San Joaquin Delta, and Suisun Bay (SWRCB 2017a).

Adverse effects of selenium may occur from either a selenium deficiency or excess in the diet (ATSDR 2003; Ohlendorf 2003); the latter is the primary concern in the case of the impaired water bodies on the Section 303(d) list. Due to the known effects of selenium bioaccumulation from water to aquatic organisms and higher trophic levels in the food chain, the fresh water, estuarine and wildlife habitat; spawning, reproduction, and early development; and rare, threatened, or endangered species beneficial uses of the water bodies are the most sensitive receptors to selenium exposure. Thus, excessive exposure can lead to selenium toxicity or selenosis and result in death or deformities of fish embryos, fry, or larvae (Ohlendorf 2003; Chapman et al. 2009). Consequently, regulatory agencies established exposure criteria to protect the beneficial uses of the water bodies.

The Agency for Toxic Substances and Disease Registry (ATSDR), California Office of Environmental Health Hazard Assessment (OEHHA), USEPA, SWRCB, and RWQCB determined acceptable selenium exposure levels for humans and water bodies in California. The ATSDR stated the minimum risk levels (MRLs) for selenium to be ingested over a 1-year period is 0.005 milligrams per kilogram per day (mg/kg/day), with an uncertainty factor of three (ATSDR 2018). The 0.005 mg/kg/day value is also used by OEHHA to develop guidelines for consuming fish (OEHHA 2008). USEPA set 50 micrograms per liter (µg/L) as the maximum MCL for selenium in drinking water and OEHHA set a more stringent draft public health goal (PHG) of 30 µg/L for selenium in drinking water (USEPA 2009; OEHHA 2010). USEPA also specified through the CTR that the water quality criteria for aquatic life in all of California's fresh water bodies, except for the San Joaquin River from Merced River to Vernalis, are 20 µg/L for short-term (1-hour average) and 5 µg/L for long-term (4-day average) exposure (USEPA 2000). For the San Joaquin River from Merced River to Vernalis, the short-term exposure is 12 µg/L and long-term limit is 5 µg/L, as stated in the Sacramento–San Joaquin River Basin Plan (Central Valley RWQCB 2011). The water quality criteria for aquatic life in all of California's water bodies is 5 µg/L (4-day average exposure) and 20 µg/L (1-hour exposure) (USEPA 2019).

USEPA, United States Department of the Interior, Bureau of Reclamation (Reclamation), SWRCB, and RWQCB created plans to reduce the toxic levels of selenium in California's impaired water bodies. USEPA's Action Plan consists of recommendations to restore water quality and to protect aquatic species in the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta), which include strengthening selenium water quality criteria to reduce the long-term exposure of sensitive aquatic and terrestrial species to selenium (USEPA 2012). Grasslands Marshes, located in the San Joaquin Valley, include an area contaminated with selenium from agricultural irrigation and drainage practices when the marshes were irrigated with a blend of subsurface agricultural drainage water and higher-quality water. Reclamation's Grassland Bypass Project reroutes the discharge of selenium-laden subsurface agriculture water from upstream agricultural dischargers that formerly passed through the Grassland Water District and nearby wildlife refuges and wetlands to Mud Slough by conveying it through a portion of the San Luis Drain. The project began in 1996 and has since reduced the selenium load discharged from the Grassland Drainage Area from 9,600 pounds (lbs) to 3,700 lbs in 2017 (Reclamation 2017). Both the USEPA Action Plan and the Grassland Bypass Project reduced selenium levels in waterways to meet water quality objectives. Updated waste discharge requirements for surface water discharges from the Grassland Bypass Project are under development in December 2019. The USEPA also released the final water quality criteria for the protection of freshwater aquatic life from toxic effects of selenium, shown in Table G.1-3, Draft Water Quality Criteria for Selenium (USEPA 2016a).

Table G.1-3. Draft Water Quality Criteria for Selenium

Media Type	Fish Tissue	–	Water Column[3]	–
Criterion Element	Egg/Ovary[1]	Fish Whole-Body or Muscle[2]	Monthly Average Exposure	Intermittent Exposure[4]
Magnitude	15.1 mg/kg	8.5 mg/kg whole body or 11.3 mg/kg muscle (skinless, boneless filet)	1.5 µg/L in lentic aquatic systems 3.1 µg/L in lotic aquatic systems	$WQC_{int} = \dfrac{WQC_{30-day} - C_{bkgrnd}(1 - f_{int})}{f_{int}}$
Duration	Instantaneous measurement[5]	Instantaneous measurement[5]	30 days	Number of days/months with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average	Not more than once in three years on average

Source: USEPA 2016a.

[1] Overrides any whole-body, muscle, or water column elements when fish egg/vary concentrations are measured.
[2] Overrides any water column element when both fish tissue and water concentrations are measured.
[3] Water column values are based on dissolved total selenium in water
[4] Where WQC30-day is the water column monthly element, for either a lentic or lotic system, as appropriate. Cbkgrnd is the average background selenium concentration, and fint is the fraction of any 30-day period during which elevated selenium concentrations occur, with fint assigned a value ≥0.033 (corresponding to 1 day).
[5] Instantaneous measurement. Fish tissue data provide point measurements that reflect integrative accumulation of selenium over time and space in the fish at a given site. Selenium concentrations in fish tissue are expected to change only gradually over time in response to environmental fluctuations.

G.1.1.4 *Cadmium, Copper, and Zinc*

Cadmium, copper, and zinc are constituents of concern primarily in the Sacramento River region (SWRCB 2017a). This impairment results largely from discharges of acid mine drainage from inactive mines in the upper Sacramento River watershed, specifically from the Iron Mountain Mines site upstream of Keswick Dam and other mines upstream of Shasta Dam (Central Valley RWQCB 2002a).

To protect aquatic life, the Central Valley RWQCB developed a TMDL program for dissolved cadmium, cooper, and zinc loading into the upper Sacramento River. Table G.1-4 lists numeric targets for dissolved cadmium, copper, and zinc.

Table G.1-4. Numeric Targets for Dissolved Cadmium, Copper, and Zinc

Metal[1]	Acute Numeric Target (micrograms per liter µg/L])	Chronic Numeric Target (µg/L)
Cadmium	0.22[2]	0.22[2]
Copper	5.6[2]	4.1[3]
Zinc	16[2]	16[2]

Source: Central Valley RWQCB 2002a.
[1] The proposed numeric targets are hardness dependent; the numbers in this table are based on a hardness of 40 milligrams per liter as calcium carbonate.
[2] Central Valley Region Water Quality Control Plan trace element water quality objectives (maximum concentrations) for Sacramento River and its tributaries above State Highway 32 Bridge at Hamilton City
[3] California Toxics Rule Criteria for Freshwater Aquatic Life Protection (4-day continuous concentration criteria, not to be exceeded more than once every three year period) for priority toxic pollutants in the State of California for inland surface waters

G.1.1.5 *Nutrients*

Nutrients are a constituent of concern in the lower Klamath River hydrologic area (Klamath Glen HSA) and the Suisun Marsh Wetlands (SWRCB 2017a). Nutrients, such as nitrogen and phosphorus, come from natural sources such as rock and soil weathering, nutrient mixing in ocean water currents, animal manure, atmospheric deposition, and nutrient recycling in sediment (NOAA 2018; USEPA 1998). Anthropogenic sources include fertilizers, detergents, sewage treatment plants, septic systems, combined sewer overflows, and sediment mobilization (USEPA 1998).

Nutrients are essential to maintaining a healthy aquatic ecosystem. However, nitrogen and phosphorus over-enrichment can contribute to a process known as eutrophication, an excessive growth of macrophytes, phytoplankton, and/or potentially toxic algal blooms. Eutrophication may also lead to a decrease of dissolved oxygen, typically at night, when plants stop producing oxygen through photosynthesis but continue to use oxygen. Low dissolved oxygen levels can kill fish, cause an imbalance of prey and predator species, and result in aquatic resources decline (USEPA 1998). Severely low dissolved oxygen conditions are referred to as anoxic and may enhance methylmercury production (San Francisco Bay RWQCB 2012). Over enrichment can also contribute to cloudy or murky water clarity by increasing the amount of materials (e.g., algae) suspended in the water.

Nutrients can also impact ecosystem dynamics in complex ways that extend beyond eutrophication. Changes in the form of available nutrients (chemical state, oxidized versus reduced, organic versus inorganic, dissolved versus particulate) and the proportion of different nutrients produce effects at multiple scales. For example, the balance of nitrogen and phosphorus (N:P) can affect other metabolic aspects of phytoplankton besides growth, including toxin production, cell membrane thickness, and other chemical constituents (Mitra and Flynn 2005; Flynn et al. 1994; Johansson and Granéli 1999a, 1999b; Granéli and Flynn 2006; Oh et al. 2000; Ha et al. 2009; Harris et al. 2016). Further, biomass of certain invasive macrophytes can be affected by the N:P ratio (You et al. 2014 as cited by Dahm et al. 2016).

For decades, researchers have explored the relative use of – or relative preference for – different forms of nitrogen (N) by phytoplankton. Ammonium (NH_4) is generally considered to be the form of nitrogen preferred by phytoplankton because it requires less energy to assimilate than nitrate (NO_3). Research indicates that the form of available nitrogen can affect phytoplankton species composition with some literature suggesting diatoms generally have a preference for NO_3, while dinoflagellates and cyanobacteria generally prefer more chemically reduced forms of nitrogen (NH_4, urea, organic nitrogen) (Berg et al. 2001; Glibert et al. 2004, 2006; Brown 2009). However, more recent research shows certain diatom and chlorophyte species grew significantly faster with NH_4 compared with NO_3 (Berg et al.

2017). This suggests differences in growth rates among species may have a greater role in phytoplankton species composition than variations in N sources (Berg et al. 2017).

At the ecosystem scale, the total load and balance of nutrient elements can have effects that propagate through the food web, with the potential of transforming ecosystems to new stable states (Sterner and Elser 2002; Peñuelas et al. 2012). Zooplankton feeding rates and egg production have been linked to variation in nutrient content of their food (Kiorboe 1989). Shifts in zooplankton communities from copepods to cladaceron and calanoid copepods to cyclopoid copepods have followed changes in nitrogen to phosphorous ratios (Glibert et al. 2011; Hessen 1997).

G.1.1.6 *Dissolved Oxygen*

Dissolved oxygen is a constituent of concern in the study area primarily in the lower Klamath River, Delta, and Suisun Marsh Wetlands (SWRCB 2017a). Oxygen in water comes primarily from the atmosphere through diffusion at the water surface, as well as from groundwater discharge into streams and when plants undergo photosynthesis, releasing oxygen in exchange for carbon dioxide (USGS 2017; NOAA 2008a). Levels of dissolved oxygen vary with several factors, including season, time of day, water temperature, salinity, and organic matter. The season and time of day dictate photosynthesis processes, which require sunlight. Increases in water temperature and salinity reduce the solubility of oxygen (NOAA 2008b). Fungus and bacteria use oxygen when decomposing organic matter in water bodies. So, the more organic matter present in a water body, the more potential for dissolved oxygen levels to decline.

Adverse effects of low dissolved oxygen are a concern for water quality and aquatic organisms. Low dissolved oxygen impairs growth, immunity, reproduction, and causes asphyxiation and death (North Coast RWQCB 2011).

To protect aquatic life, USEPA established water quality standards for dissolved oxygen (USEPA 1986a). USEPA also established site-specific water quality objectives to protect the beneficial uses of California's water bodies (Table G.1-1), including warm and cold freshwater habitats in both tidal and non-tidal waters.

G.1.1.7 *Pesticides*

Pesticides are constituents of concern throughout the study area and particularly in the Central Valley. Major pesticides of concern include organophosphate (OP) pesticides, primarily diazinon and chlorpyrifos, and organochlorine (OC) pesticides, mainly Dichloro-Diphenyl-Trichloroethane (DDT) and Group A pesticides. The toxicity and fates of these pesticides are described in the following sections. Project-related changes in flow can potentially affect the concentration of pesticides within the area of analysis.

G.1.1.7.1 <u>Organophosphate Pesticides</u>

The two most prevalent OP pesticides in the study area are man-made pesticides, diazinon and chlorpyrifos, which were used extensively in agricultural and residential applications. Former and current uses of diazinon and chlorpyrifos resulted in water body contamination throughout the Central Valley, as identified in the Section 303(d) list (SWRCB 2017a). The Central Valley RWQCB also identified hot spots of contamination, particularly in the Delta and urban areas of Stockton and Sacramento (Central Valley RWQCB 2003).

Pesticides are primarily transported into streams and rivers in runoff from agriculture (Central Valley RWQCB 2011), but they also occur or have occurred in urban non-point runoff and stormwater discharges. Treated municipal wastewater can also be a point source. OP pesticides, diazinon and chlorpyrifos, have been banned from non-agricultural uses since December 31, 2004 and December 2001. Reported non-agricultural pesticide use of diazinon and chlorpyrifos declined substantially in some counties between 2000 and 2009 (Central Valley RWQCB 2014). However, the reduction of OP pesticide use resulted in the increasing use of pyrethroids and carbamates as alternative pesticides in urban and agricultural areas.

Diazinon was one of the most common insecticides in the U.S. for household lawn and garden pest control, indoor residential crack and crevice treatments, and pet collars until all residential uses of diazinon were phased out, between 2002 and 2004 (USEPA 2004). Diazinon usage was then prohibited for several agricultural functions in 2007, with only a few remaining agricultural uses permitted, including on some fruit, vegetable, nut and field crops, and as an ear-tag on non-lactating cattle (USEPA 2007). The highest continued use of diazinon is on almonds and stone fruits (USEPA 2004).

G.1.1.7.2 Organochlorine Pesticides

OC pesticides are primarily comprised of DDT and Group A Pesticides (Central Valley RWQCB 2010b). DDT is a persistent chemical that binds tightly to soil and sediment and breaks down slowly in the environment. It degrades to the isomers o,p'- and p,p'- DDT; o,p'- and p,p'-Dicholoro-Diphenyl-Dichloroethylene (DDE) and o,p'- and p,p'- Dichloro-Diphenyl-Dichloroethane (DDD). Group A Pesticides are the total concentration of the OC pesticides: aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, chlordane (total), hexachlorocyclohexane (total), and include Lindane (gamma-BHC), alpha-BHC, endosulfan (total), and toxaphene. These pesticides have similar chemical properties to DDT and are also persistent in the environment.

The transport of OC pesticides into streams and rivers is primarily from agriculture runoff (Central Valley RWQCB 2011). Other potential point sources of OC pesticides include storm sewer discharges and historic spills. Non-point sources can include areas of previous residential applications, open space and channel erosion, and some background sources through wet and dry atmospheric deposition. Most OC pesticides were previously deposited on terrestrial soils; thus, the erosion and transport of contaminated sediments continue to contribute to detectable levels in stream bed sediment (Central Valley RWQCB 2010b).

Historically, OC pesticides were used as insecticides, fungicides, and antimicrobial chemicals in residential and agricultural pest control (Central Valley RWQCB 2010b). Most were banned in the mid-1970s, and fish tissue concentrations declined rapidly since the ban through the mid-1980s (Greenfield et al. 2004). However, OC pesticides continue to be detected in fish tissue, the water column, and sediment in the Central Valley.

G.1.1.7.3 Pyrethroid Pesticides

Pyrethroids (e.g., bifenthrin, permethrin, cypermethrin) are synthetic insecticides used in agriculture and households. The Surface Water Ambient Monitoring Program studies indicate that the replacement of organophosphate pesticides by pyrethroids resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011). In the water column, toxicity to the water flea *Ceriodaphnia dubia (C. dubia)* is caused by organophosphate and pyrethroid pesticides. Pyrethroids are also the major chemical class of concern in urban stormwater, as indicated by toxicity testing using the amphipod *Hyalella azteca (H. azteca),* which is highly sensitive to pyrethroids (Weston and Lydy 2010). Of the pyrethroid pesticides, bifenthrin is a major concern (Markiewicz et al. 2012).

Fong et al. (2016) suggest that pyrethroid use may have played a role in the Pelagic Organism Decline and urge additional research be conducted. In June 2017, the Central Valley RWQCB adopted the *Amendment to the Basin Plan for the Control of Pyrethroid Pesticide Discharges*, establishing measurable pyrethroid concentration goals and a program of implementation to control pyrethroid pesticides (SWRCB 2017b). On the sediment side, as indicated by *H. azteca*, most of toxicity is attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012).

G.1.1.7.4 <u>Other Pesticides</u>

Recent monitoring programs are routinely detecting multiple pesticides in each water sample from the Bay-Delta. Fong et al. (2016) reported that, "27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was 9." The effects of chemical mixtures on aquatic organisms is generally unknown but many chemicals may have additive or synergistic effects. Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea, or DCMU) was introduced in 1954 and is currently is one of the most-used herbicides in California (Central Valley RWQCB 2012). Analysts identified non-polar organic compounds, especially herbicides, and the herbicide Diuron as causes of algal toxicity in the Central Valley. It is an herbicide that inhibits photosynthesis and used to control annual broadleaf and grassy weeds. USEPA has not developed a Water Quality Control (WQC) specific to Diuron, but a TMDL in development will include the development of a water quality objective for Diuron in the Central Valley.

G.1.1.8 *Polychlorinated Biphenyls*

Polychlorinated biphenyls (PCBs), a group of synthetic organic chemicals, is a constituent of concern throughout California including the Sacramento River region (Sacramento, Feather, and American Rivers), the Delta, Suisun Bay, Carquinez Strait, and San Pablo Bay (SWRCB 2017a). PCBs cause harmful environmental effects and pose a risk to human health (ATSDR 2000).

PCBs are mixtures of a variety of individual chlorinated biphenyl components, known as congeners. In the United States, many of these mixtures were sold under the trade name Aroclor, and manufactured from 1930 to 1977 primarily to be used as coolants and lubricants in transformers, capacitors, and other electrical equipment. Although manufacture was banned in 1979, PCBs continue to cause environmental degradation because they are environmentally persistent, easily redistributed between air, water and soil, and tend to accumulate and biomagnify in the food chain (ATSDR 2000; OEHHA 2008).

The "weathering" of PCBs is a process by which the composition of Aroclor mixtures undergo differential partitioning, degradation, and biotransformation. This results in differential environmental persistence and bioaccumulation of the mixtures, which increase with the degree of chlorination of new mixtures (OEHHA 2008). The PCBs with more chlorine atoms tend to be heavier and remain close to the source of contamination, whereas those with fewer chlorine atoms are easily transported in the atmosphere. Atmospheric deposition is the primary source of PCBs to surface waters, although the redissolution of sediment-bound PCBs also contributes to surface water contamination. PCBs leave the water column through sorption to suspended solids, volatilization from water surfaces, and concentration in plants and animals (ATSDR 2000).

PCBs cannot be distinctly assessed for health effects, as their toxicity is determined by the interactions of individual congeners and the interactions of PCBs with other structurally related chemicals, including those combined with or used in the production of PCBs. However, studies identify several general health effects of PCB exposure. When PCBs are absorbed, they are distributed throughout the body and accumulate in lipid-rich tissues, including the liver, skin tissue, and breast milk. They can also be transferred across the placenta to the fetus. Studies link oral exposure to cancer and adverse neurological, reproductive, and developmental effects. The International Agency for Research on Cancer listed PCBs as probable human carcinogens, and OEHHA administratively listed PCBs on the Proposition 65 list of chemicals known to the State of California to cause cancer (OEHHA 2008).

G.1.2 Trinity and Klamath Rivers

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

This water quality analysis includes Trinity Lake, Lewiston Lake, Trinity River downstream of Lewiston Dam, and the Klamath River from its confluence with the Trinity River to the Pacific Ocean. The analysis does not include Trinity River upstream of Trinity Lake, the South Fork of the Trinity River, or the Klamath River upstream of Trinity River, because these areas are not affected by changes in CVP operation.

Several water quality requirements affect the Klamath River and Trinity River basins. Beneficial uses and water quality objectives provided by the North Coast RWQCB and the Hoopa Valley Tribal Environmental Protection Agency (Hoopa Valley TEPA) are described below, as well as relevant TMDLs. The Yurok Tribe Basin Plan for the Yurok Indian Reservation and the Resighini Rancheria Tribal Water Quality Ordinance also regulate portions of the Trinity and Klamath rivers that flow into and through the reservations; however, because they have not yet been approved by the USEPA, their objectives are not described in detail here. Oregon water quality requirements also affect the water quality of the Klamath River, which originates in Oregon. However, this section only discusses the requirements within the Trinity and lower Klamath River Basins.

G.1.2.1 *State-Designated Beneficial Uses*

Beneficial uses for all water bodies in the study area are determined by the North Coast RWQCB and the Hoopa Valley TEPA (Table G.1-1). In addition to the beneficial uses listed in the Trinity and Klamath River basins, the *Water Quality Control Plan for the North Coast Region* (North Coast Basin Plan) notes that recreational use (i.e., water contact recreation [REC-1] and non-contact water recreation [REC-2]) occurs in all hydrologic units of the Klamath River Basin, with Trinity River being one of the rivers receiving the largest levels of recreational use (North Coast RWQCB 2018). Fish and wildlife reside in virtually all the surface waters within the North Coast Region (North Coast RWQCB 2018). These species include several designated as rare, threatened, and endangered. Trinity Dam also provides the beneficial use of hydroelectric power generation (POW).

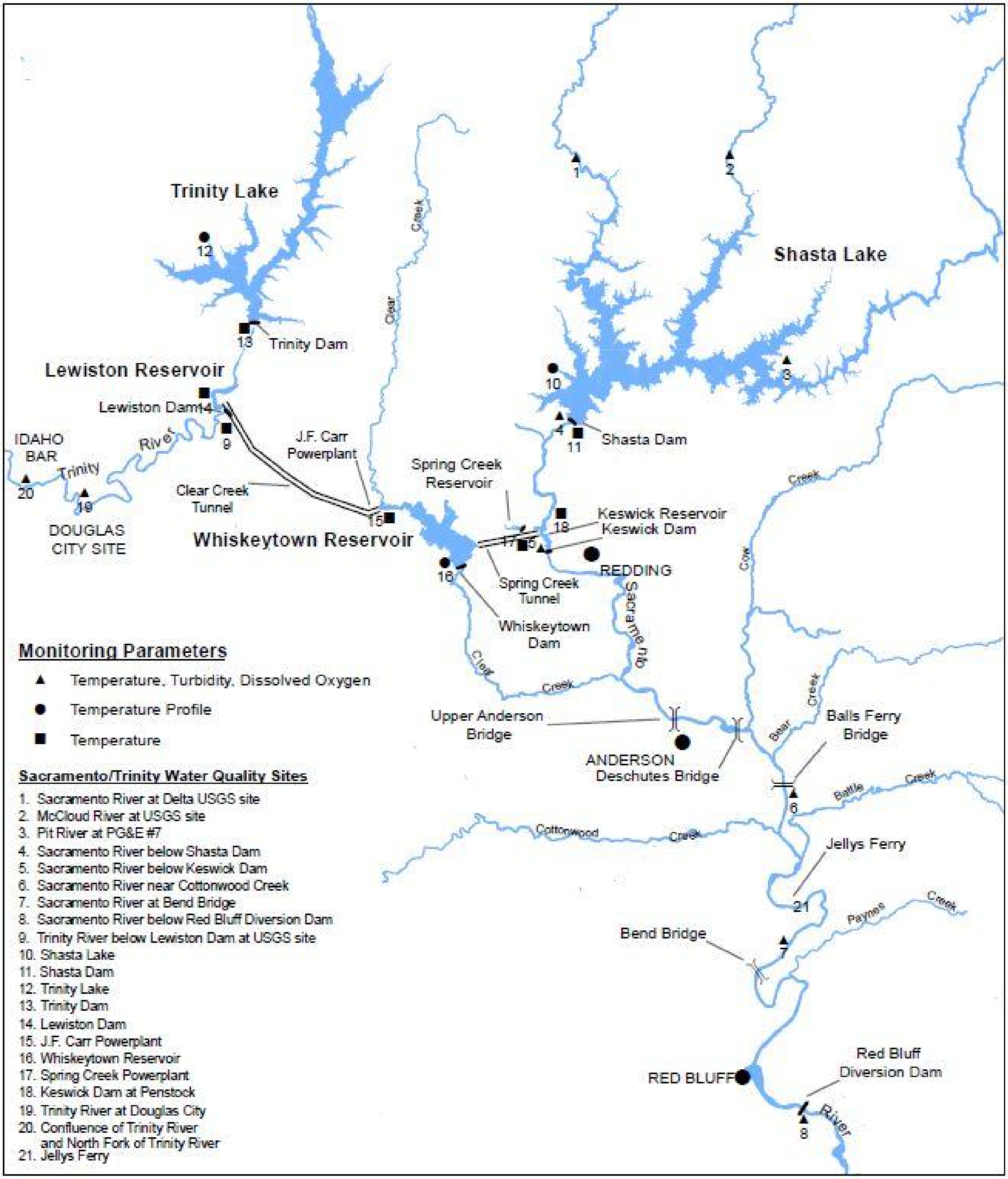
G.1.2.2 *Constituents of Concern*

Under Section 303(d), 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 jurisdiction. Listed waters do not meet water quality standards even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that action plans, or TMDLs, be developed to monitor and improve 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. A TMDL defines the maximum amount of a pollutant that a water body can receive and still meet water quality standards. TMDLs can lead to more stringent National Pollutant Discharge Elimination System permits (CWA section 402). The constituents of concern within the Trinity and Lower Klamath Rivers that are not currently in compliance with existing water quality standards, for which TMDLs are adopted or are in development, are summarized in Table G.1-5, Constituents of Concern per the Section 303(d) list within the Trinity and Lower Klamath Rivers, and discussed below. Figure G.1-1, Water Quality Compliance Stations along Trinity River and Upper Sacramento River presents compliance locations for water quality monitoring along the Trinity River.

Table G.1-5. Constituents of Concern per the Section 303(d) list within the Trinity and Lower Klamath Rivers

Waterbody	Constituent of Concern	TMDL Status[1]
Trinity Lake (was Claire Engle Lake)	Mercury	Expected: 2019
Trinity River HU, Lower Trinity HA; Trinity River HU, Middle HA; Trinity River HU, South Fork HA; Trinity River, Upper HA; Trinity River HU, Upper HA, Trinity River, East Fork	Sedimentation/Siltation, Temperature[2], Mercury[3]	Approved: 2001
Klamath River HU, Lower HA, Klamath Glen HAS	Nutrients, Organic, Enrichment/Low Dissolved Oxygen, Water Temperature	Approved: 2010
	Sedimentation/Siltation	Expected: 2025

Source: SWRCB 2017a.
Key:
HU = hydrologic unit
HA = hydrologic area
Notes:
[1] TMDL status is either expected to be completed or approved by USEPA in the year specified
[2] Water temperature is only a constituent of concern for the South Fork Trinity River and a TMDL is expected to be completed in 2019.
[3] Mercury is only a constituent of concern for the East Fork Trinity River in the upper hydrologic area and a TMDL is expected to be completed in 2019.



Source: Reclamation 2015.

Figure G.1-1. Water Quality Compliance Stations along Trinity River and Upper Sacramento River

G.1.2.2.1 Mercury

Trinity Lake and the upper hydrologic area of the East Fork Trinity River are two water bodies in the North Coast that are Section 303(d) listed as impaired by mercury (SWRCB 2017a). Mercury in Trinity Lake is attributed to unknown sources (SWRCB 2017c). Substantial mercury contamination is likely due to historical gold and mercury mining activities along the East Fork Trinity River at the inactive Altoona Mercury Mine (May et al. 2004).

The commercial or recreational collection of fish, shellfish, or organisms was deemed impaired since fish tissue exceeded USEPA's recommended fish tissue residue criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2017c-h). This criterion is based on the consumption-weighted rate of 0.0175 kg of total fish and shellfish per day. In samples from fish in Trinity Lake in September 2001 and 2002, 14 out of 57 fish tissue samples exceeded this fish tissue criterion. White Catfish (*Ameirus catus*), Smallmouth Bass (*Micropterus dolomieu*), and Chinook Salmon (*Oncorhynchus tshawytscha*) composite fish tissue samples exceeded the criterion.

For the protection of marine aquatic life, water quality objectives for mercury were set for discharges within the area specified in the North Coast RWQCB Basin Plan as follows (North Coast RWQCB 2011):

- Six-Month Median: 0.04 µg/L;
- Daily Maximum: 0.16 µg/L;
- Instantaneous Maximum: 0.4 µg/L (conservative estimate for chronic toxicity).

A TMDL is expected to be complete by 2019 to meet the water quality standards in Trinity Lake and the East Fork of Trinity River. The 2011 North Coast RWQCB Basin Plan (North Coast RWQCB 2011) established an approach for calculating effluent limitations.

G.1.2.2.2 Nutrients

The lower Klamath River is on the SWRCB's CWA Section 303(d) list as impaired by nutrients (SWRCB 2017a). Nutrient levels in the Klamath Estuary may cease to be a limiting factor and can promote levels of algal growth that cause a nuisance or adversely affect beneficial uses when excess growth is not consumed by animals or exported by flows (DOI and CDFG 2012).

The Klamath River receives the greatest nutrient loading from the Upper Klamath basin, comprising approximately 40% of its total contaminant load (North Coast RWQCB 2010). Tributaries to the Klamath River are the greatest contributors of the remaining nutrient loads, with the Trinity River contributing the most.

The Hoopa Valley TEPA also designates water quality objectives to address contamination by nutrients, presented in Table G.1-6, Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation.

Table G.1-6. Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation

Contaminant	Trinity River	Klamath River
Maximum Annual Periphyton Biomass	–	150 mg chlorophyll *a*/m^2 of streambed area
pH	MUN-designated waters: 5.0 – 9.0 All other designated uses: 7.0 – 8.5	7.0 – 8.5
Total Nitrogen[1]	–	0.2 mg/L
Total Phosphorus[1]		0.035 mg/L
Microcystis aeruginosa cell density	–	< 5,000 cells/mL for drinking water < 40,000 cells/mL for recreational water
Microcystin toxin concentration		< 1 µg/L total microcystins for drinking water < 8 µg/L total microcystins for recreational water
Total potentially toxigenic blue-green algal species[2]		< 100,000 cells/mL for recreational water
Cyanobacterial scums		There shall be no presence of cyanobacterial scums

Source: Hoopa Valley TEPA 2008.

[1] There should be at least two samples per 30-day period. If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus. Through consultation, the ongoing TMDL process for the Klamath River is expected to further define these natural conditions.

[2] Includes: Anabaena, Microcystis, Planktothrix, Nostoc, Coelsphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia, and Oscillatoria.

In addition to the water quality criteria established by the Hoopa Valley TEPA (2008), the 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provides TMDLs for nutrients which address elevated pH levels (DOI and CDFG 2012). Nutrient targets include numeric targets for total phosphorus, and total nitrogen (North Coast RWQCB 2010).

The North Coast RWQCB and other affiliated agencies, including SWRCB, USEPA, Reclamation, USFWS, the Oregon Department of Environmental Quality (responsible for implementation of the Klamath TMDLs in Oregon), and other state, federal, and private agencies with operations that affect the Klamath River are implementing the Klamath River nutrient TMDLs (North Coast RWQCB 2010).

G.1.2.2.3 Organic Matter

The lower Klamath River is on the SWRCB's CWA Section 303(d) list as impaired by organic matter (SWRCB 2017a).

The Klamath River has several natural sources of organic matter. The river originates from the Upper Klamath Lake, which is a naturally shallow, eutrophic lake, with high levels of organic matter (algae), including nitrogen fixing blue-green algae (North Coast RWQCB 2010). Other sources of organic matter include runoff from agricultural lands (e.g., irrigation tailwater, storm runoff, subsurface drainage, and animal waste), flow regulations/modification, industrial point sources, and municipal point sources (SWRCB 2011).

The North Coast RWQCB established a TMDL for organic matter and other constituents to protect the beneficial uses of the lower Klamath River, including cold freshwater habitat, in 2010. The TMDL equals 143,019 lbs of Carbonaceous Biochemical Oxygen Demand (CBOD) per day from the Klamath River (North Coast RWQCB 2018). The average organic matter (measured as CBOD) loads from all other Klamath River tributaries are sufficient to meet other related objectives, including dissolved oxygen and biostimulatory substances objectives, in the Klamath River (North Coast RWQCB 2010). The dissolved oxygen objectives are the primary targets associated with organic matter and nutrients. The North Coast RWQCB also established organic matter allocations for the Klamath River below Salmon River, and the major tributaries to the Klamath, including Trinity River.

Implementation actions and other objectives were established to ensure the TMDL is met to protect the beneficial uses of the Klamath River and other water bodies downstream. The North Coast Basin Plan states that a water quality study will be completed to identify actions for monitoring, evaluating, and implementing any necessary actions to address organic matter loading so that the TMDL will be met (North Coast RWQCB 2018).

G.1.2.2.4 Dissolved Oxygen

The lower Klamath River is on the SWRCB's CWA Section 303(d) list as impaired by dissolved oxygen (SWRCB 2017a).

Sources that contribute to low dissolved oxygen include sources of organic enrichment, water temperature, and salinity. Other sources that contribute to low dissolved oxygen are runoff from roads and agriculture that can transport nutrients into water bodies and lower dissolved oxygen through biostimulatory effects (North Coast RWQCB 2010). The over-enrichment and growth of algae and aquatic plants can produce oxygen during the day through photosynthesis, but those same plants can deplete dissolved oxygen at night.

To protect the beneficial uses of the lower Klamath River, including the cold freshwater habitat, water quality objectives were established in the North Coast Basin Plan (North Coast RWQCB 2018) and the Hoopa Valley TEPA (2008) for dissolved oxygen in the Klamath River and its major tributary, the Trinity River (Table G.1-7 and Table G.1-8) (North Coast RWQCB 2011). Site Specific Objectives (SSOs) for dissolved oxygen were calculated as part of TMDLs developed by the North Coast RWQCB (2011) and have been incorporated into the North Coast Basin Plan (2018) (Table G.1-9). For those waters without location-specific dissolved oxygen criteria, dissolved oxygen should not be reduced below minimum levels, shown in Table G.1-10, at any time to protect beneficial uses.

Table G.1-7. Water Quality Objectives for Dissolved Oxygen in Trinity and Lower Klamath

Water body	Dissolved Oxygen (mg/L)	
	Minimum	50% Lower Limit[1]
Trinity Lake and Lewiston Reservoir	7.0	10.0
Lower Trinity River	8.0	10.0
Lower Trinity Area Streams	9.0	10.0
Lower Klamath River Area Streams	8.0	10.0

Source: North Coast RWQCB 2011.

[1] 50% lower limit represents the 50 percentile values of the monthly means for a calendar year. 50 percent or more of the monthly means must be greater than or equal to the lower limit.

Table G.1-8. Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation

Contaminant	Trinity River	Klamath River
Minimum Water Column Dissolved Oxygen Concentration	11.0 mg/L	SPWN-designated waters[1]: 11.0 mg/L[2] COLD-designated waters: 8.0 mg/L[2]
Minimum Inter-gravel Dissolved Oxygen Concentration	8.0 mg/L	SPWN-designated waters[1]: 8.0 mg/L[2]

Source: Hoopa Valley TEPA 2008.
[1] Whenever spawning occurs, has occurred in the past or has potential to occur.
[2] 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

Table G.1-9. Site Specific Objectives for Dissolved Oxygen in the Klamath River[1]

Location[2]	Percent Dissolved Oxygen Saturation Based On Natural Receiving Water Temperatures[3]	Time Period
Downstream of Hoopa-California Boundary to Turwar	85	June 1 through August 31
	90	September 1 through May 31
Upper and Middle Estuary	80	August 1 through August 31
	85	September 1 through October 31 and June 1 through July 31
	90	November 1 through May 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of the Lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

Source: North Coast RWQCB 2018.
[1] States may establish site specific objectives equal to natural background (USEPA 1986a; Davies 1997). For aquatic life uses, where the natural background condition for a specific parameter is documented, by definition that condition is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans (Davies 1997). These dissolved oxygen objectives are derived from the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 Modeling Scenarios: Klamath River Model for TMDL Development (Tetra Tech, Inc. et al. 2009). They represent natural dissolved oxygen background conditions due only to non-anthropogenic sources and a natural flow regime.
[2] These objectives apply to the maximum extent allowed by law. To the extent that the State lacks jurisdiction, the Site Specific Dissolved Oxygen Objectives for the Mainstem Klamath River are extended as a recommendation to the applicable regulatory authority.
[3] Corresponding dissolved oxygen concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 (Tetra Tech, Inc. et al. 2009). Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available. After opportunity for public comment, any update or improvements to the estimate of natural receiving water temperature must be reviewed and approved by Executive Officer before being used for this purpose.

Table G.1-10. Water Quality Objectives for Dissolved Oxygen for Specified Beneficial Uses

Beneficial Use Designation	Minimum Dissolved Oxygen Limit (mg/L)
WARM, MAR, or SAL	5.0
COLD	6.0
SPWN	7.0
SPWN – during critical spawning and egg incubation periods	9.0

Klamath River Water Column[1] SPWN-designated waters[2]: COLD-designated waters:	 11.0 mg/L[3] 8.0 mg/L[3]
Klamath River Inter Gravel[1] SPWN-designated waters[2]:	8.0 mg/L[3]

Source: North Coast RWQCB 2018.

[1] Hoopa Valley TEPA (2008)

[2] Whenever spawning occurs, has occurred in the past or has potential to occur.

[3] 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

The 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provides numerical targets for dissolved oxygen and other constituents (North Coast RWQCB 2010). This TMDL proposed site-specific objectives for dissolved oxygen, which were adopted into the North Coast Basin Plan. The dissolved oxygen objectives are the primary targets associated with nutrient and organic matter, with additional dissolved oxygen-related TMDLs prescribed for total phosphorus, total nitrogen, and organic matter (CBOD) loading. The TMDL also provides numerical targets for benthic algae biomass, suspended algae chlorophyll-a, *microcystis aeruginosa*, and microcystin toxin.

Chapter 7 of the Klamath River TMDLs established plans to monitor dissolved oxygen and other constituents in the Klamath River below Trinity River, near Turwar, and the Klamath River Estuary to further protect the beneficial uses of the Trinity and lower Klamath Rivers (North Coast RWQCB 2010). The TMDL also includes a proposal to revise SSOs for dissolved oxygen in the Klamath River.

G.1.2.2.5 Sedimentation and Siltation

The lower Klamath River and Trinity River are on the SWRCB’s CWA Section 303(d) list as impaired by sedimentation and siltation (SWRCB 2017a). The source of sedimentation and siltation in the Trinity and Klamath rivers is not attributed to CVP operation.

Trinity River

Disturbance of sediment and silt is a natural part of stream ecosystems, which can contribute to fluctuating salmonid populations in response to fine sediment embedded in spawning gravels. However, human activities resulted in an increased severity and frequency of habitat disturbance (TRRP and North Coast RWQCB 2009). In the mainstem Trinity River, sediment loading can be attributed to runoff from areas of active or past mining, timber harvest, and road-related activities. Natural sources, such as landsliding, bank erosion, and soil creep, contribute the greatest sediment loads each year (North Coast RWQCB 2008). Future point sources of sedimentation into the Trinity River Basin, including Caltrans facilities and construction sites larger than five acres, must meet discharge requirements pursuant to California’s NPDES general permit for construction site runoff (USEPA 2001c).

The primary adverse impacts of excess sedimentation are those affecting the spawning habitat for anadromous salmonids (TRRP and North Coast RWQCB 2009). The main affected beneficial uses include commercial or sport fishing; cold freshwater habitat; the migration of aquatic organisms; spawning, reproduction, and early development; and rare, threatened, and endangered species. Recreation in the Trinity River Basin, such as boating, fishing, camping, swimming, sightseeing, and hiking, is also potentially affected because sedimentation can affect the water clarity and water quality (USEPA 2001c). The North Coast Basin Plan established water quality objectives for sedimentation and siltation.

In addition to these water quality objectives, the North Coast Basin Plan also prohibits the discharge of soil, silt, bark, sawdust, or other organic and earthen material from any logging, construction, or associated activity into any stream or watercourse in quantities harmful to beneficial uses. It also prohibits the placing or disposal of such materials in locations where they can pass into any stream or watercourse in quantities harmful to beneficial uses (North Coast RWQCB 2018).

The Trinity River TMDL, approved by USEPA in December 2001, addresses sediment loading in the mainstem Trinity River, which exceeds applicable water quality standards (SWRCB 2017c-h; USEPA 2001c). The TMDL determined assimilation capacity for sediment loading and provides the percent reduction of managed sediment discharge required for each subarea. These allocations are adequate to protect aquatic habitat and are expected to be evaluated on a ten-year rolling average (USEPA 2001c).

Lower Klamath River

The Section 303(d) list also includes the Klamath River downstream of Weitchpec for contamination from sedimentation and siltation, due to exceedances of the sediment water quality criteria, and long-term sedimentation and siltation influxes (SWRCB 2017i).

Major sources of sediment discharge in the lower Klamath River are ongoing logging and runoff from major storm events. According to reports cited by the SWRCB, water quality in runoff from timber harvest in all lower Klamath watersheds exceed cumulative effect thresholds (SWRCB 2017i).

The *Long Range Plan for the Klamath River Basin Fishery Conservation Area Restoration Program* (1986 to 2006) emphasizes sedimentation in the lower Klamath Basin, and notes that the sediment is creating problems with fish passage and stream bed stability (Klamath River Basin Fisheries Task Force 1991). The near extinction of the eulachon indicated problems with sediment supply, size, and bed load movement (SWRCB 2017i). Largely due to timber harvest in all Lower Klamath watersheds, aggradations in salmon spawning reaches are expected to persist for decades (Higgins 2004). Increased sediment loads also result from the widening of stream channels, through processes like bank erosion, and, with the related reduction of riparian shade, can contribute to elevated stream temperatures (North Coast RWQCB 2010). The North Coast Basin Plan includes the TMDLs for the region that address sedimentation and siltation (North Coast RWQCB 2018).

G.1.3 Sacramento River

G.1.3.1 *Sacramento River from Shasta Lake to Verona*

Releases from Shasta Lake and diversions from Trinity Lake Water influence water quality in the upper Sacramento River. Annual and seasonal flows in the Sacramento River watershed are highly variable from year to year. These variations in flow are a source of variability in Sacramento drainage water quality.

The water quality constituents currently not in compliance with existing water quality standards, for which TMDLs are adopted or are in development, in this region are: mercury, PCBs, unknown toxicity, and multiple pesticides. Changes to the North Coast Basin Plan addressed chlorpyrifos and diazinon. A TMDL addressed cadmium, copper, and zinc, and temperature is also closely monitored. Figure G.1-2, 303(d) Listed Waterways in the Sacramento River, Feather River, and American River Regions, presents 303(d) listed waterways in the Sacramento River Region.

G.1.3.1.1 Mercury

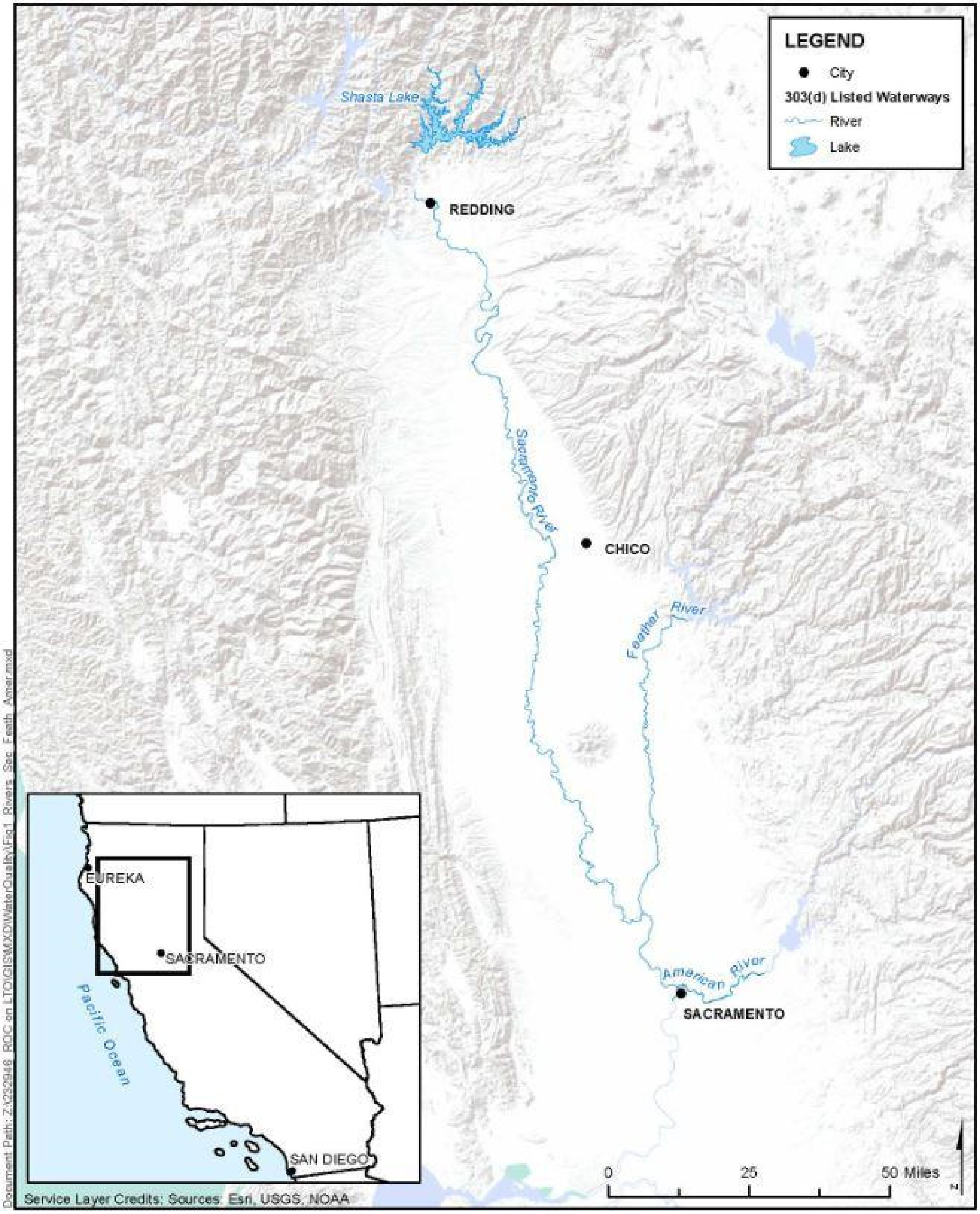
Shasta Lake and the Sacramento River from Cottonwood Creek to Red Bluff are on the Section 303(d) list for mercury contamination (SWRCB 2017a). Mercury is not a constituent of concern for the Sacramento River between Shasta Dam and the Cottonwood Creek. Mercury in the Sacramento River Basin can be attributed to resource extraction (SWRCB 2017j,k).

A 2008 CALFED Bay-Delta Program (CALFED) report titled *Methylmercury Concentrations and Loads in the Central Valley and Freshwater Delta,* tabulates methylmercury concentrations in the Sacramento River from Redding (0.3 nanogram per liter [ng/L]) to Freeport (0.11 ng/L) from 2003 to 2006 (Foe et al. 2008). For the 2016 listing, composite fish tissue samples were collected from Shasta Lake and the Sacramento River from Cottonwood Creek to Knights Landing. The SWRCB deemed the commercial or recreational collection of fish, shellfish, or organisms impaired, since fish tissue exceeded USEPA's recommended Fish Tissue Residue Criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2017j,k).

USEPA recommended maximum exposure concentrations in an effort to protect the beneficial uses of these water bodies, including the protection of aquatic and human health. In addition, a TMDL is expected to be completed in 2027 to meet the water quality standards in these water bodies (SWRCB 2017f-g).

G.1.3.1.2 Cadmium, Copper, and Zinc

Shasta Lake where West Squaw Creek enters the lake, Spring Creek (from Iron Mountain Mine to Keswick Reservoir), and Keswick Reservoir downstream of Spring Creek are on the Section 303(d) list for impairment by cadmium, copper, and zinc (SWRCB 2017a). The Upper Sacramento River from Keswick Dam to Cottonwood Creek was previously listed on the Section 303(d) list for impairment by cadmium, copper, and zinc, but was delisted after a TMDL completion in 2002 led to the SWRCB determining that the water quality standard was met. Acid mine drainage discharged from inactive mines in the upper Sacramento River watershed, located upstream of Shasta and Keswick dams was the primary cause of the elevated levels (Central Valley RWQCB 2002a). Abatement projects are underway to clean up many inactive mine sites that discharge high concentrations of metals (Central Valley RWQCB 2018a).



Source: SWRCB 2017a.

Figure G.1-2. 303(d) Listed Waterways in the Sacramento River, Feather River, and American River Regions

The *2002 Upper Sacramento River TMDL for Cadmium, Copper and Zinc*, and water quality objectives in the North Coast Basin Plan address cadmium, copper, and zinc contamination in the Sacramento River (Central Valley RWQCB 2002a). Although cadmium, copper, and zinc are generally found as mixtures in surface water, the mixtures tend to be antagonistic, less toxic than when found as individual components, and thus the water quality objectives focus on individual parameters. Levels of water hardness affect the toxicity of these metals; increased hardness decreases toxicity. Specific levels of water hardness determine the water quality objectives at certain locations (Central Valley RWQCB 2002a). The TMDL for cadmium, copper, and zinc in Shasta Lake, Spring Creek, and Keswick Reservoir is expected to be completed in 2020 (SWRCB 2017j,l,m).

G.1.3.1.3 Pesticides

The Sacramento River from Red Bluff to Knights Landing is on the Section 303(d) list as impaired by DDT and the Group A pesticide dieldrin. The Sacramento River from Knights Landing to the Delta is on the Section 303(d) list as impaired by chlordane, DDT, and dieldrin (SWRCB 2017a). Chlordane, DDT, and dieldrin are legacy pesticides and were discontinued from the early 1970s to the late 1980s.

Although these pesticides were discontinued in the late 1980s, the narrative water quality objective for toxicity, which applies to single or the interactive effect of multiple pesticides or substances and states that "waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life," has not been met (Central Valley RWQCB 2018a). Fish concentrations of DDT collected in 2005 exceeded the Total DDT OEHHA screening value of 21 micrograms per kilogram (μg/kg) by up to five times, which was used as a criterion to evaluate the narrative water quality objective by up to five times. Concentrations of dieldrin also exceeded the OEHHA Evaluation Guideline of 0.46 μg/kg (SWRCB 2017n).

To protect the beneficial uses of the Sacramento River and other water bodies downstream, including the impaired commercial or recreational collection of fish, shellfish, or organisms, TMDLs for DDT and dieldrin in the Sacramento River from Red Bluff to Knights Landing are expected to be completed in 2027 (SWRCB 2017n). For the Sacramento River from Knights Landing to the Delta, TMDLs are expected to be completed in 2021 for chlordane, in 2022 for dieldrin, and in 2027 for DDT.

Although the Sacramento River is not on the Section 303(d) list for chlorpyrifos and diazinon contamination, these pesticides are a concern in the Sacramento River because they potentially affect the beneficial uses of Warm and Cold Freshwater Habitat (SWRCB 2017n; Central Valley RWQCB 2007a). Water quality sampling from 1999 to 2006 revealed concentrations of both pesticides at levels of concern in the Sacramento Rivers. In addition to runoff of applied pesticides into irrigation and stormwater runoff into the Sacramento Rivers, atmospheric transport of diazinon from the Central Valley to the Sierra Nevada Mountains has occurred.

G.1.3.1.4 PCBs

The stretch of the Sacramento River from Red Bluff to Knights Landing is on the Section 303(d) list as impaired by PCBs (SWRCB 2017a). According to the Section 303(d) list /305(b) Report Supporting Information, sources of PCBs in Sacramento River are unknown (SWRCB 2017n).

The OEHHA Fish Contaminant Goal (FCG) of total PCBs in fish is 3.6 parts per billion (ppb) (or 3.6 nanograms per gram [ng/g]) (SWRCB 2017n). Fish tissue samples collected in August and October 2005 exhibited exceedances. Six composite samples were analyzed for 48 individual PCB congeners and four Aroclor mixtures, with the four exceedances reported as 102.499 ng/g in Channel Catfish (*Ictalurus* *punctatus*) at Colusa, 9.151 ng/g in Channel Catfish at Grimes, 6.504 ng/g in Sacramento Sucker (*Catostomus occidentalis*) at Colusa, and 5.767 ng/g in Sacramento Sucker at Woodson Bridge.

To protect the beneficial uses of the Sacramento River, including the impaired beneficial use of commercial and sport fishing, a TMDL is expected to be complete in 2027 (SWRCB 2017n).

G.1.3.1.5 Unknown Toxicity

The Sacramento River from Keswick Reservoir to Knights Landing is on the Section 303(d) list as impaired for unknown toxicity (SWRCB 2017a).

Results of survival, growth, and reproductive toxicity tests performed from 1998 to 2007 showed an increase in mortality and a reduction in growth and reproduction in *C. dubia*, the Fathead Minnow (*Pimephales promelas*) and the alga *Pseudokirchneriella subcapitata* (*P. subcapitata*, formerly known as *Selenastrum capricornutum*) (SWRCB 2017k,n-p). Observations violated the narrative toxicity objective found in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Sacramento–San Joaquin River Basin Plan), which states that all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, or aquatic life (Central Valley RWQCB 2018a). This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Further research is being conducted on the causes of toxicity in the Sacramento River. The TMDL for unknown toxicity in the Upper Sacramento River was expected to be completed in 2019; however, no TMDL has been released as of December 2019. The Middle and Lower Sacramento River TMDL is expected to be complete in 2027 (SWRCB 2017k,n-p).

A 2012 Surface Water Ambient Monitoring Program (SWAMP) report summarized the occurrences and causes of toxicity in the Central Valley (Markiewicz et al. 2012). The SWRCB's SWAMP defines toxicity as a statistically significant adverse impact on standard aquatic test organisms in laboratory exposures. SWAMP testing uses laboratory test organisms as surrogates for aquatic species in the environment to assess the causes of toxicity in California waterways (Anderson et al. 2011).

Sediment toxicity was noted to be higher in urban areas including Sacramento, Yuba City, Redding, and Antioch, while sediments from agricultural areas were generally non-toxic (Markiewicz et al. 2012). Moderate water toxicity was observed throughout the agricultural and urban-agricultural areas in the upper Sacramento watershed, including in the Colusa Basin, the Sutter Buttes area, and along the eastern valley floor between Chico and Lincoln.

SWAMP studies indicate that replacing organophosphate pesticides by pyrethroids has resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011).In sediment, as indicated by H. azteca, the majority of toxicity is attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012). Of the pyrethroid pesticides, bifenthrin is a major concern.

G.1.3.2 *Sacramento River from Verona to Freeport*

The water quality of the lower Sacramento River is influenced by the upstream sources discussed above, as well as by inflows from the American River and surrounding urban and agricultural runoff.

G.1.3.2.1 Mercury

The Sacramento River from Knights Landing to the Delta is on the Section 303(d) list for mercury contamination (SWRCB 2017a).

Mercury in this reach of the river is attributed to waterborne inputs from the upper Sacramento, Feather, Yuba, and American rivers (SWRCB 2017p). These major tributaries are also listed as impaired due to mercury. As in the Klamath and Trinity river basins, historical mining has resulted in mercury contamination in the Sacramento River Basin.

Flows from the Yuba River are an important source of mercury loading to the lower Sacramento River. Tailings discharged from gold mines in the Sierra Nevada mountains during the nineteenth century contained substantial amounts of mercury-laden sediment, due to the use of mercury to extract gold. These discharges caused alluvial fans to form at the base of the Sierra Nevada, most notably the Yuba Fan. Singer et al. (2013) predicted that mercury-laden sediment from the original fan deposit will continue to be transported to the Sacramento River for the next 10,000 years.

The Sacramento River is a key source of mercury contamination into the Delta. Over 80% of total mercury flux to the Delta can be attributed to the Sacramento River Basin (Central Valley RWQCB 2010a). The Central Valley RWQCB (2016) compiled data from 2000 to 2003 and reported an average of 0.10 ng/L in the Sacramento River at Freeport. CALFED reported that the Sacramento River at Freeport contributed an average of 0.11 ng/L of methylmercury to the Delta from 2003 to 2006 (Foe et al. 2008).

Water samples were collected from the lower Sacramento River and its tributaries from March 2003 to June 2006 (Foe et al. 2008). Major tributaries to the lower Sacramento River, including the Feather River (0.05 ng/L), American River (0.06 ng/L), Colusa Basin Drain (0.21 ng/L), and Yuba River (0.05 ng/L), contribute to the mean methylmercury concentration of 0.11 ng/L at Freeport in the Sacramento River.

Table G.1-11, Streambed Sediment Concentrations of Mercury in The Sacramento River and Delta Regions presents streambed sediment mercury concentrations from the Sacramento River and Delta regions in 1995, sampled as part of the National Water Quality Assessment (NWQA) Program for the Sacramento River Basin (MacCoy and Domagalski 1999). Limited data for mercury in sediment exist, but the existing data exhibits levels of mercury greatly exceeding the average amount of mercury found on the earth’s surface, 0.05 micrograms per gram (µg/g). The highest streambed sediment concentrations of mercury were measured downstream from the Sierra Nevada and Coast Ranges. Within the Sacramento River, sites downstream of the Feather River had higher concentrations of mercury than sampled locations upstream of the confluence. The Yuba River, Bear River, Sacramento River at Verona, and the Feather River had the highest reported mercury concentrations, which exceeded the threshold effect concentration (0.18 µg/g), but not the probable effect concentration (1.06 µg/g) reported by MacDonald et al. (2000).

Table G.1-11. Streambed Sediment Concentrations of Mercury in The Sacramento River and Delta Regions

Water body/Site	Concentration
Feather River sites	
Feather River	0.21 µg/g
Yuba River	0.37 µg/g
Bear River	0.37 µg/g
Feather & Sacramento Rivers Downstream of the confluence at Verona	0.24 µg/g
Sacramento River sites	
Bend Bridge	0.16 µg/g
Freeport	0.14 µg/g
Cache Creek	0.15 µg/g

Water body/Site	Concentration
Arcade Creek	0.13 µg/g
American River	0.16 µg/g

Source: MacCoy and Domagalski 1999.
Reported in bottom material <63 micron fraction dry weight.
* Concentration exceeds the MacDonald et al. (2000) threshold effect concentration (0.18 µg/g dry weight) but not the probable effect concentration (1.06 µg/g dry weight).

The Central Valley RWQCB (2016) made recommendations for the future reduction of mercury contamination in an effort to protect the beneficial uses of the Sacramento River, including the impaired commercial and recreational collection of fish, shellfish, or organisms. The Delta Mercury Control Program (MERP 2012) provides potential load allocations for mercury pertaining to the Sacramento River and the Yolo Bypass, while the Cache Creek Watershed Mercury Program provides load allocations for Cache Creek, Bear Creek, Sulphur Creek, and Harley Gulch.

G.1.3.2.2 Pesticides

The Sacramento River is on the Section 303(d) list as impaired by the pesticides chlordane, DDT, and dieldrin from Knights Landing to the Delta (SWRCB 2017a). The three pesticides listings were based on the evaluation of fish contaminant data from 2005. Chlordane, DDT, and dieldrin are legacy pesticides discontinued in the early 1970s to the late 1980s. However, samples collected in the Sacramento River at the Veterans Bridge in September 2005 revealed elevated pesticide concentrations (SWRCB 2017p).

A composite sample of carp and a composite sample of Channel Catfish had total chlordane concentrations of 6.72 µg/kg and 10.20 µg/kg, both exceeding OEHHAs (2008) FCG of 5.6 µg/kg for total chlordane in fish tissue (SWRCB 2017p).

Composite samples of carp and Channel Catfish contained total DDT concentrations of 59. µg/kg and 109. µg/kg, respectively. These concentrations exceeded the OEHHAs (2008) FCG of 21 µg/kg (SWRCB 2017p).

Composite samples of carp and Channel Catfish contained total dieldrin concentrations of 0.98 µg/kg and 1.49 µg/kg, respectively. These concentrations both exceeded the OEHHAs (2008) FCG of 0.46 µg/kg (SWRCB 2017p).

G.1.3.2.3 PCBs

The Sacramento River from Knights Landing to the Delta is on the Section 303(d) list as impaired by PCBs (SWRCB 2017a).

According to the Section 303(d) List/305(b) Report Supporting Information, sources of PCBs in this reach of the Sacramento River are unknown (SWRCB 2017p).

The Sacramento River from Knights Landing to the Delta was recently listed as contaminated by PCBs. Three of three composite samples analyzed for total PCBs in September 2005 exceeded the OEHHA Fish Contaminant Goal for total PCBs of 3.6 ppb (or 3.6 ng/g), wet weight. The exceeding concentrations were recorded at 53 ng/g in Channel Catfish, 6.0 ng/g in Sacramento sucker, and 26 in carp (SWRCB 2017p).

A TMDL for PCBs in the Sacramento River from Knights Landing to the Delta is expected to be completed in 2021 to protect the beneficial uses of the Sacramento River and downstream waterbodies (SWRCB 2017p).

G.1.3.2.4 Dissolved Oxygen

The Sacramento River is not on the Section 303(d) list for low dissolved oxygen (SWRCB 2017a).

G.1.3.2.5 Salinity, Electrical Conductivity, and Total Dissolved Solids

The Sacramento River is not on the Section 303(d) list as impaired by salinity (SWRCB 2017a).

G.1.3.2.6 Selenium

Water bodies in the Sacramento River Basin are not on the Section 303(d) list as impaired by selenium. Waterborne selenium concentrations in the Sacramento River near Verona are relatively low compared to concentrations in the San Joaquin River Basin. However, the much larger flow that the Sacramento River contributes to the Delta, in comparison to the San Joaquin River's flow, results in a substantial contribution to the mass loading of selenium to the Delta from the Sacramento River (Cutter and Cutter 2004; SWRCB 2008). Loads to the Delta from the Sacramento River were projected to be about half of what the Grasslands basin was projected to contribute to the San Joaquin River, with subsequent loading to the Delta from the San Joaquin River dependent on flow (Presser and Luoma 2006).

Data for selenium in fish from the Sacramento River is limited, but the Central Valley RWQCB sampled Largemouth Bass (*Micropterus salmoides*) in 1999, 2000, 2005, and 2007 from the lower Sacramento River, San Joaquin River, and Delta. The fillet data and whole-body selenium concentrations, estimated using an equation from Saiki et al. (1991), were used to evaluate potential human and wildlife health risks (Foe 2010). Selenium concentrations of the bass from the Sacramento River at Veterans Bridge were well below the draft criteria released in May 2014 (11.8 mg/kg for fillets and 8.1 mg/kg for whole body) (USEPA 2014).

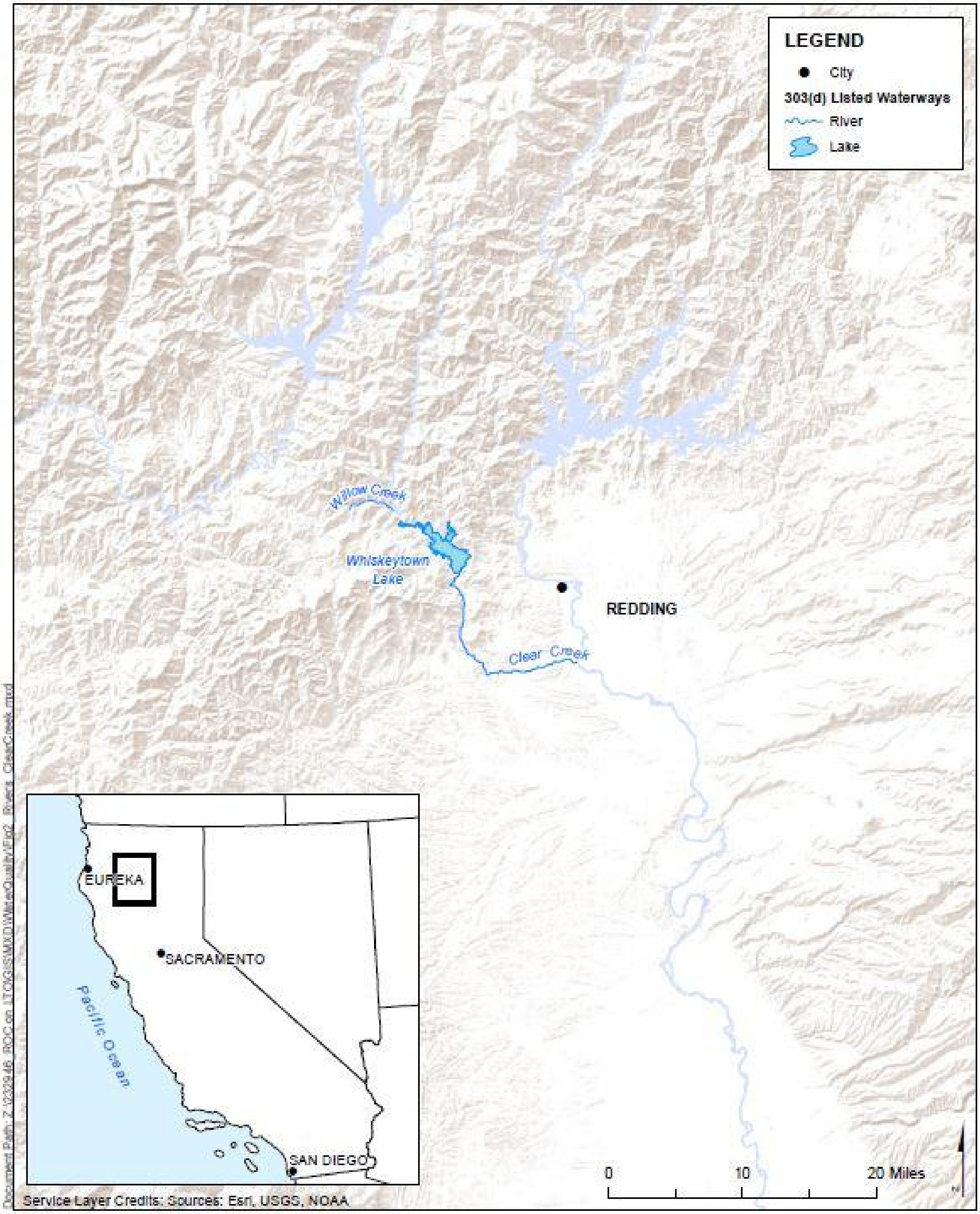
G.1.3.2.7 Unknown Toxicity

The Sacramento River from Knights Landing to the Delta is listed as impaired by toxicity due to the results of survival, growth, and reproductive toxicity tests performed in 2006 and 2007. Observations of increased mortality and reduction in growth and reproduction in *C. dubia* and *P. promelas* compared to laboratory controls violated the narrative toxicity objective of the Sacramento–San Joaquin River Basin Plan. The TMDL for toxicity in this reach of the river is expected to be completed in 2019 (SWRCB 2017p).

G.1.4 Clear Creek

As the main hydrologic barrier between Upper and Lower Clear Creek, Whiskeytown Dam controls the timing and magnitude of flows into Lower Clear Creek. Whiskeytown Reservoir has the potential to affect several supported beneficial uses for cold and warm water, including agricultural water supply, contact and non-contact water recreation, and fish habitat and migration uses.

Willow Creek, a Clear Creek tributary just upstream of Whiskeytown Reservoir, is on the SWRCB's CWA Section 303(d) list as impaired for metals (copper and zinc) (SWRCB 2017a). The contamination comes from an abandoned copper mine operated in the early 1900s, however, monitoring data has not shown a substantial impact on Clear Creek from the metal-contaminated Willow Creek drainage (Sacramento River Watershed Program n.d.). Clear Creek (below Whiskeytown Lake, Shasta County) and Whiskeytown Lake (areas near Oak Bottom, Brandy Creek Campgrounds and Whiskeytown) are not on the Section 303(d) list as impaired by copper or zinc (SWRCB 2017a). Figure G.1-3, 303(d) Listed Waterways in the Clear Creek Region presents 303(d) listed waterways in the Clear Creek region.



Source: SWRCB 2017a.

Figure G.1-3. 303(d) Listed Waterways in the Clear Creek Region

G.1.4.1 *Mercury*

Clear Creek (below Whiskeytown Lake, Shasta County) and Whiskeytown Lake (areas near Oak Bottom, Brandy Creek Campgrounds and Whiskeytown) are on the SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). The major source of this contamination is mercury deposits from in the expansive tailings piles of 1800s dredging gold mining operations (Sacramento River Watershed Program n.d.).

In an effort to meet the water quality standards in Clear Creek and Whiskeytown Lake, a TMDL is expected to be complete by 2027 (SWRCB 2017q,r).

G.1.5 Feather River

Water quality constituents of concern in the Lower Feather River have the potential to affect several supported beneficial uses for cold and warm water, including municipal and agricultural water supply, contact and non-contact water recreation, and fish habitat and migration uses. The Section 303(d) listed contaminants in this reach of the Feather River are water temperature (discussed in Appendix O, *Aquatic Resources Technical Appendix*), mercury, pesticides, PCBs, and others. Figure G.1-2, presented above, displays 303(d) listed waterways in the Feather River region.

G.1.5.1 *Mercury*

The Lower Feather River is on SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). The Feather River does have relatively large mercury loadings and high mercury concentrations in suspended sediment, contributing to mercury loading to the Delta. The Feather River transports much of the mercury to the Sacramento River that was released in the Sierra Nevada Mountains during gold mining operations (Central Valley RWQCB 2010a).

Federal Energy Regulatory Commission (FERC) relicensing studies indicate that mercury consistently exceeds USEPA guidelines in most fish species and locations, and that biomagnification appears to cause elevated mercury levels in fish (FERC 2007). Lake Oroville has the beneficial effect of capturing contaminated sediments, preventing their further transport downstream.

In the Delta Estuary TMDL for methylmercury, the Central Valley RWQCB (2010a) recommends that the Feather River be targeted for mercury reduction during initial efforts, focusing on the watersheds that export the largest volumes of highly mercury-contaminated sediment to the Delta.

G.1.5.2 *Pesticides*

The Feather River below Lake Oroville is listed as contaminated for chlorpyrifos. Samples collected during storm events at the Feather River near Nicolaus in 2004 exceeded the CDFG Hazard Assessment Criteria of 25 ng/L over a 1-hour average. The TMDL for chlorpyrifos in the Feather River is expected to be completed in 2019 (SWRCB 2017s).

Group A Pesticides were also detected in exceedance of water quality criteria (SWRCB 2017s). NPDES permit program data collected between 2000 and 2009 for organochlorine pesticide contamination in the Feather River did not indicate exceedances of CTR criteria, but did show detections in all samples in the water column. Channel Catfish tissue samples from the Feather River at Highway 99 between 1978 and 2008 exhibited high concentrations of DDT and dieldrin. Supplemental documents for a Sacramento–San Joaquin River Basin Plan amendment to address organochlorine pesticides in Central Valley water bodies presented this water quality and fish tissue data. The amendment is currently in development and will include organochlorine pesticides in the Feather River (Central Valley RWQCB 2010c).

G.1.5.3 *PCBs*

The Lower Feather River is on the SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a). PCBs have been used in the Feather River watershed in the electric power generation industry and in other activities. Two events in the 1980s resulted in PCB contamination in the Feather River watershed, in response some remediation was performed (SWRCB 2017s). These past events have contributed to the current status of PCBs in the Feather River watershed.

According to the Section 303(d) List/305(b) Report) Supporting Information, sources of PCBs in the Feather River are unknown (SWRCB 2017s). However, the Final Environmental Impact Report for Oroville Facilities FERC relicensing notes that PCBs have been detected in all fish and crayfish species from all sampled water bodies (FERC 2007). DWR detected Aroclors in at least some fish in all water bodies, as well as in crayfish in the Feather River downstream from the State Route 70 bridge (DWR 2008). Two events in the 1980s resulted in PCB contamination in the Feather River watershed: oil containing PCBs was applied to a dirt road and entered the Ponderosa Reservoir in surface runoff, and PCB-contaminated soil and water at Belden Forebay due to a landslide, which damaged powerhouses. Some remediation was performed in response to these events.

The Feather River evaluation used the same narrative water quality objective and evaluation criteria of 3.6 ng/g as the guidance to place the Sacramento River on the Section 303(d) list. Composite samples of Largemouth Bass and crayfish collected in 2002 and 2003 showed high exceedances of the FCG. Upstream of the Thermalito Afterbay Outlet, a composite sample of Largemouth Bass had a concentration of 15.6 ng/g total PCBs, wet weight. Downstream of the outlet, the concentration of total PCBs in two composite samples of Largemouth Bass were 11.2 and 15.0 ng/g. Downstream of the Highway 70 Bridge, the concentration of total PCBs in a composite sample of crayfish was 56 ng/g (SWRCB 2017s).

An additional study performed in 2003 and 2004 also revealed high exceedances of the OEHHA FCG for PCBs. Concentrations of total PCBs in composite samples of hardhead (*Mylopharodon conocephalus*) and pikeminnow (*Ptychocheilus grandis*) were 26 ng/g and 31 ng/g wet weight. All samples were analyzed for 48 individual PCB congeners and two Aroclor mixtures (SWRCB 2017s).

A TMDL for PCBs in the Lower Feather River is expected to be completed in 2021 to protect the beneficial uses of the Feather River and other water bodies downstream (SWRCB 2017s).

G.1.5.4 *Other Constituents of Concern*

The Lower Feather River is listed as impaired by unknown toxicity due to exceedances of the toxicity criteria outlined by the Central Valley RWQCB (SWRCB 2017s; Central Valley RWQCB 2018a). Water samples were tested with *C. dubia, P. promelas*, and *P. subcapitata* for survival, growth and reproductive toxicity between 1998 and 2007. Of 212 samples tested with *C. dubia* for survival and reproductive toxicity, 85 exceeded the narrative toxicity objective. Of 34 samples tested with *P. promelas* for survival and growth toxicity, seven exceeded the objective. Of 23 samples tested with *P. subcapitata*, none exceeded the objective. Samples taken from the Feather River at Nicolaus, the Thermalito Diversion Pool, downstream from the Feather River Hatchery, upstream and downstream from the Thermalito Afterbay Outlet, downstream from the Sewage Commission Oroville Region (SCOR) Outlet, and downstream from the FERC Project 2100 project boundary were in violation of the toxicity objective.

G.1.6 American River

The lower American River flows for 23 miles from Nimbus Dam to its confluence with the Sacramento River. Water quality in this reach of the river is influenced by releases from upstream reservoirs, including Lake Natoma and Folsom Lake. The runoff that flows into Folsom Reservoir and Lake Natoma, upstream of the lower American River, is generally high quality (Wallace, Roberts, and Todd et al. 2003). Water quality parameters measured in Folsom Reservoir, upstream of the lower American River, include pH, turbidity, dissolved oxygen (DO), total organic carbon (TOC), nutrients (nitrogen and phosphorus), electrical conductivity, total dissolved solids (TDS), and fecal coliform. Figure G.1-2, presented above, displays 303(d) listed waterways in the American River region.

G.1.6.1 *Mercury*

The American River from Nimbus Dam to the confluence with the Sacramento River is on SWRCB's CWA Section 303(d) list as contaminated by mercury, due to exceedances of OEHHA's guidance tissue levels for mercury (SWRCB 2017t). The major source is mercury from historical mining activities that is slowly distributed downstream.

The American River contributes mercury to the Sacramento River, and thus the Delta, due to its relatively large mercury loadings and high mercury concentrations in suspended sediment (Central Valley RWQCB 2010a). Like the Feather River, the lower American River is recommended for initial mercury reduction efforts as part of the Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury. In addition to load allocations recommended as part of the Delta TMDL for methylmercury, mercury contamination in the American River and its reservoirs will be addressed as part of the statewide water quality control program for mercury (SWRCB 2018a).

G.1.6.2 *PCBs*

The lower American River is on the SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a).

Composite samples of White Catfish and Sacramento Sucker collected in the American River at Discovery Park were analyzed for 48 individual PCB congeners and three Aroclor mixtures (SWRCB 2017t). The total PCBs recorded in the White Catfish and Sacramento Sucker were 3.934 ng/g and 44.094 ng/g. An additional Sacramento Sucker composite sample collected at Nimbus Dam did not exceed the OEHHA goal.

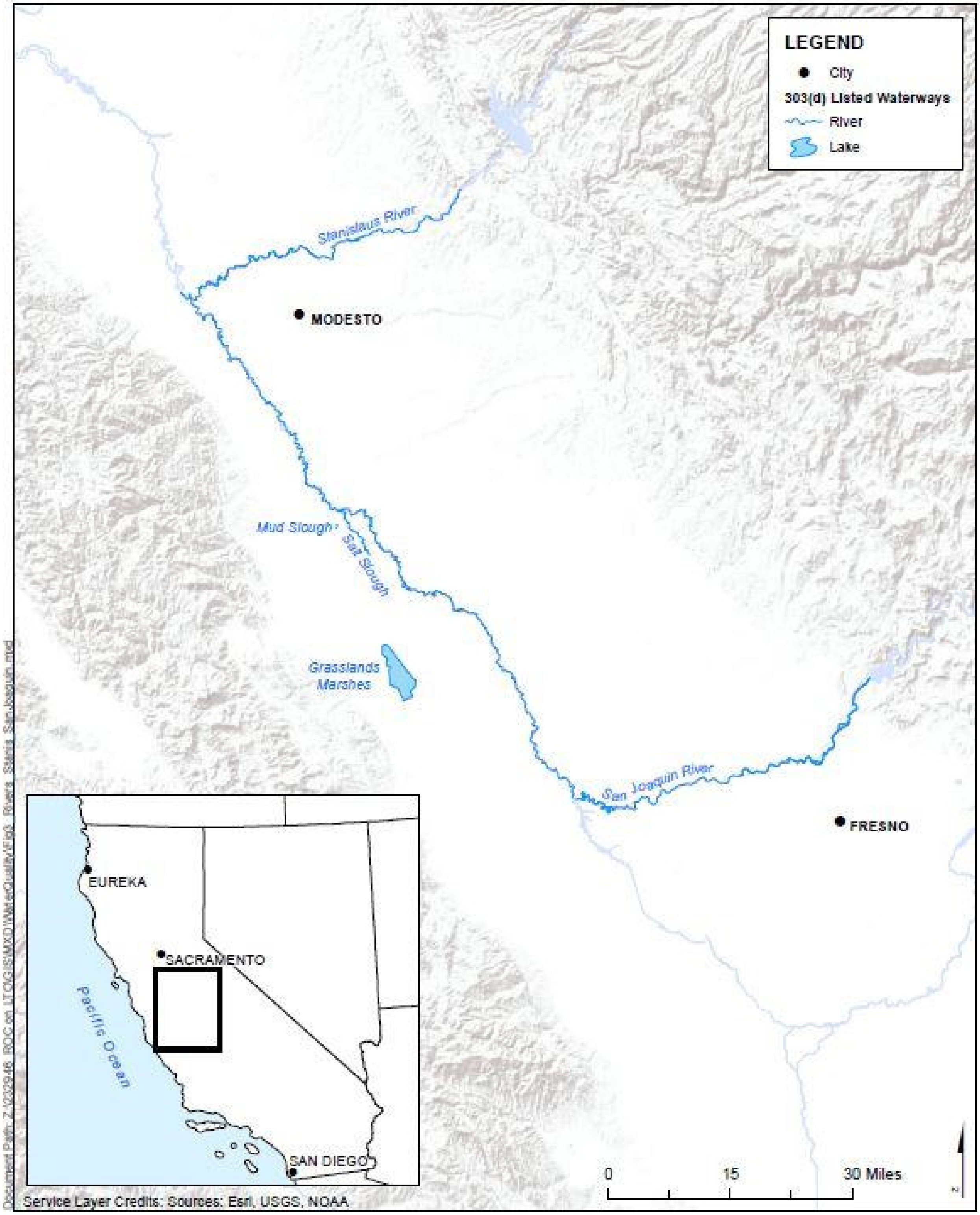
A TMDL for PCBs in the lower American River is expected to be completed in 2021 to protect the beneficial uses of the American River and other water bodies downstream (SWRCB 2017t).

G.1.6.3 *Unknown Toxicity*

The lower American River is on the SWRCB's CWA Section 303(d) list as impaired by unknown toxicity. Samples collected at Discovery Park indicated toxicity for vertebrates and invertebrates, based on survival, growth, and reproduction toxicity tests with *C. dubia* and *P. promelas*. These tests, conducted between 1998 and 2007, exhibited increases in mortality and reductions in growth and reproduction in the test organisms (SWRCB 2017t). The TMDL is expected to be completed in 2021 (SWRCB 2017t).

G.1.7 Stanislaus River

Figure G.1-4, 303(d) Listed Waterways in the Stanislaus River and San Joaquin River Regions presents 303(d) listed waterways within the Stanislaus River region.



Source: SWRCB 2017a.

Figure G.1-4. 303(d) Listed Waterways in the Stanislaus River and San Joaquin River Regions

G.1.7.1 *Mercury*

The Lower Stanislaus River is on the SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). Mercury has impaired the beneficial use of the commercial or recreational collection of fish, shellfish, or organisms (SWRCB 2017u-w). The lower Stanislaus River was evaluated prior to 2006, so the evidence for the list is not readily available. However, the total methylmercury concentration in the Stanislaus River at Caswell State Park from 2003 to 2006 was 0.12 ng/L (Foe et al. 2008). Concentrations of methylmercury in Largemouth Bass, carp, Channel Catfish, and White Catfish tissue samples from the Stanislaus River between 1999 and 2000 exceeded the USEPA methylmercury fish tissue criterion (0.3 mg/kg wet weight) for the protection of human health (Shilling 2003).

To protect the beneficial uses of the water bodies mentioned above, including the commercial and recreational collection of fish, shellfish, or organisms, TMDLs are expected to be completed between 2019 to 2021 to meet the water quality standards in these water bodies (SWRCB 2017u-w).

G.1.7.2 *Pesticides*

The Lower Stanislaus River is on SWRCB's CWA Section 303(d) list as impaired by pesticides (chlorpyrifos, diazinon, Group A Pesticides) (SWRCB 2017a). OP pesticides (e.g., diazinon and chlorpyrifos) and OC pesticides (e.g., Group A Pesticides) are primarily transported to streams and rivers in runoff from agriculture (Central Valley RWQCB 2011). Sources and descriptions of the listed pesticides are discussed further in Section G.1.1.7, *Pesticides*.

G.1.7.3 *Other Constituents of Concern*

The Lower Stanislaus River is on SWRCB's CWA Section 303(d) list as impaired by unknown toxicity (SWRCB 2017a). The Central Valley RWQCB (2011) Basin Plan established a narrative water quality objective, which addresses *E. coli*, to protect the beneficial uses of Lower Stanislaus River. A TMDL aiming to meet the water quality standards in the lower Stanislaus River is expected to be complete in 2021.

G.1.8 San Joaquin River

Water quality conditions in the San Joaquin River are described for locations that would be influenced by the alternatives, including Stanislaus River near Caswell Park by the confluence with the San Joaquin River, San Joaquin River near Vernalis, and San Joaquin River near Buckley Cove and Stockton.

Water quality concerns in the San Joaquin River near Vernalis are primarily salinity, boron, and selenium, which are influenced by low flows due to upstream diversions, as well as water use and agricultural return flows. Figure G.1-4, presented above, shows the 303(d) listed waterways in the San Joaquin River region.

G.1.8.1 *Selenium*

The San Joaquin River from Mud Slough to Merced River is on the SWRCB's CWA list as impaired by selenium (SWRCB 2017a). Other water bodies that drain to the San Joaquin River upstream of this reach and are listed as impaired by selenium contamination on the Section 303(d) list include Mendota Pool, Panoche Creek from Silver Creek to Belmont Avenue, Agatha Canal, Grasslands Marshes, and Mud Slough (North, downstream of San Luis Drain).

USEPA approved TMDLs for selenium for the San Joaquin River (Mud Slough to Merced River) (in 2002), Grasslands Marshes (in 2000), Agatha Canal (in 2000), and Mud Slough (north, downstream of San Luis Drain) (in 2002) (SWRCB 2017z-ac). A TMDL is expected to be completed for Panoche Creek in 2019 and another for Mendota Pool in 2021. Table G.1-12, Water Quality Objectives for Selenium in the San Joaquin River Region, mg/L, presents water quality objectives defined in the Basin Plan for the Sacramento River basin and the San Joaquin River basin are shown in (Central Valley RWQCB 2018a).

Table G.1-12. Water Quality Objectives for Selenium in the San Joaquin River Region, mg/L

Objective	Applies to:
0.012 (maximum concentration)	San Joaquin River, mouth of the Merced River to Vernalis
0.005 (4-day average)	–
0.020 (maximum concentration)	Mud Slough (north), and the San Joaquin River from Sack Dam to the mouth of Merced River
0.005 (4-day average)	–
0.020 (maximum concentration)	Salt Slough and constructed and re-constructed water supply channels in the Grassland watershed*
0.002 (monthly mean)	–

Source: Central Valley RWQCB 2018a.
*Applies to channels identified in Appendix 40 of the Central Valley RWQCB (2018) Basin Plan

The drainage area for the Grasslands Bypass Project is a major but decreasing source of selenium to the San Joaquin River. Selenium from subsurface agricultural drainage waters originating in the drainage area was historically transported through the Grassland Marshes via tributaries such as Mud Slough and Salt Slough (Central Valley RWQCB 2001). Efforts to decrease the selenium loading to the San Joaquin River include the Grassland Bypass Project, discussed in more detail below, which has decreased selenium loading by an average of 55% from the Grasslands Drainage Area in comparison to pre-Grassland Bypass Project conditions (1986–1996 to 1997–2011) (GBPOC 2013). In the San Joaquin River below the Merced River, selenium concentrations decreased from an average of 4.1 µg/L during pre-project conditions (1986 to 1996) to 2 µg/L (1997 to 2011). The continued operation of the Grassland Bypass Project is expected to achieve the Central Valley RWQCB Basin Plan objectives for the San Joaquin Valley (Reclamation and SLDMWA 2009).

The Central Valley RWQCB sampled Largemouth Bass from the San Joaquin River, lower Sacramento River, and Delta during 1999, 2000, 2005, and 2007 (Foe 2010). The samples were analyzed as fillets to evaluate potential human health risks, and whole-body selenium concentrations were estimated using an equation from Saiki et al. (1991) to evaluate risks to wildlife. The data do not exceed the May 2014 USEPA draft water quality criteria.

The 2014 Central Valley RWQCB draft discharge requirements aim to meet the water quality objective for the San Joaquin River. In 2010, the Central Valley RWQCB and SWRCB approved amendments (Resolution 2010-0046) to the Sacramento–San Joaquin River Basin Plan to address selenium control in the San Joaquin River basin as related to the Grassland Bypass Project, described below (Central Valley RWQCB 2010d; SWRCB 2010).

Other relevant requirements/actions to meet the water quality objectives for the San Joaquin River, in addition to the Central Valley RWQCB draft waste discharge requirements (2010d) include the following:

- The Basin Plan amendments (Central Valley RWQCB 2010d; SWRCB 2010) modify the compliance time schedule for discharges regulated under waste discharge requirements to meet the selenium objective or comply with a prohibition of discharge of agricultural subsurface drainage to Mud Slough (north), a tributary to the San Joaquin River, in Merced County. For Mud Slough (north) and the San Joaquin River from the Mud Slough confluence to the mouth of the Merced River:
  - The interim performance goal is 15 µg/L (monthly mean) by December 31, 2015.
  - The water quality objective to be achieved by December 31, 2019, is 5 µg/L (4-day average).

An extensive water quality and biological monitoring program was implemented in conjunction with the Grassland Bypass Project, and reports are issued periodically through the San Francisco Estuary Institute (e.g., SFEI 2011).

G.1.8.2 *Electrical Conductivity and Salinity*

Grasslands Marshes, North Mud Slough (downstream of San Luis Drain), and Salt Slough (upstream from confluence with the San Joaquin River) are Central Valley water bodies placed on the Section 303(d) list approved by USEPA in 2010 as impaired by electrical conductivity (SWRCB 2011), and continue to be Section 303(d) listed in the most recent, 2016 update (SWRCB 2017a). Salinity, which is linked to electrical conductivity, is a major concern for water quality in the San Joaquin Valley (Central Valley RWQCB 2018a). The RWQCB has adopted a TMDL for the San Joaquin River upstream of Vernalis for salt and boron.

Elevated electrical conductivity in the Grasslands Marshes, North Mud Slough (downstream of San Luis Dam), Salt Slough (upstream from confluence with the San Joaquin River), and San Joaquin River (Bear Creek to Vernalis) can be attributed to agriculture (SWRCB 2017x-aa,ac-af). Likewise, high salinity in the San Joaquin River near Vernalis is linked to the discharge of water from agricultural practices (CALFED 2007a). Saline water from agricultural return flow is added to the southern Delta by the San Joaquin River, where a portion is pumped by the export pumps back to the farms that eventually drain back to the river, exacerbating the problem of salinity control and salt buildup in the San Joaquin Valley.

The SWRCB (2006) Basin Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary established water quality objectives to protect the beneficial uses of these water bodies, including agricultural supply, and municipal and domestic supply. It focuses particularly on the San Joaquin River from Bear Creek to Mud Slough (Table G.1-13, SWRCB Water quality objectives for electrical conductivity in the San Joaquin River [Airport Way Bridge, Vernalis]).

Table G.1-13. SWRCB Water quality objectives for electrical conductivity in the San Joaquin River (Airport Way Bridge, Vernalis)

Time Period	Water Quality Objective[1]
April 1 to August 31	0.7 mmhos (700 µS/cm)
September 1 to March 31	1.0 mmhos (1000 µS/cm)

Source: SWRCB 2006.

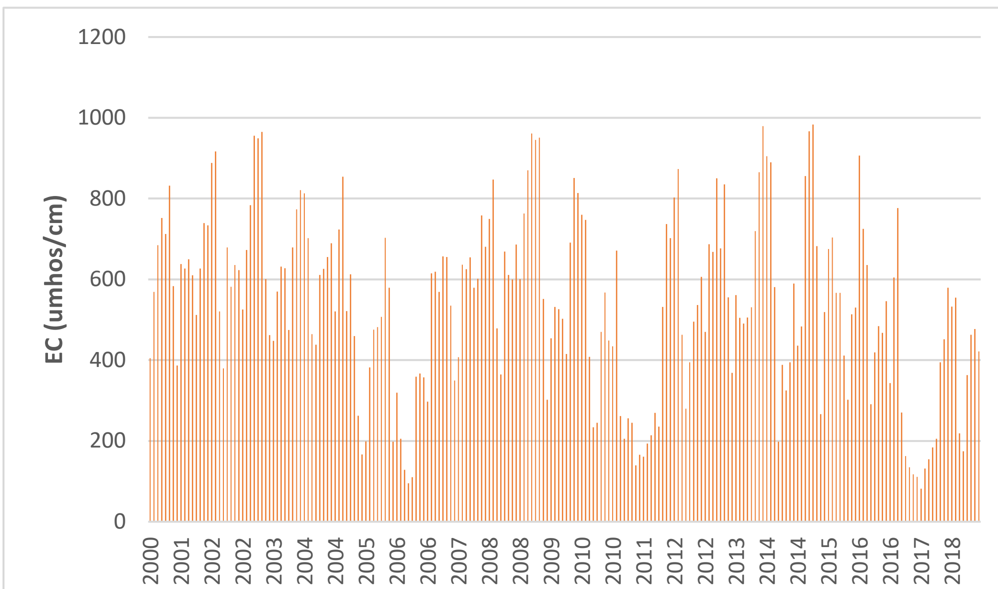
[1] Maximum 30-day running average of mean daily

Several samples from the San Joaquin River (Bear Creek to Vernalis) between October 1995 and February 2007 exceeded the SWRCB Basin Plan's water quality objective for electrical conductivity in the San Joaquin River (SWRCB 2017x-aa, ac-af).Samples were collected from the San Joaquin River at Lander Avenue, Fremont Ford, Patterson Fishing Access, Hills Ferry Bridge, and Crows Landing.

Guidelines for evaluating the Grasslands Marshes, North Mud Slough, and Salt Slough are not available because the listing was made prior to 2006.

Figure G.1-5, Monthly Average Specific Conductance in San Joaquin River at Vernalis shows salinity in the lower San Joaquin River as observed at Vernalis. The record of monthly average electrical conductivity (EC) readings for recent years for the San Joaquin River at Vernalis is shown on often exceeds the water quality objective for individual records during summer months. The highest salt concentrations emanate from Mud and Salt sloughs, while less saline water provides dilution from the Merced River (CALFED 2007a). There is a marked increase in salinity during dry months and dry years at Vernalis, ranging from midwinter lows near 100 micromhos per centimeter (µmhos/cm) up to summer high values near 1000 µmhos/cm.

A TMDL is expected to be completed in 2019, except for the San Joaquin River from Tuolumne to Stanislaus River, which is expected to be completed in 2021 (SWRCB 2017x-aa, ac-af). The Central Valley RWQCB implemented the comprehensive salt management program, known as CV-SALTS (Central Valley Salinity Alternatives for Long Term Sustainability), to develop salt control strategies for the San Joaquin and the entire Central Valley watershed (Central Valley RWQCB 2010e, 2011). The San Joaquin River Water Quality Improvement Program (SJRIP) is designed to address issues of chronically saline water, reuse, treatment options, and the development of salt-tolerant crops for this area of the valley, as part of the Grasslands Bypass Project.



Source: DWR 2019a.

Figure G.1-5. Monthly Average Specific Conductance in the San Joaquin River at Vernalis

G.1.8.3 *Mercury*

Mercury is a constituent of concern for the San Joaquin River from Bear Creek to Mud Slough (SWRCB 2017a). The San Joaquin River from Friant Dam to Bear Creek was not included on the Section 303(d) list for mercury contamination.

Mercury in this reach of the San Joaquin River can be attributed to resource extraction. Historically, there were gold mining operations along the major tributaries of the San Joaquin River, including the Merced

River, Tuolumne River, Stanislaus River, and Cosumnes River in the San Joaquin River basin (Central Valley RWQCB 2010a).

Mercury and enhanced mercury methylation can affect the beneficial uses of the San Joaquin River and receiving waters downstream. At the Delta boundary in Vernalis, the waterborne methylmercury concentration in the San Joaquin River from 2003 to 2006 ranged from 0.10-0.75 ng/L with an average of 0.19 ng/L (Foe et al. 2008). The average fish tissue mercury concentration in Largemouth Bass from Vernalis in 2000 was 0.68 mg/kg (wet weight) (Central Valley RWQCB 2010a). This fish tissue concentration exceeds the USEPA wet weight methylmercury fish tissue criterion (0.3 mg/kg) for the protection of human health.

To further protect the health of humans and wildlife, the Delta TMDL specified narrative and more-stringent numeric water quality objectives for the most bioavailable and toxic form of methylmercury. The Delta TMDL (Central Valley RWQCB 2010a), which is applicable to the Delta, Yolo Bypass, and their waterways, includes the reach of the San Joaquin River from Bear Creek to Mud Slough.

G.1.8.4 *Pesticides*

The San Joaquin River (all segments from Mendota Pool to Vernalis), North Mud Slough (downstream of San Luis Drain), and Salt Slough (upstream from confluence with the San Joaquin River) are on the SWRCB's CWA Section 303(d) list as impaired by pesticides (SWRCB 2017a). North Mud Slough is listed as impaired by pesticides. Salt Slough is listed as impaired by chlorpyrifos and prometryn. The San Joaquin River is listed as impaired by OC pesticides (DDT, DDE, Group A Pesticides, including toxaphene) and alpha.-BHC. The San Joaquin River was previously listed as impaired by OP pesticides (chlorpyrifos and diazinon) and Diuron, however assessment of readily available data indicated the San Joaquin River is now meeting water quality standards for those pesticides (Central Valley RWQCB 2019). Impairment listings vary between reaches of the San Joaquin River. Several other small tributaries to the San Joaquin River from the west are also on the Section 303(d) as impaired by pesticides (i.e., Mud Slough North [upstream and downstream of San Luis drain]).

Pesticides in North Mud Slough, Salt Slough, and the San Joaquin River are from agriculture runoff, with the exception of the alpha-BHC in the San Joaquin River (from Merced to Tuolumne) and toxaphene in the San Joaquin River (from Stanislaus to the Vernalis), whose sources are unknown (SWRCB 2017x-z,ac-ag).

G.1.8.5 *Boron*

The lower San Joaquin River upstream of Vernalis is listed as impaired due to elevated concentrations of boron (Central Valley RWQCB 2002b, 2007c). An Amendment to the Sacramento–San Joaquin River Basin Plan for the control of salt and boron discharges into the lower San Joaquin River (resolution R5-2004-0108) (Central Valley RWQCB 2007b) describes a pending TMDL and establishes Waste Load Allocations to meet boron water quality objectives near Vernalis (at the Airport Way Bridge).

Mean salinity in the lower San Joaquin River at Vernalis has doubled since the 1940s, and boron and other trace elements also increased to concentrations that exceed the water quality criteria of 750 µg/L. These criteria were established to protect sensitive crops under long-term irrigation (USEPA 1986b). Water quality improves in the San Joaquin River downstream of confluences with the Merced, Tuolumne, and Stanislaus rivers.

Most of the boron load to the Delta comes from the lower San Joaquin River's surface and subsurface agricultural discharges (Central Valley RWQCB 2007b) on soils overlying old marine deposits, and from groundwater (Hoffman 2010; CALFED 2000). Major boron contributions come from Salt and Mud sloughs to the lower river (Central Valley RWQCB 2002b). Point sources contribute a minimal salt and boron load to the San Joaquin River (Central Valley RWQCB 2007b).

Boron concentrations in surface water from two surface water sources in the lower San Joaquin River are variable and range from 100 to over 1000 µg/L (Hoffman 2010). Effluent from subsurface drains in the New Jerusalem Drainage District were reported up to 4200 µg/L (Hoffman 2010). These concentrations at times exceed the water quality criteria and thresholds for sensitive crops (i.e., bean tolerance threshold is 750 to 1000 µg/L).

In 2018, the Central Valley RWQCB approved amendments to the Sacramento–San Joaquin River Basin Plan to incorporate a Central Valley-wide Salt and Nitrate Control Program (Central Valley RWQCB 2018b).

G.1.8.6 *Arsenic*

The San Joaquin River from Bear Creek to Mud Slough is on the SWRCB’s CWA Section 303(d) list as impaired by arsenic (SWRCB 2017a). Arsenic can cause adverse dermal, cardiovascular, respiratory, gastrointestinal, and neurological effects, as well as cancer (ATSDR 2007a). A TMDL addressing impairment due to arsenic is expected to be complete in 2021 to protect the beneficial uses of this reach of the San Joaquin River, including the municipal and domestic supply (SWRCB 2017ah).

G.1.8.7 *Bacteria*

The San Joaquin River (Mud Slough to Merced River) and Salt Slough (upstream from confluence with the San Joaquin River) is on the SWRCB’s CWA Section 303(d) list as impaired by indicator bacteria (SWRCB 2017a).

G.1.8.8 *Invasive Species*

The San Joaquin River (Friant Dam to Mendota Pool) is on the SWRCB’s CWA Section 303(d) list as impaired by invasive species (SWRCB 2017a).

A TMDL for invasive species is expected to be completed in 2019. It will aim to meet the narrative water quality objective in the San Joaquin River (Friant Dam to Mendota Pool).

G.1.9 Bay-Delta

The “Bay-Delta” region includes the legal Delta, Suisun Bay and Marsh, and San Francisco Bay.

G.1.9.1 *Overview*

Primary factors affecting water quality in the Delta, Suisun Bay, and Suisun Marsh include patterns of land use in the upstream watersheds; inter-annual hydrologic variations; operations of the SWP, CVP, and flow control gates within the Delta and Marsh; and activities and sources of pollutants within and upstream of these water bodies. Point and nonpoint pollutant sources include drainage from inactive and abandoned mines and related debris/sediment from headwaters, industrial and municipal wastewater treatment plant discharges, agricultural return flows, urban storm water runoff, atmospheric deposition, recreational uses, and metabolic waste from wildlife and livestock. Natural erosion, in-stream sediments, and atmospheric deposition also affect water quality. The magnitude of each source’s effect correlates with the relative contribution from each source at a given location and can differ by constituent or with hydrologic and climatic conditions during different times of year, and from year-to-year.

The San Francisco Bay water quality is similarly affected by upstream land uses; hydrologic variations; pollutant source input from municipal wastewater discharges, agricultural return flows, urban runoff, and mining activities; and recreational uses (Cohen 2000). The northern and central portions of San Francisco Bay are strongly influenced by freshwater Delta inputs, whereas the southern portion of the Bay is often dominated by ocean water and is generally isolated from the northern portion (Cohen 2000). Thus, this water quality effects discussion will focus on the northern and central portions of the Bay.

G.1.9.2 *State-Designated Beneficial Uses*

The Delta, Suisun Bay and Marsh, and San Francisco Bay provide water for many state-designated beneficial uses, as shown in Table G.1-1. The *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (San Francisco Bay RWQCB 2017) designates beneficial uses of the Delta. The *Central Valley Regional Water Quality Control Board Water Quality Control Plan* (Central Valley RWQCP; Central Valley RWQCB 2018a) also designates beneficial uses of the Delta within its jurisdiction, which includes the western, northwestern, southern, central, and eastern portions. Additionally, the *San Francisco Bay Regional Water Quality Control Board Water Quality Control Plan* (San Francisco Bay RWQCP; San Francisco Bay RWQCB 2017) designates beneficial uses for the western portion of the Delta within its jurisdiction, and for Suisun Bay, Suisun Marsh, and San Francisco Bay.

G.1.9.3 *Constituents of Concern*

The Section 303(d) list for California identifies the Delta waterways, Suisun Bay, Suisun Marsh, and San Francisco Bay as impaired for many constituents as shown in Table G.1-14, Clean Water Act Section 303(d) Listed Pollutants and Sources in the Delta, Suisun Bay, and Suisun Marsh, and Table G.1-15, Clean Water Act Section 303(d) Listed Pollutants and Sources in the Delta and San Francisco Bay.

The Delta, Suisun Bay, and San Francisco Bay are listed as impaired by invasive species on the SWRCB's Section 303(d) list because they have invasive species, with specific sources to these water bodies unknown (SWRCB 2017a). Changes in water quality can make conditions more favorable for invasive species (e.g., aquatic vegetation and benthic macroinvertebrates), and invasive species can affect water quality conditions (e.g., turbidity, organic enrichment). However, invasive species are biological parameters and not water quality parameters; thus, invasive species within the Delta, Suisun Bay, and San Francisco Bay are not addressed further within this technical appendix.

The entire Delta is also listed on the SWRCB's Section 303(d) list as impaired by unknown toxicity. Aquatic toxicity refers to the mortality of aquatic organisms or sublethal effects (e.g., reduced growth or reproduction) and can be caused by any number of individual constituents of concern, or through additive or synergistic effects attributable to the presence of multiple toxicants. Within the Delta, toxicity is known to occur, but the constituent(s) causing toxicity is unknown (SWRCB 2017a). Thus, unknown toxicity within the Delta is not addressed further within this technical appendix.

The central and lower portions of San Francisco Bay are included on the SWRCB's Section 303(d) list of impaired water bodies due to trash. The presence of trash is associated with humans discarding unwanted items on land or in surface waters, not CVP/SWP operations. Thus, trash within San Francisco Bay is not addressed further within this technical appendix.

Additional constituents of concern for the Delta include bromide, organic carbon, and nutrients. Bromide is a salinity-related parameter of concern in the Delta because it reacts with ozone, and other municipal water treatment plant disinfectants. These reactions forms bromate, bromoform, and other brominated trihalomethane compounds, as well as haloacetic acids, which are regulated disinfection byproducts in drinking water. Organic carbon is also of concern in the Delta because of the potential for disinfection byproducts to form in treated drinking water supplies. The Delta was not included on the SWRCB's Section 303(d) list approved as impaired by nutrients, however, nutrients are of interest in the Delta (e.g., Central Valley RWQCB 2010f) and are the focus of ongoing research.

Table G.1-14. Clean Water Act Section 303(d) Listed Pollutants and Sources in the Delta, Suisun Bay, and Suisun Marsh

Pollutant/ Stressor	Listed Source	Delta Region								Specific Delta Waterways																		Suisun	
		Central	Eastern	Export Area	Northern	Northwestern	Southern	Stockton DWSC	Western	Lower Calaveras River	Bear Creek	Lower Cosumnes River	Duck slough	Five Mile Slough	French Camp Slough	Kellogg Creek	Marsh Creek	Middle River	Lower Mokelumne River	Mormon Slough	Mosher Slough	Old River	Pixley Slough	Sand Creek	Smith Canal	Tom Paine Slough	Walker Slough	Suisun Bay	Suisun Marsh
Arsenic	Source unknown								X																				
Chlordane	Source unknown				X				X																			X	
Chloride	Source unknown																									X			X
Chlorpyrifos	Source unknown, agriculture, urban runoff/ storm sewers	X	X	X	X	X	X	X	X	X			X	X	X				X	X	X	X	X	X					
Copper	Source unknown										X								X										
DDE/DDT	Source unknown	X	X	X	X	X	X	X	X															X				X	
Diazinon	Source unknown, agriculture, urban runoff/storm sewers	X	X	X	X	X	X	X	X	X	X			X	X						X		X	X					
Dieldrin	Source unknown				X				X															X				X	
Dioxin	Source unknown							X																				X	
Disulfoton	Source unknown																						X	X					
Electrical conductivity / salinity	Source unknown			X		X	X		X							X						X		X		X			X
Furan compounds	Source unknown							X																				X	
Group A pesticides [a]	Source unknown	X	X	X	X	X	X	X	X																				
Organophosphorus Pesticides	Source unknown																								X				
Indicator bacteria	Source unknown, urban runoff/storm sewers									X	X	X		X	X	X	X			X	X		X	X	X		X		

Pollutant/ Stressor	Listed Source	Delta Region								Specific Delta Waterways																		Suisun	
		Central	Eastern	Export Area	Northern	Northwestern	Southern	Stockton DWSC	Western	Lower Calaveras River	Bear Creek	Lower Cosumnes River	Duck slough	Five Mile Slough	French Camp Slough	Kellogg Creek	Marsh Creek	Middle River	Lower Mokelumne River	Mormon Slough	Mosher Slough	Old River	Pixley Slough	Sand Creek	Smith Canal	Tom Paine Slough	Walker Slough	Suisun Bay	Suisun Marsh
Invasive species	Source unknown	X	X	X	X	X	X	X	X																			X	
Mercury	Resource extraction, industrial-domestic wastewater, atmospheric deposition, nonpoint source	X	X	X	X	X	X	X	X	X							X		X		X							X	X
Nutrients	Source unknown																												X
Organic enrichment/ low dissolved oxygen	Municipal point sources, urban runoff/storm sewers, hydromodification, source unknown							X		X	X			X	X	X		X	X	X	X	X	X		X	X			X
PAHs	Source unknown								X																				
PCBs	Source unknown				X			X	X																			X	
Temperature	Source unknown							X																					
TDS	Source unknown																					X							X
Toxicity [b]	Source unknown	X	X	X	X	X	X	X	X						X	X	X		X	X			X	X					
Selenium	Source unknown																											X	
Zinc	Source unknown																		X										

Source: SWRCB 2017a.

Notes:

DDT = dichlorodiphenyltrichloroethane, PCB = polychlorinated biphenyls, EC = electrical conductivity, DO = dissolved oxygen, TDS = total dissolved solids.

[a] Group A pesticides include aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, benzene hexachloride (BHC; including lindane), endosulfan, and toxaphene.

[b] Toxicity is known to occur, but the constituent(s) causing toxicity is unknown.

Table G.1-15. Clean Water Act Section 303(d) Listed Pollutants and Sources in the Delta and San Francisco Bay

Pollutant/ Stressor	Listed Source	San Francisco Bay					
		Delta	Carquinez Straight	San Pablo Bay	Central	Lower	South
Arsenic	Source unknown						
Chlordane	Source unknown	x	x	x	x	x	x
Chloride	Source unknown						
Chlorpyrifos	Source unknown, agriculture, urban runoff/ storm sewers						
Copper	Source unknown						
DDT	Source unknown	x	x	x	x	x	x
Diazinon	Source unknown, agriculture, urban runoff/storm sewers						
Dieldrin	Source unknown	x	x	x	x	x	x
Dioxin	Source unknown	x	x	x	x	x	x
Disulfoton	Source unknown						
Electrical conductivity / salinity	Source unknown						
Furan compounds	Source unknown	x	x	x	x	x	x
Group A pesticides [a]	Source unknown						
Organophosphorus Pesticides	Source unknown						
Indicator bacteria	Source unknown, urban runoff/storm sewers						
Invasive species	Source unknown	x	x	x	x	x	x
Mercury	Resource extraction, industrial-domestic wastewater, atmospheric deposition, nonpoint source	x	x	x	x	x	x
Nutrients	Source unknown						
Organic enrichment/ low dissolved oxygen	Municipal point sources, urban runoff/storm sewers, hydromodification, source unknown						
PAHs	Source unknown						
PCBs	Source unknown	x	x	x	x	x	x
Temperature	Source unknown						
TDS	Source unknown						
Toxicity [b]	Source unknown						
Trash	Source unknown				x	x	
Selenium	Source unknown	x	x	x	x		x
Zinc	Source unknown						

Source: SWRCB 2017a.

G.1.9.4 *Salinity*

G.1.9.4.1 Delta, Suisun Bay, and Suisun Marsh

Salinity in the Delta channels can vary depending on several factors, including surface water hydrology and inflow quality, water project operations, and hydrodynamics. Hydrology and upstream water project operations influence Delta inflows, which in turn influence the balance with the highly saline seawater intrusion. Delta salinity conditions are affected by upstream source water quality that flows into the Delta, as well as in-Delta sources such as agricultural returns, natural leaching, and municipal and industrial discharges. Operation of various Delta gates and barriers, pumping rates of various diversions, and the volume of open water bodies are other key factors influencing Delta hydrodynamics and salinity.

Salinity in Suisun Bay is primarily affected by Delta outflow to the bay and tidal inflows from San Francisco Bay. Salinity within Suisun Marsh is similarly affected by inflows from the Delta, as affected by water project operations, Suisun Bay inflows, and the use of the Suisun Marsh Salinity Control Gates, which are located on Montezuma Slough near Collinsville. The Salinity Control Gates are operated periodically from September to May to meet the Bay-Delta WQCP objectives and D-1641 requirements. The Salinity Control Gate operations restrict the inflow of high-salinity flood-tide water from Grizzly Bay into the marsh, but allow freshwater ebb-tide flow from the mouth of the Delta to pass through. The gate operation lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west. When the Delta outflow is low to moderate and the gates are not operating, net movement of water is from west to east, resulting in higher-salinity water in Montezuma Slough.

The Bay-Delta WQCP (SWRCB 2006) includes numeric salinity-related objectives for the Delta and Suisun Marsh. It includes chloride objectives to protect municipal and industrial water supply beneficial uses. It also includes Electrical Conductivity (EC) objectives for multiple western, interior, and south Delta compliance locations to protect agricultural supply beneficial uses. The Bay-Delta WQCP specifies salinity objectives for fish and wildlife protection: EC objectives for the Delta and Suisun Marsh, a narrative salinity objective for brackish tidal marshes of Suisun Bay, and the X2 standard that regulates the location and number of days of allowable encroachment into the west Delta of salinity exceeding 2 parts per thousand isohaline (2.64 millisiemens per centimeter) (SWRCB 2006). In general, the chloride and EC objectives vary depending on the month and water-year type. Compliance with salinity objectives is largely dependent on Delta inflows and outflows. The CVP and SWP are operated to achieve Delta salinity objectives.

Waterways within the Delta and Suisun Marsh have been identified as impaired due to elevated salinity and are included on the SWRCB's Section 303(d) list (SWRCB 2017a). The Delta waterways listed as impaired due to elevated EC include southern, western, and northwestern portions, the export area, the Stockton Deep Water Ship Channel, Old River, and Tom Paine Slough. Tom Paine Slough is also listed as impaired for chloride. Suisun Marsh is listed as impaired due to elevated chloride, EC, and total dissolved solids (TDS).

The SWRCB is in the process of updating flow and water quality objectives in the Bay-Delta WQCP. The SWRCB adopted the Lower San Joaquin River and Southern Delta portion of the Bay-Delta WQCP update in December 2018. Updates for the Sacramento River and its tributaries, including Delta eastside streams (Calaveras, Cosumnes, and Mokelumne Rivers) are in development (SWRCB 2018b).

In addition to EC and chloride, the salinity-related constituent bromide is of concern in Delta waters, even though the Delta is not listed as impaired by bromide. The complex interplay between hydrology, water project operations, bromide sources, and hydrodynamics results in bromide's presence in Delta waters. The primary source of bromide in the Delta is seawater intrusion. Bromide concentrations also are generally higher in the lower San Joaquin River and Delta island agricultural drainage because of irrigation practices and evaporative concentration that occurs in water diverted from the Delta for irrigated agriculture. Recirculation, or the process of agricultural drainage entering the San Joaquin River and its subsequent and repetitive diversion for agricultural practices, also contributes to elevated bromide concentrations in the San Joaquin River.

There are no federally-promulgated or state adopted water quality objectives for bromide in surface waters.

G.1.9.4.2 San Francisco Bay

Cohen (2000) characterizes the salinity of the San Francisco Bay estuary into three broad regions, when considering the bay's biota. The first zone is the Delta as the freshwater region. The second zone is the lower salinity region, which consists of Suisun Bay and extends sometimes into Carquinez Strait and San Pablo Bay, as well as areas along other freshwater inflows, such as the Napa River and Petaluma River on San Pablo Bay, and sloughs and creeks entering the southern portion of the bay. The third zone, the higher salinity region, is the main portions of the South, Central, and San Pablo bays. The freshwater inflows from the Delta flows into the bay near the water surface and gradually mixes in due to its lower density as compared to sea water (Cohen 2000). The Delta inflows also create horizontal salinity gradients, with lower salinity water near the Delta and higher salinity water near the mouth of the bay (Cohen 2000).

The twice daily tidal cycle results in substantial water movement in and out of San Francisco Bay. With each tidal cycle, an average of 1,300,000 acre-feet of seawater moves into and out of San Francisco Bay (Cohen 2000). By comparison, daily freshwater inflow averages about 50,000 acre-feet (Cohen 2000), which is about 4% of the inflow volume of seawater.

The San Francisco Bay RWQCP water quality objective for salinity requires that controllable water quality factors shall not increase the total dissolved solids or salinity of waters of the state in a way that would negatively affect state-designated beneficial uses, particularly fish migration and estuarine habitat (San Francisco Bay RWQCB 2017).

G.1.9.5 *Mercury*

G.1.9.5.1 Delta

Legacy mining in the headwaters of the Sacramento River watershed is the primary source of mercury contamination in the Delta and Suisun Bay. Over 80% of the total mercury flux to the Delta can be attributed to the Sacramento River and Yolo Bypass (Central Valley RWQCB 2010g). The Sacramento River is the primary tributary source of mercury to the Delta in dry years and the proportion of mercury loading from the Yolo Bypass increases in wet years to the extent that it is comparable to that of the Sacramento River. Cache Creek is also a major source of mercury to the Yolo Bypass where high mercury concentrations are transported in suspended sediment. Therefore, a priority for mercury reduction management strategies is controlling mercury inputs from tributary sources.

Sediment in Cache Creek that is not captured by the Cache Creek Settling Basin is transported into the Yolo Bypass (approximately half of the sediment transported by Cache Creek). Outflow from the settling basin (and possibly in other tributaries to the Yolo Bypass) exceeds the CTR mercury criterion of 0.050 μg/l for drinking water; thus, when flows from Cache Creek dominate Yolo Bypass, the bypass also likely exceeds the CTR criterion (Central Valley RWQCB 2010g). Compounding the issue of mercury contamination in the Yolo Bypass, a U.S. Geological Survey (USGS) study noted that the bypass has conditions conducive to the production of methylmercury, including stagnant waters and marshes with an abundance of sulfate and organic carbon (USGS 2002). Mine remediation, erosion control in mercury-enriched areas, and removing floodplain sediments containing mercury will reduce mercury loads in Cache Creek (Central Valley RWQCB 2010g). Regularly excavating the sediment accumulating in the Cache Creek Settling Basin will also reduce mercury entering the Delta.

It has been estimated that the flux of methylmercury from Delta sediments contributes over 30% of the waterborne methylmercury load in the Delta (Central Valley RWQCB 2010g). Therefore, the spatial variability of mercury and methylmercury in sediments is an important characteristic of the Delta's current condition for mercury exposure and could be important for determining future mercury risk. The National Water Quality Assessment Program for the Sacramento River basin sampled streambed sediment mercury concentrations from the Delta in 1995 (MacCoy and Domagalski 1999: 13). Sediment mercury concentrations of 0.14 µg/g (dry weight basis in the <63 micron fraction) at Freeport and 0.15 µg/g in Cache Creek were less than the threshold effect concentration (0.18 µg/g) and probable effect concentration (1.06 µg/g) reported by MacDonald et al. (2000: 23–24). These reported mercury concentrations in sediment greatly exceeded the average amount of background mercury found on the earth's surface, which is about 0.05 µg/g.

The Central Valley RWQCB initiated the Delta Regional Monitoring Program (Delta RMP) to establish a coordination system among the many agencies and groups that monitor water quality, flows, and ecological conditions in the Delta. The Delta RMP ensures that all data are synthesized and assessed on a regular basis, with the primary goal of tracking and documenting beneficial use protection and restoration efforts' effectiveness through the comprehensive monitoring of contaminants and contaminant effects in the Delta. The Delta RMP began a methylmercury monitoring program in 2016 to establish baseline concentrations and support long-term trend monitoring as a critical performance measure for mercury control programs. Field workers collected Largemouth Bass and Spotted Bass (*Micropterus punctulatus*) from August and September 2016 at six locations distributed across the Delta that coincide with the TMDL subareas (Davis et al. 2018: 4). Total mercury in fish tissues (length-normalized to 350 millimeters [mm]) ranged from 0.15 mg/kg wet weight at Little Potato Slough to 0.61 mg/kg wet weight at the Sacramento River at Freeport. Methylmercury concentrations in unfiltered water ranged from 0.021 to 0.22 ng/L among four monitoring events from August 2016 to April 2017. Concentrations of total mercury in unfiltered water ranged from 0.91 to 13 ng/L.

USEPA approved the Sacramento–San Joaquin Delta Estuary TMDL for methylmercury (Delta Methylmercury TMDL) (Central Valley RWQCB 2010g) in 2011 to protect human health, wildlife, and aquatic life. The TMDL establishes methylmercury fish tissue objectives and waste load allocations for agricultural drainage, tributary inputs, and point and non-point source dischargers in the Delta (including Yolo Bypass). The methylmercury objective requires fish tissue concentrations to not exceed 0.08 and 0.24 mg/kg, wet weight, in muscle tissue of trophic level three and four fish, respectively (150–500 mm total length). Further, the average methylmercury concentrations shall not exceed 0.03 mg methylmercury/kg, wet weight, in whole fish less than 50 mm in length.

In conjunction with the mercury and methylmercury load reduction goals of the Delta Methylmercury TMDL, the Central Valley RWQCB developed a Delta Mercury Exposure Reduction Program (Delta MERP; Sacramento–San Joaquin Delta Conservancy 2019) as a multiple stakeholder effort to promote a better understanding of mercury bioaccumulation in Delta fish and support approaches for reducing human exposure to mercury from fish caught in the Delta.

The Central Valley RWQCB is also developing a state-wide mercury control program for reservoirs and a Central Valley mercury control program for rivers (Central Valley RWQCB 2017a).

G.1.9.5.2 San Francisco Bay, Suisun Bay and Suisun Marsh

Delta inputs primarily drive mercury concentrations in northern San Francisco Bay, Suisun Bay, and Suisun Marsh. Methylmercury concentrations in surface waters and sediment are highest in the South Bay because of conditions favoring methylation and historical mercury inputs from the New Almaden Mine. These sources led to higher average total mercury concentrations in striped bass (*Morone saxatilis*) tissues (0.44 mg/kg wet weight) from the San Francisco Bay than any other estuary in the United States (Davis et al. 2014). The San Francisco Bay Regional Monitoring Program (Bay RMP) conducts fish tissue sampling and analysis in the San Francisco Bay every three years to monitor tissue mercury concentrations in fish tissues. Concentrations in several sport fish did not decline from 1994 to 2009 and tissue samples from most species exceeded 0.2 mg/kg wet weight total mercury in fish from San Pablo Bay, Central Bay, and South Bay (Davis et al. 2012). Sampling from shorelines throughout the Bay area in 2008 to 2010 found average total mercury tissue concentrations of Mississippi Silverside (*Menidia beryllina*) exceeded 0.2 mg/kg wet weight in the South Bay and ranged from <0.06 to 0.197 mg/kg wet weight in all areas of the Bay (Greenfield et al. 2013).

The San Francisco Bay Mercury TMDL includes Suisun Bay and describes numeric targets for mercury in fish tissue (San Francisco Bay RWQCB 2006). The San Francisco Bay Mercury TMDL added Suisun Marsh more recently (San Francisco Bay RWQCB 2018); the Suisun Marsh TMDL is pending USEPA approval.

G.1.9.6 *Selenium*

G.1.9.6.1 Delta, Suisun Bay, and Suisun Marsh

Inputs from the Sacramento and San Joaquin rivers drive selenium concentrations in the Delta. Concentrations are higher in the San Joaquin River; however, greater flows in the Sacramento River result in a substantial contribution to the mass loading of selenium to the Delta (Cutter and Cutter 2004; Tetra Tech, Inc. 2008). Presser and Luoma (2006) project that loads to the Delta from the Sacramento River are about half of the Grasslands basin’s projected contribution to the San Joaquin River, with subsequent loading to the Delta from the San Joaquin River dependent on flow (Presser and Luoma 2006).

Implementation of the Grassland Bypass Project in 1996 led to a 60% decrease in selenium loads to the Delta from the San Joaquin River at Vernalis from the Grassland Drainage Area in comparison to pre-project conditions (Tetra Tech, Inc. 2008).

Suisun Bay is on the SWRCB’s CWA Section 303(d) list as impaired due to elevated concentrations of selenium. However, the list does not identify Suisun Marsh as an impaired water body for selenium contamination. The Suisun Bay selenium impairment is attributed to discharge from natural sources, industrial point sources such as oil refineries, and the presence of exotic species, which increase selenium bioaccumulation into the food web (SWRCB 2017a). *Corbula* (*Potamocorbula*) *amurensis*, a species of clam and an important food source for sturgeon and certain ducks, bioaccumulates selenium at a high rate (Stewart et al. 2004 as cited by Beckon and Maurer 2008). The exotic species was first discovered in Suisun Bay in 1986 and was common by 1990 in estuarine waters from San Pablo Bay to Suisun Bay (Cohen 2011).

USEPA developed national recommended chronic aquatic life criteria for selenium, promulgated criteria specific to the San Francisco Bay, Suisun Bay, and Delta, and recently proposed separate selenium criteria for California and the Bay-Delta. In 1992, USEPA promulgated water quality criteria for selenium applicable to San Francisco Bay, Suisun Bay, and the Delta, expressed as a total recoverable water column concentration (58 FR 103 (December 22, 1992)). In 2016, USEPA published the current national recommended chronic aquatic life criterion for selenium, which consists of fish tissue and water column concentration thresholds (USEPA 2016a). USEPA also proposed aquatic life and aquatic-dependent wildlife criteria in 2016 specifically for the Bay-Delta (USEPA 2016b). The proposed Bay-Delta criteria include the same whole body and muscle criteria for fish as USEPA's national recommended criterion, but has lower criteria for water column concentrations to account for greater bioaccumulation of selenium in the tissues of organisms residing in Delta waters. Unlike the national criterion, the proposed Bay-Delta criteria do not include a tissue-based criterion for fish eggs/ovaries, but do include a tissue-based criterion for clams. In 2018, USEPA proposed selenium criteria for California that consist of the 2016 national recommended criterion with a bird tissue criterion added, and a performance-based approach to translate the tissue criterion elements into protective water column elements on a site-specific basis instead of specific water column criterion elements. The proposed USEPA (2019) criteria for California would not apply to surface waters where site-specific selenium criteria have been adopted or in waters with selenium criteria promulgated in the National Toxics Rule (e.g., the lower San Joaquin River, Grasslands watershed, San Francisco Bay, Suisun Bay, and the Delta).

G.1.9.6.2 San Francisco Bay

The entire San Francisco Bay is on the SWRCB's CWA Section 303(d) list as impaired by selenium. Surface water exports from the Delta, local tributaries, and atmospheric deposition are the primary selenium sources to the northern portion of the bay (San Francisco Bay RWQCB 2015). To protect the most susceptible fish, White Sturgeon (*Acipenser transmontanus*), from selenium toxicity, a selenium TMDL was adopted in 2016 for the North San Francisco Bay, defined to include a portion of the Delta (i.e., Delta segment), Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central Bay (SWRCB 2016a). The TMDL included numeric targets for selenium in fish tissue (8.0 µg/g dry weight in whole body; 11.3 µg/g dry weight in muscle) and the water column (0.5 µg/L dissolved total selenium) (San Francisco Bay RWQCB 2015). Selenium concentrations in White Sturgeon muscle collected from the North Bay from 2015 to 2017 averaged 11.8 µg/g dry weight in 2015, 10.6 µg/g dry weight in 2016, and 7.3 µg/g dry weight in 2017 (Sun et al. 2019). When considered with water-year type, data suggests that selenium concentrations in sturgeon tissues were driven more by hydrology than water column concentrations (Sun et al. 2019).

Existing selenium concentrations in the water column are below the TMDL target of 0.5 µg/L and have been declining since the late 1990s. Therefore, the TMDL does not require load reductions below current levels and the implementation plan's main goal is to prevent increases of selenium concentrations in North Bay waters and attain safe levels of selenium in fish, specifically benthic feeders (e.g., Sacramento Splittail [*Pogonichthys macrolepidotus*] and sturgeon). The TMDL includes a load allocation for the Central Valley watershed (4070 kg/year) and requires monitoring to identify any need for adaptive implementation (San Francisco Bay RWQCB 2015).

The TMDL does not include the South Bay because it is affected by local and watershed sources not associated with the Delta or refineries, while the primary selenium loading to the North Bay and the Suisun Bay area is from the Delta and oil refineries in the vicinity of Carquinez Strait (Lucas and Stewart 2007; Stewart et al. 2013).

G.1.9.7 *Trace Metals*

Trace metals impairments within the assessment area include arsenic in the western Delta, copper in Bear Creek and the lower Mokelumne River, and zinc in the lower Mokelumne River (SWRCB 2017a).

Arsenic is a tasteless and odorless semi-metal element highly toxic to humans. Long-term, chronic exposure to arsenic has adverse dermal, cardiovascular, respiratory, gastrointestinal, and neurological effects, and has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver, and prostate (ATSDR 2007b). Short-term exposure to high doses of arsenic can cause acute symptoms such as skin damage, circulatory system dysfunction, stomach pain, nausea and vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness. The Section 303(d) impairment listing is based on elevated arsenic concentrations in *Corbicula* tissue samples collected from 1993–2008 in Bear Creek. A TMDL to protect the state-designated beneficial uses due to arsenic impairment is expected to be completed in 2027 (SWRCB 2017a).

Copper occurs in organic and inorganic forms. Organic copper is an essential micronutrient for animals, while exposure to high concentrations of inorganic copper can be toxic (ATSDR 2004). In humans, short-term exposure to copper can cause nausea and vomiting; long-term exposure can cause liver or kidney damage (ATSDR 2004). Copper levels in Bay-Delta waters are not sufficiently high to result in health effects to humans, but copper is of concern because low (i.e., at the parts per billion) levels can be toxic to aquatic life, depending on other ambient water quality conditions (e.g., hardness, organic carbon levels). The Section 303(d) listing for copper for the lower Mokelumne River was based on decisions made prior to 2006 and no additional data was considered for the current listing. In Bear Creek, 4 of 19 surface water samples collected in 2000–2002 exceeded the CTR criteria for copper for the protection of aquatic life (SWRCB 2017a). TMDLs to address these water quality impairments are expected to be complete by 2020 for the lower Mokelumne River and 2021 for Bear Creek (SWRCB 2017a).

Zinc is an essential micronutrient for plants and animals, but at elevated concentrations in surface water interferes with the metabolism of calcium and iron (ATSDR 2005). This can lead to osteomalacia (softening of the bone) from deficiency in minerals including calcium and phosphorous. Zinc can also damage fish gills and lead to hypoxia from reduced oxygen exchange. The lower Mokelumne River Section 303(d) listing was based on decisions made prior to 2006 and no additional data was considered, although, zinc concentrations measured in 2002 did not exceed the CTR criteria (SWRCB 2017a). A TMDL addressing zinc impairments in the lower Mokelumne River is expected to be complete by 2027 (SWRCB 2017a).

G.1.9.8 *Nutrients*

Nutrients such as nitrogen and phosphorus originate from natural sources and anthropogenic sources, including point and non-point source discharges. Although nutrients are necessary for a healthy ecosystem, the over-enrichment of nitrogen and phosphorus can lead to eutrophication, increased production of blue green algae, more invasive aquatic macrophytes, and nutrient-related problems in drinking water systems.

G.1.9.8.1 Delta, Suisun Bay, and Suisun Marsh

A decline in pelagic fish species in the Delta, known as the pelagic organism decline (POD), including the endangered Delta Smelt (*Hypomesus transpacificus*), may be related to bottom-up effects from nutrients among other drivers (Baxter et. al. 2008; Sommer et al. 2007). Nutrients are also affected by flow and other factors (e.g., temperature, turbidity, and invasive species) that are potentially associated with the POD.

Unlike most water bodies where nutrients cause too much primary production, the problem affecting state-designated beneficial uses in parts of the Delta is too little primary production to support fish populations (Hammock et al. 2019 and references within). Despite decades of monitoring and intensive research efforts, the cause for low productivity remains unclear (Hammock et al. 2019). Several hypotheses to explain the low productivity have been proposed. Jassby recognizes light as the limiting factor preventing high primary production within the Delta, rather than nutrients (Jassby et al. 2002;

Jassby 2008). Dugdale et al. (2007) and Parker (2012) offer another hypothesis, that ammonium (a dominant form of nitrogen in the Delta and Suisun Bay) inhibits the uptake of nitrate, which is more conducive to beneficial algae blooms. Glibert et al. (2011) suggest that the current form and ratio of nutrients (i.e., elevated nitrogen, resulting in a high nitrogen to phosphorus ratio) in the Delta may give preferential advantage to smaller celled and less nutritious primary producers. Alternatively, other factors contributing to little primary production may be caused by invasive clams introduced in the mid-1980s that consume algae, reducing food availability for zooplankton and fish (Lucas and Thompson 2012; Kimmerer et al. 1994) or reduced phosphorus that becomes a limiting factor for primary production (Van Nieuwenhuyse 2007). Grazing by invasive clams (i.e., *Potamocurbula ameurensis*) is the most widely accepted hypothesis for why productivity remains low (Hammock et al. 2019 and references within).

More classical signs of eutrophication are often found in the central and southern Delta near Stockton where nutrient enrichment feeds algal blooms that can cause areas of oxygen depletion. High nutrient concentrations, warm temperatures, and low flow are conditions shown to be conducive to toxic blue-green algae growth (i.e., cyanobacteria) with Microcystis blooms becoming more prevalent in the central and southern Delta (Lehman et al. 2008). Recent studies have shown that many of these Microcystis blooms are fueled by ammonium, not nitrate (Lehman et al. 2015, 2017).

Municipal discharges into the Delta and its source waters contribute nutrients. The Sacramento Regional Wastewater Treatment Plant is the largest point source of ammonium in the Delta, contributing 90% of the ammonium in the Sacramento River from 1986 to 2005 (Jassby 2008). The ammonium is transformed to nitrate as it is transported through the Delta (Kraus et al. 2017). Future nitrogen inputs to the Delta from treated wastewater will be reduced by 2021 because the Sacramento Regional Wastewater Treatment Plant is implementing nitrification and denitrification tertiary treatment to comply with NPDES permit requirements. The Stockton Regional Wastewater Control Facility, which discharges to the San Joaquin River, was another source of nitrogen loading. Stockton implemented nitrification in 2007 to reduce ammonium discharged in their treated effluent and is required to reduce nitrate discharges by 2024 to comply with NPDES permit requirements.

Another source of nutrients to the Delta is agricultural return flows. The Central Valley RWQCB Irrigated Lands Regulatory Program aims to prevent agricultural runoff containing nutrients from impairing surface waters. Growers are required to implement management practices to protect surface water, especially in areas where monitoring has identified problems associated with irrigated agriculture. Growers must conduct farm evaluations to determine the effectiveness of farm practices in protecting water quality.

Nutrients and their effects on Delta water quality are a focus of the Delta RMP, as part of its mission is to understand regional water quality conditions and trends, and to inform regulatory and management decisions. The program supports efforts by the USGS to monitor and synthesize existing data to understand how nitrogen and phosphorus from fertilizers and in runoff may be affecting Delta waterways. High frequency nutrient monitoring data (about every 15 minutes) is collected in the Delta to examine the relationships between nutrient concentrations, nutrient cycling, and aquatic habitat conditions (Downing et al. 2017). High frequency data collection by the USGS began in 2013 and 11 stations operated throughout the Delta by 2016, measuring temperature, pH, specific conductance, turbidity, dissolved oxygen, nitrate, chlorophyll-a, phycocyanin, and dissolved organic matter concentrations (Downing et al. 2017). The spatial and temporal trends in nutrient concentrations and nutrient-related parameters are reasonably well understood (Jabusch et al. 2018a). The data indicates increasing trends for chlorophyll-a at the Sacramento and San Joaquin River confluence, Suisun Bay, and Franks Tract. Efforts are ongoing to understand the sources, sinks, and nutrient transformation behind these trends (Novick et al. 2015).

Suisun Marsh is currently listed as impaired due to nutrients (SWRCB 2017a). Specific sources of nutrients to Suisun Marsh include agricultural, urban, and livestock grazing drainage through tributaries, the Delta, nutrient exchange with Suisun Bay, atmospheric deposition, and discharge from the treated sewage (Tetra Tech, Inc. et al. 2013). Concentrations of total ammonia from 2000–2011 in Boynton, Peytonia, Sheldrake, and Chadbourne Sloughs (0–0.4 mg/L), as well as in Suisun Slough (0–0.3 mg/L), exceeded the water quality objective (Tetra Tech, Inc. et al. 2013). Elevated concentrations of chlorophyll-a, in comparison to concentrations at reference sites at Mallard, suggest possible impairments by nutrients. Research suggests other possible narrative nutrient criteria impairments caused by excess algal growth in wetlands, elevated organic carbon, and trends in dissolved oxygen and mercury methylation.

Central Valley RWQCB, California EPA, and stakeholders developed a *Delta Nutrient Research Plan* (Central Valley RWQCB 2018c) to determine if numeric water quality objectives for nutrients are needed to address nutrient-associated water quality concerns in the Delta. The nutrient-associated water quality concerns include harmful algal blooms and associated toxins and nuisance compounds, excess aquatic plant growth, the low abundance of phytoplankton species that support the food web, and low dissolved oxygen in some waterways. The *Delta Nutrient Research Plan* reports that scientific data gaps currently limit the ability to develop nutrient benchmarks, goals, triggers, targets, and water quality objectives. The plan presents a framework and prioritized actions to gather the information necessary to develop protective thresholds and identify management options to reduce nutrient-associated adverse effects.

G.1.9.8.2 San Francisco Bay

The San Francisco Bay is recognized as a nutrient-enriched estuary. However, dissolved oxygen concentrations are much higher and phytoplankton biomass is much lower than what would be expected in an estuary with such nutrient enrichment (Cloern 1996). The Bay has some of the lowest primary production rates of an estuarine coastal ecosystem in the world (Cloern et al. 2014 as cited by Fichot et al. 2015). A growing body of recent evidence suggests that the Bay's characteristic nutrient enrichment resilience is weakening (SFEI 2016). In response to concerns over nutrient enrichment and low phytoplankton growth, the San Francisco Bay RWQCB worked collaboratively with stakeholders to develop the *San Francisco Bay Nutrient Management Strategy* with goals to manage nutrient loads and maintain state-designated beneficial uses within the Bay (SFEI 2016).

Large nutrient loads entering the San Pablo Bay from Suisun Bay, which includes Delta outflows, are the dominant source of nutrients to the San Pablo Bay throughout much of the year (Novick and Senn 2014). Therefore, nutrient loads to and transformations within the Delta, combined with Delta outflow, affect nutrient concentrations entering San Pablo Bay. The dissolved inorganic nitrogen and dissolved inorganic phosphorus loads from Suisun Bay dominate nutrient inputs throughout much of the year and are drivers of nutrient-dependent processes (e.g., algae growth).

The influence of Delta-derived freshwater flows is muted in the South Bay and Lower South Bay by oceanic flows in and out of the Golden Gate (Senn and Novick 2013). The dominant source of dissolved inorganic nitrogen and dissolved inorganic phosphorus year-round in the lower South Bay, South Bay, and Central Bay is discharge from municipal wastewater treatment plants (Novick and Senn 2014).

G.1.9.9 *Organic Enrichment and Dissolved Oxygen*

G.1.9.9.1 Delta, Suisun Bay, and Suisun Marsh

Localized incidents of organic enrichment and depressed dissolved oxygen concentrations occur in the eastern, southern, and western Delta, and in Suisun Marsh. Several Delta waterways in the eastern and southern Delta, and Suisun Marsh are included on the SWRCB's Section 303(d) list of impaired water bodies due to organic enrichment and low dissolved oxygen (Table G.1-14, Clean Water Act Section

303(d) Listed Pollutants and Sources in the Delta, Suisun Bay, and Suisun Marsh; Table G.1-15, Clean Water Act Section 303(d) Listed Pollutants and Sources in the Delta and San Francisco Bay).

Notable low dissolved oxygen concentrations occur in the Delta in the Stockton Deep Water Ship Channel, most often during the months of June through October, although low dissolved oxygen conditions have also occurred in the winter months (Central Valley RWQCB 2005; Schmieder et al. 2008). Historical low dissolved oxygen concentrations are attributed to a combination of low flow and high nutrient loads (USEPA 2015). Dissolved oxygen concentrations increased since the Stockton Deep Water Ship Channel TMDL's adoption in 2007. The duration and magnitude with which dissolved oxygen levels are lower than water quality objectives are smaller than before adoption (USEPA 2015). Low (e.g., 3 mg/L) dissolved oxygen concentrations of a short duration are considered not harmful to aquatic life (USEPA 2015). The Port of Stockton operates two aeration facilities located within the Deep Water Ship Channel to improve dissolved oxygen concentrations. The Port operates the aerators whenever dissolved oxygen concentrations drop below 5.2 mg/L. However, from August to November, that threshold is raised to 6.2 mg/L to benefit the endangered Winter-Run Chinook Salmon that immigrate through on their way to upstream spawning habitat (Port of Stockton 2019).

Notable low dissolved oxygen conditions also occur in the Suisun Marsh sloughs, and are attributed to aquatic plant material and detritus decomposition. Operations and discharges from managed wetlands within the Marsh show a strong effect on dissolved oxygen within the Marsh sloughs (San Francisco Bay RWQCB 2018). The San Francisco Bay RWQCB adopted a TMDL to address low dissolved oxygen in the Marsh (San Francisco Bay RWQCB 2018), which has been approved by the SWRCB and California Office of Administrative Law and is pending approval by USEPA. The TMDL aims to address low dissolved oxygen/organic enrichment (and mercury problems) and evaluate the degree to which nutrients may contribute to dissolved oxygen deficit. The implementation plan is projected to attain the water quality standard within twenty years.

The Bay-Delta WQCP and Central Valley RWQCP contain numeric dissolved oxygen objectives applicable to the Delta, and the San Francisco Bay RWQCP contains numeric objectives applicable to Suisun Bay and Marsh. The Bay-Delta WQCP dissolved oxygen objective is 6 mg/L for the protection of state-designated fish and wildlife beneficial uses and applies to the San Joaquin River between Turner Cut and Stockton (SWRCB 2006). The Central Valley RWQCP dissolved oxygen objectives apply to all Delta waters except for those bodies of water constructed for special purposes and from which fish have been excluded or where the fishery is not important as a beneficial use (Central Valley RWQCB 2018a). The objectives are: 7.0 mg/L in the Sacramento River (below the I Street Bridge) and in all Delta waters west of the Antioch Bridge; 6.0 mg/L in the San Joaquin River (between Turner Cut and Stockton, 1 September through 30 November); and 5.0 mg/L in all other Delta waters except for those bodies of water constructed for special purposes, and from which fish have been excluded, or where the fishery is not important as a beneficial use.

G.1.9.9.2 San Francisco Bay

San Francisco Bay is not listed as impaired due to organic enrichment or dissolved oxygen. As noted above in Section F.1.9.8.2, dissolved oxygen concentrations are much higher and phytoplankton biomass is much lower than what would be expected in an estuary with such nutrient enrichment (Novick and Senn 2014).

Minimum dissolved oxygen objectives are described in the San Francisco Bay RWQCP. The objective is 5 mg/L in tidal waters downstream of Carquinez Bridge. In non-tidal waters upstream of the Carquinez Bridge, the minimum objectives are 7.0 mg/L in cold water habitat and 5 mg/L in warm water habitat.

G.1.9.10 *Pathogens and Indicator Bacteria*

The term *pathogens* refers to viruses, bacteria, and protozoa that pose human health risks. Pathogens of concern include bacteria, such as *Escherichia coli* and *Campylobacter*; viruses, such as hepatitis and rotavirus; and protozoans, such as *Giardia* and *Cryptosporidium*. Most data that exists regarding pathogens are for coliform bacteria, which are indicators of potential fecal contamination by humans or other warm-blooded animals, because of their relative abundance and ease of measuring in water samples.

G.1.9.10.1 Delta, Suisun Bay, and Suisun Marsh

The *Conceptual Model for Pathogens and Pathogen Indicators in the Central Valley and Sacramento–San Joaquin Delta* (Pathogens Conceptual Model; Tetra Tech, Inc. 2007) characterizes relative pathogen contributions to the Delta from the Sacramento and San Joaquin rivers and various pathogen sources, including wastewater discharges and urban runoff. The Pathogens Conceptual Model determined that coliform indicators vary by orders of magnitudes over small distances and short time-scales. Pathogens concentrations appear to be more closely related to what happens in the proximity of a sampling station, rather than what happens in the larger watershed where substantial travel time and concomitant pathogen die-off can occur. Of the known sources of coliform, total coliform concentrations for wastewater treatment plant effluents were fairly low, whereas the highest total coliform concentrations in water were observed near samples influenced by urban areas. In the San Joaquin River valley, the model observed comparably high concentrations of *E. coli* for waters affected by urban environments and intensive agriculture in the San Joaquin Valley. Fecal indicator data showed minimal relationships with flow rates, although the model observed most of the high concentrations during the wet months of the years, possibly indicating the contribution of stormwater runoff. The model observed the highest total coliform and *E. coli* concentrations in the discharge from the Natomas East Main Drainage Canal and several stations near sloughs, indicating the relative influence of urban and wildlife pathogen sources on receiving water concentrations.

The Central Valley RWQCP (Central Valley RWQCB 2018a) specifies numerical water quality objectives for fecal coliform bacteria to protect water contact recreation. The Central Valley RWQCP also includes a narrative water quality objective for *Cryptosporidium* and *Giardia* that states: “Waters shall not contain *Cryptosporidium* and *Giardia* in concentrations that adversely affect the public water system component of the MUN beneficial use.” The objective applies to the Delta and tributaries below the first major dams and allows utilities to request assistance from the state to conduct source evaluations and implement potential control actions if the drinking water utility monitoring at intakes indicates increased risks to treatment from these pathogens. The San Francisco Bay RWQCP (San Francisco Bay RWQCB 2017) specifies numerical water quality objectives for bacteria applicable to Suisun Bay and Marsh for the protection of water contact and non-contact water recreation, and shellfish harvesting.

Areas of the Delta are on the SWRCB Section 303(d) list of impaired water bodies due to elevated indicator bacteria (SWRCB 2017a). A TMDL is developed for six of the urban waterways listed in the Stockton area: Lower Calaveras River, Five Mile Slough, Mormon Slough, Mosher Slough, Smith Canal, and Walker Slough. The other listed water bodies include the Stockton Deep Water Ship Channel and French Camp Slough, which are also located in the Stockton area. Suisun Marsh and Suisun Bay are not on the SWRCB Section 303(d) list as impaired due to elevated indicator bacteria.

G.1.9.10.2 San Francisco Bay

Section 303(d) does not list San Francisco Bay surface waters as impaired due to pathogens or indicator bacteria. However, six beaches located on San Francisco Bay are listed as impaired due to fecal indicator bacteria. A San Francisco Bay Beaches Bacteria TMDL (San Francisco Bay RWQCB 2016) addresses the impairment to protect human health.

G.1.9.11 *Legacy Contaminants*

G.1.9.11.1 Dioxins and Furans

Dioxins and dioxin-like compounds are chemical compounds with similar chemical structures and biotic effects. There are several hundred of these compounds, which can be grouped into three families: chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans, and certain PCBs. PCBs are addressed separately below.

Chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans are created unintentionally, usually through combustion processes. Forest fires and volcanoes can contribute these compounds to the atmosphere, as well as certain human activities (e.g., incineration of municipal solid waste, metal smelting, coal fired power plants, wood burning, and chlorine bleaching of wood pulp).

Dioxin and furan compounds are extremely persistent, and once released into the environment can cycle through various phases including water, sediment, soil, air, and biota. Dioxin and furan compounds bioaccumulate in the tissues of exposed organisms because of their stability, affinity for accumulation in the fats of animals, and slow biodegradation rates. Dioxin and furan compounds can affect state-designated beneficial uses including municipal and domestic (drinking water) supply, commercial and sport fishing, the preservation of rare and endangered species, shellfish harvesting, and warm fresh water, cold fresh water, estuarine, and wildlife habitat.

The Stockton Deep Water Ship Channel is on the SWRCB's Section 303(d) list as impaired due to dioxin and furan compounds. The listing is associated with localized high dioxin and furan concentrations in sediment traced to a wood preserving facility, McCormick and Baxter Creosoting Company, immediately south of Mormon Slough (Hayward et al. 1996). The facility is now a Superfund site and has undergone substantial cleanup efforts. The surface water-sediment remedy (sand cap) and soil remedy (soil excavation, consolidation and capping) are implemented and considered protective of human health and the environment (USACE 2018).

Section 303(d) listed the entire San Francisco Bay for dioxin and furan compounds in 1999, due to a OEHHA fish consumption advisory issued in San Francisco Bay. The Delta was later added to the SWRCB's Section 303(d) list for dioxin and furan compounds because of the migration of striped bass and sturgeon from the Bay into the Delta. Stormwater runoff is approximately 80% of the dioxins and furans load in the Bay (USEPA 2017). Atmospheric deposition is believed to be the primary source because of roughly equivalent concentrations in stormwater runoff around the Bay. Direct atmospheric deposition onto the Bay accounts for approximately 18% of the Bay's dioxins and furans load. The remaining 2% of the load is from wastewater treatment plants and refineries (USEPA 2017).

G.1.9.11.2 Polychlorinated Biphenyls (PCBs)

PCB manufacturing in the United States was discontinued in 1979. Today, PCBs can enter the environment from a variety of sources, including leaking pre-1979 electrical transformers still in use, atmospheric deposition over connected watersheds, and industrial and municipal wastewater discharges. PCBs are extremely stable, and once released to the environment, can cycle through various phases including water, sediment, soil, air, and biota.

Section G.1.1.8, *Polychlorinated Biphenyls*, provides additional background information regarding sources of PCBs in the environment, and associated human health and environmental concerns.

The northern and western Delta, Stockton Deep Water Ship Channel, Suisun Bay, and all segments of San Francisco Bay are listed as impaired due to PCBs, with the source of the impairment unknown (SWRCB 2017a). Although research has not quantified sources of PCB loading to the Delta, suspension and transport of contaminated sediments is likely a dominant process. Leatherbarrow et al. (2005) found that PCB concentrations at Mallard Island fluctuated with tide, with highest PCB concentrations associated with flood tide (i.e., Bay water inflow to the Delta). This observation is consistent with their hypothesis that legacy contaminants resuspended from Bay sediments and transported into the west Delta on a flood tide contain higher concentrations of PCBs than riverine suspended sediment being transported from the Delta into the Bay. Furthermore, the mixture of PCBs in riverine suspended sediment is indicative of recent atmospherically-deposited PCBs rather than the resuspension of PCBs deposited in the Delta decades earlier.

The narrative water quality objective, which states that controllable water quality factors shall not cause a detrimental increase in toxic substances found in bottom sediments or aquatic life, and the numeric water quality objective of 0.00017 µg/L total PCBs in surface water, are exceeded. There are also elevated concentrations in sport-fish. The San Francisco Bay RWQCB (2017) describes an action plan and TMDL approved by USEPA in 2010 for PCBs, including dioxin-like congeners, in the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, Richardson Bay, and the Central and Lower San Francisco Bay. The TMDL includes a numeric target of 10 µg/kg wet weight in fish tissues to protect human health and aquatic life. Clean-up investigations are ongoing at sources of contamination to the Delta from the legacy contaminants. The implementation plan describes reductions in PCB sources (i.e., storm water runoff and PCB contaminated sites within the Bay), actions to reduce risks to people consuming fish from the Bay, and monitoring PCB concentrations in fish tissues, surface water, and sediments. Actions to reduce PCB concentrations in San Francisco Bay will include dredging and material disposal outside of the Bay, natural attenuation, and outflow through the Golden Gate.

A TMDL for the Stockton Deep Water Ship Channel is expected in 2019.

G.1.9.11.3 Polyaromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) have limited industrial utility and largely enter the environment by natural means, such as from volcanoes and forest fires, or incidental means related to human activities, such as burning wood, fossil fuel burning, and trash. Particles contaminated with PAHs can eventually settle to the ground throughout a watershed and ultimately enter waterways through stormwater runoff. Hundreds of PAH compounds exist; naphthalene and benzo(a)pyrene are among the common compounds.

PAHs can potentially affect beneficial uses including municipal and domestic drinking water supply, commercial and sport fishing, preserving rare and endangered species, shellfish harvesting, and warm fresh-water, cold fresh-water, estuarine, and wildlife habitat.

The western Delta is on the Section 303(d) list as impaired due to PAHs (SWRCB 2017a). The specific sources of the Delta impairment are unknown (SWRCB 2017a), however, sources of PAHs to San Francisco Bay provide insight into possible sources to the Delta. A major source of PAHs to San Francisco Bay water and sediments is petroleum combustion, while minor amounts of PAHs are derived from biomass (wood and grasses) and coal combustion, and from uncombusted petroleum (Oros et al. 2007). Storm water runoff is the primary contributor of PAHs to the Bay, followed by tributary inflow, wastewater treatment plant effluent, atmospheric deposition, and dredged material disposal (Oros et al. 2007).

G.1.9.12 *Pesticides*

G.1.9.12.1 Delta, Suisun Bay, and Suisun Marsh

The entire Delta region is on SWRCB's CWA Section 303(d) list as impaired by Group A pesticides, DDE/DDT, chlorpyrifos, and diazinon (SWRCB 2017a). Smith Canal within the Delta is impaired by organophosphorus pesticides. Pixie Slough and Sand Creek are impaired by disulfoton (SWRCB 2017a). The north Delta, and the west Delta are impaired by chlordane and dieldrin, while Sand Creek is listed for dieldrin. Pesticide impairments in Suisun Bay include dieldrin and DDT, while Suisun Marsh is impaired by chlordane (SWRCB 2017a). The Central Valley RWQCP includes a diazinon and chlorpyrifos TMDL for the Delta (Central Valley RWQCB 2018a).

Current use pesticide data collected under the Delta RMP reflects pesticide conditions in Delta surface waters. The Delta RMP monitored 154 current use pesticides and toxicity monthly from July 2015–June 2016 at five major inputs to the Delta: the San Joaquin River at Vernalis, the San Joaquin River at Buckley Cove, the Sacramento River at Hood, Mokelumne River at New Hope Road, and Ulatis Creek at Browns Road (De Parsia et al. 2018; Jabusch et al. 2018b). All of the water samples detected pesticides, with mixtures ranging from 2 to 25 pesticides. A total of 52 pesticide compounds were detected: 19 fungicides, 17 herbicides, 9 insecticides, 6 breakdown products, and 1 synergist. The most frequently detected pesticide compounds were the herbicides hexazinone (95% of samples) and diuron (73% of samples) and the fungicides boscalid (93% of samples) and azoxystrobin (75% of samples).

The Central Valley RWQCB Irrigated Lands Regulatory Program aims to prevent agricultural runoff containing pesticides from impairing surface waters. Growers are required to implement management practices to protect surface water. Growers must conduct farm evaluations to determine the effectiveness of farm practices in protecting water quality.

G.1.9.12.2 San Francisco Bay

Section 303(d) listed San Francisco Bay (Central, Lower, and South) and the Delta segment as impaired by the legacy pesticides chlordane, DDT, and dieldrin in 1988. The bioaccumulation DDT and dieldrin in fish led to the listings. The 303(d) impairment list added the organophosphate pesticide diazinon after repeated episodic observations of toxicity in Bay waters following runoff events (SFEI 2007). Historical pesticide sources include domestic and commercial uses, and a former DDT and dieldrin manufacture and distribution site adjacent to the Lauritzen Channel, within the Richmond Inner Harbor, where stockpiles led to contamination of Bay sediments (Swartz et al. 1994). The United Heckathorn Superfund Site in Richmond's sediment was remediated in 1990 and the attenuation of these legacy pesticides in sediment and aquatic organism tissues throughout the Bay are currently monitored.

The San Francisco Bay RWQCB (2005) adopted a TMDL for diazinon and pesticide-related toxicity in urban creeks to address beneficial use impairments in all San Francisco Bay Region urban creeks and to reduce pesticide concentrations in the Bay where these urban creeks discharge. Proposed targets are expressed in terms of toxic units and diazinon concentrations.

G.1.9.13 *Organic Carbon*

In an aquatic system, organic carbon encompasses a broad range of compounds that fundamentally contain carbon in their structure. Organic carbon may be contributed to the aquatic environment by degraded plant and animal materials, and from anthropogenic sources such as domestic wastewater, urban runoff, and agricultural discharge. Organic carbon is a critical part of the food web and sustains aquatic life in the Delta, Suisun Bay, and San Francisco Bay. However, the presence of organic carbon in Delta waters also is of concern because it is a precursor contributing to disinfection byproduct formation at the drinking water treatment plants that divert water from the Delta.

Sources of organic carbon in the Delta include peat soils, upland, agricultural and urban runoff, wetlands, algae production, and municipal wastewater discharges. Organic carbon is present in all the streams and rivers flowing into the Delta, and the upstream sources supply most of the organic carbon load to the Delta. Between 50% and 90% of the dissolved organic carbon load entering the Delta arrives from river flows (CALFED 2008). Major in-Delta sources include wetlands (5%–30%), algae (approximately 5%), and peat islands (40%) (CALFED 2008). The upstream and internal loads, and their related sources, vary by season (CALFED 2008). Approximately 5% to 50% is lost due to internal recycling (CALFED 2008).

Delta inflows are a primary source of organic carbon, followed by in-Delta sources. Across seasons, the San Joaquin River and Sacramento River inflow concentrations to the Delta exhibit contrasting relationship. The highest concentrations in the Sacramento River occur in the wet months, whereas in the highest concentrations in the San Joaquin River occur in the dry months (Tetra Tech, Inc. 2006). The higher dry month San Joaquin River concentrations are attributed to the contribution of agricultural drainage to total flows in the San Joaquin River during the dry season (Tetra Tech, Inc. 2006).

Monthly average total organic carbon concentrations in the Sacramento River at Hood/Greene's Landing range from 2 to 3 mg/L. San Joaquin River monthly average total organic carbon concentrations range from 3 to 4 mg/L at Vernalis (Tetra Tech, Inc. 2006). Most organic carbon in the Delta is in the dissolved form, which is generally less bioavailable to the base of the food web compared with particulate organic carbon (POC) or organic carbon derived from primary production (Tetra Tech, Inc. 2006). Conversely, dissolved organic carbon has the greatest potential to form disinfectant byproducts (e.g., THMs) in reactions with chlorine as part of wastewater and drinking water treatment.

The Delta is an important source of organic carbon to Suisun Bay and the northern portion of San Francisco Bay. Jassby et al. (1993) found that, in 1980, 83% of the dissolved organic carbon load in Suisun Bay and 62% of the dissolved organic carbon load in the northern portion of San Francisco Bay was from Delta inflow. Within Suisun Marsh, managed wetlands are the largest direct source of organic carbon to the sloughs. The watersheds surrounding Suisun Marsh also contribute a substantial portion of the organic carbon load via stormwater, followed by tidal marshes and treated wastewater effluent from the Fairfield Suisun Sewer District's wastewater treatment facility (San Francisco Bay RWQCB 2018).

Organic carbon flows from the Delta into the San Francisco Bay estuary where it supports microbial production at the base of the food web (CALFED 2008). There are no federal or state numeric surface water quality objectives for organic carbon. There is a state narrative water quality objective, federal drinking water treatment requirements related to total organic carbon levels, and a CALFED goal. The Central Valley RWQCP (Central Valley RWQCB 2018a) contains a narrative water quality objective that waters shall not contain chemical constituents, including organic carbon, in concentrations that adversely affect beneficial uses. Under USEPA's Disinfectants and Disinfection Byproducts Rule (63 FR 69390), municipal drinking water treatment facilities are required to remove specific percentages of total organic carbon in source waters through enhanced treatment methods, unless the drinking water treatment system can meet alternative criteria. USEPA's action thresholds begin at 2 to 4 mg/L and, depending on source water alkalinity, may require a drinking water utility to employ treatment to achieve as much as a 35% reduction in total organic carbon. Where source water total organic carbon is between 4 and 8 mg/L, a 45% reduction in total organic carbon may be required.

The CALFED Bay-Delta Program (2000) established a goal to achieve 3 mg/L as a long-term average for total organic carbon at Delta drinking water intakes. The goal is based on a study prepared by California Urban Water Agencies recommending Delta source water quality targets sufficient to achieving disinfection byproduct criteria in treated drinking water and sufficient to allow continued flexibility in treatment technology. Specifically, the CALFED Drinking Water Program goal aims to achieve either: average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 3.0 mg/L total organic carbon along with 50 μg/l bromide, or an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies (CALFED 2000). In establishing its goal, CALFED assumed more stringent disinfection byproduct criteria for treated drinking water than are currently in place. California Urban Water Agencies (1998) have concluded that source water with total organic carbon between 4 and 7 mg/L is sufficient to meet currently established drinking water criteria for disinfection byproducts, depending on the amount of *Giardia* inactivation required.

Monthly median concentrations of total organic carbon in the San Joaquin River at Vernalis are 3 to 5 mg/L, and 90th percentile concentrations are 7 mg/L or less, except in September and October, when 90th percentile concentrations are 10 mg/L (Tetra Tech, Inc. 2006). In the Sacramento River at Hood/Greene's Landing, monthly median concentrations range between 1 and 3 mg/L, and monthly average concentrations range from 2 to 3 mg/L, and 90th percentile concentrations are 4 mg/L or less (Tetra Tech, Inc. 2006).

G.1.10 CVP and SWP Service Areas (south to Diamond Valley)

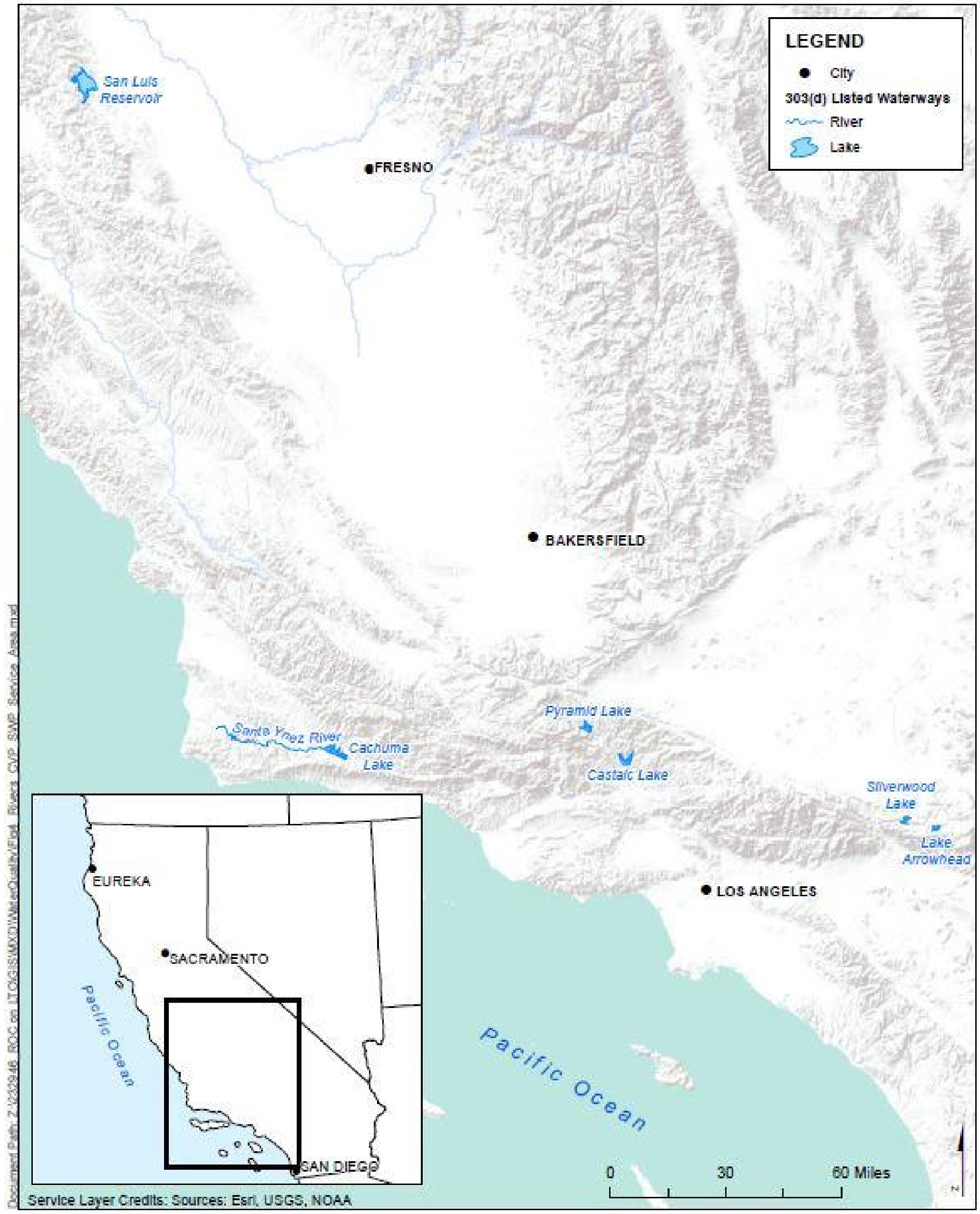
Figure G.1-6, 303(d) Listed Waterways in the CVP and SWP Service Areas presents 303(d) listed waterways in the CVP and SWP service areas.

G.1.10.1 *San Luis Reservoir*

San Luis Reservoir is an off-stream storage facility located along the California Aqueduct downstream of Jones and Banks Pumping Plant and could be potentially affected by CVP/SWP project implementation.

G.1.10.1.1 Mercury

San Luis Reservoir is on the SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). Mercury in San Luis Reservoir is from an unknown source (SWRCB 2017ai).



Source: SWRCB 2017a.

Figure G.1-6. 303(d) Listed Waterways in the CVP and SWP Service Areas

Mercury and enhanced mercury methylation can affect the beneficial uses of San Luis Reservoir. In 2009, fish tissue analysis collected at four location from San Luis Reservoir, showed an average mercury concentration in Largemouth Bass ranging from 0.51 ppm to 0.62 ppm and 0.19 ppm to 0.35 ppm in Common Carp (*Cyprinus carpio*) (Surface Water Ambient Monitoring Program [SWAMP] 2009). A total of 33 out of 47 samples exceeded the OHHEA fish tissue screening value for human health (SWRCB 2017ai).

TMDLs are expected to be completed by 2027 to meet the water quality standards in San Luis Reservoir to protect the beneficial uses of San Luis Reservoir, including the commercial and recreational collection of fish, shellfish, or other organisms of beneficial use (SWRCB 2017ai).

G.1.10.1.2 Pesticides

San Luis Reservoir is on the Section 303(d) list as impaired by pesticides (Total DDT and chlordane) (SWRCB 2017a). Orangochlorine pesticides (e.g., DDT and chlordane) are primarily transported to streams and rivers in runoff from agriculture. Sources and descriptions of the listed pesticides are discussed further in Section G.1.1.7.

G.1.10.1.3 PCBs

San Luis Reservoir is on SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a), based on composite samples of Common Carp collected from the San Luis Reservoir for PCB congeners and Aroclor mixtures (SWRCB 2017ai). The total PCBs recorded ranged from 42 ppb to 133 ppb (SWAMP 2009).

A TMDL for PCBs in the lower American River is expected to be completed in 2027 to protect the beneficial uses of San Luis Reservoir (SWRCB 2017ai).

G.1.10.2 *Cachuma Lake*

Reclamation in Santa Barbara County owns and operates the Cachuma Lake facility. Mercury is a constituent of concern for Cachuma Lake. The Santa Ynez River flows through Cachuma Lake. The Santa Ynez River (above Lake Cachuma) is on SWRCB's CWA Section 303(d) list as impaired by temperature and toxicity (SWRCB 2017a). TMDLs for temperature and toxicity are expected to be completed in 2023 (SWRCB 2017aj). The Santa Ynez River (Cachuma Lake to below city of Lompoc) is on the SWRCB's CWA Section 303(d) list as impaired by sedimentation/siltation, temperature, sodium, TDS, and toxicity (SWRCB 2017a). TMDLs for sediment/siltation, sodium, and TDS are expected to be complete in 2027 (SWRCB 2017ak).

G.1.10.2.1 Mercury

Cachuma Lake is on SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a) from an unknown source (SWRCB 2017al).

Mercury and enhanced mercury methylation can affect the beneficial uses of Cachuma Reservoir. In 2009, all five tissue samples from fish collected at one Cachuma Lake location exceeded the criterion for Mercury (SWRCB 2017al).

SWRCB set TMDLs in 2018 to protect the beneficial uses of Cachuma Lake, including the commercial and recreational collection of fish, shellfish, or organisms' beneficial use (SWRCB 2017al). As of February 2019, USEPA has not approved TMDLs for Cachuma Lake (DWR 2019b).

G.1.10.3 *Quail Lake*

Section 303(d) does not list Quail Lake, a SWP facility in Los Angeles County as impaired for any constituents of concern (SWRCB 2017a).

G.1.10.4 *Pyramid Lake*

Pyramid Lake is a SWP facility located in Los Angeles County, upstream of Castaic Lake on the West branch of the California Aqueduct.

G.1.10.4.1 Mercury

Section 303(d) does not list Pyramid Lake as impaired by mercury (SWRCB 2017a).

Mercury and enhanced mercury methylation can affect the beneficial uses of Pyramid Lake. In 2009, analysts generated 24 sample composites of Largemouth Bass and Brown Bullhead (*Ameiurus nebulosus*) from two locations on Pyramid Lake (SWAMP 2009). A total of 14 out of 24 samples exceeded the OHHEA fish tissue screening value for human health (SWRCB 2017am).

To protect the commercial and recreational collection of fish, shellfish, or organisms beneficial use of Pyramid Lake, TMDLs are set for completion by 2021 (SWRCB 2017am).

G.1.10.4.2 Pesticides

Pyramid Lake is on SWRCB's CWA Section 303(d) list as impaired by chlordane, DDT and the Group A pesticide dieldrin (SWRCB 2017a). Three of four fish samples (two Brown Bullhead and one Largemouth Bass) collected in 2009 at Pyramid Lake exceeded the Total DDT OEHHA screening value of 21 µg/kg (SWRCB 2017am).

To protect the beneficial uses of the Pyramid Lake, TMDLs for chlordane, DDT, and dieldrin are expected to be completed in 2027 (SWRCB 2017am).

G.1.10.4.3 PCBs

Pyramid Lake is on SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a). In 2009, composite samples of Largemouth Bass and Brown Bullhead from Pyramid Lake at two locations and analyzed them for PCBs concentrations (SWRCB 2017am). The average PCB concentrations at Pyramid Lake were among the highest in the state, with 238 ppb in Brown Bullhead. Pyramid Lake was one of two lakes in the state exceeding the 120 ppb no consumption advisory tissue levels (SWAMP 2009).

A TMDL for PCBs in Pyramid Lake is expected to be completed in 2027 to protect beneficial uses (SWRCB 2017am).

G.1.10.5 *Castaic Lake*

Castaic Lake is a SWP facility located in Los Angeles County at the terminal end of the West Branch of the California Aqueduct.

G.1.10.5.1 Mercury

Castaic Lake is on SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). TMDLs are set for completion by 2027 (SWRCB 2017an).

Twenty-four sample composites were collected from two locations at Castaic Lake generated from Largemouth Bass (22) and Common Carp (2). Eight samples exceeded the 0.3 mg/kg OEHHEA fish tissue screening value for human health (SWAMP 2009).

G.1.10.5.2 PCBs

Castaic Lake is on SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a). To protect the commercial and recreational collection of fish, shellfish, or organisms beneficial use of Castaic Lake, TMDLs are set for completion by 2027 (SWRCB 2017an).

G.1.10.6 *Silverwood Lake*

Silverwood Lake is a SWP facility located in San Bernardino County along the East Branch of the California Aqueduct.

G.1.10.6.1 Mercury

Silverwood Lake is on the SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). All fifteen samples collected from Silverwood Lake in 2009 exceeded criterion for Mercury (SWRCB 2017ao). To protect the commercial and recreational collection of fish, shellfish, or organisms beneficial use of Silverwood Lake, TMDLs are set for completion by 2025 (SWRCB 2017ao).

G.1.10.6.2 PCBs

Silverwood Lake is on the SWRCB's CWA Section 303(d) list as impaired by PCBs (SWRCB 2017a). In 2009, composite samples of Largemouth Bass were collected in Silverwood Lake and analyzed for PCBs concentrations (SWRCB 2017ao). Average PCB concentrations at Silverwood Lake were among the highest in the state, with 93 ppb in largemouth bass (SWAMP 2009).

A TMDL for PCBs in Pyramid Lake is expected to be completed in 2025 to protect beneficial uses (SWRCB 2017ao).

G.1.10.7 *Crafton Hills Reservoir*

Section 303(d) does not list Crafton Hills Reservoir, a SWP facility located in the City of Yucaipa within San Bernardino County, as impaired for any constituents of concern (SWRCB 2017a).

G.1.10.8 *Lake Perris*

Section 303(d) does not list Lake Perris, a SWP facility located in Riverside County, as impaired for any constituents of concern (SWRCB 2017a).

G.1.10.9 *Diamond Valley Lake*

Section 303(d) does not list Diamond Valley Lake, an offstream storage facility located in Riverside County, as impaired for any constituents of concern (SWRCB 2017a).

G.1.10.10 *Lake Piru*

Section 303(d) does not list Lake Piru, an offstream storage facility located in Riverside County, as impaired for any constituents of concern (SWRCB 2017a).

G.1.10.11 *Lake Arrowhead*

G.1.10.11.1 <u>Mercury</u>

Lake Arrowhead is on the SWRCB's CWA Section 303(d) list as impaired by mercury (SWRCB 2017a). In 2009, 12 out of 15 Largemouth Bass sample composites from Lake Arrowhead exceeded the OHHEA fish tissue screening value for human health (SWAMP 2009; SWRCB 2017ap).

To protect the commercial and recreational collection of fish, shellfish, or organisms beneficial use of Lake Arrowhead, TMDLs are set for completion by 2025 (SWRCB 2017ap).

G.2 Evaluation of Alternatives

This section describes the technical background for the evaluation of environmental consequences associated with the CVP/SWP Alternatives and the No Action Alternative.

G.2.1 Methods and Tools

The impact analysis considers changes in surface water quality conditions related to changes in CVP/SWP operation under the alternatives as compared to the No Action Alternative due to changes in river flows and surface water deliveries. For all regions except the Bay-Delta, the analysis used changes in flow to investigate potential water quality impacts. Section G.2.1.2, *Bay-Delta Region Specific Methods*, provides a detailed description of the methods used for the Bay-Delta region.

If the Summer-Fall Delta Smelt Habitat action includes operations of the SMSCG or a Fall X2 action, the water requirements in the summer and fall could be greater than shown for Alternative 1. Alternative 1 indicates some water quality benefits when flows increase, as described below in more detail. In years with the summer or fall actions, the water quality benefits would be less than indicated in the Alternative 1 modeling.

G.2.1.1 *Changes in Flow*

Changes in CVP/SWP operation will change the flow in rivers within the study area. Flow is used as a surrogate for water quality in this analysis. Flow reductions in rivers could result in increased concentrations of constituents of concern because there would be less water in the waterway to dilute runoff containing those constituents. Constituents of concern are present in study area waterways due to a number of sources, including urban and agricultural runoff along with legacy drainage from areas that historically had supported mining activities. If the constituent source is downstream from a reservoir, reductions in flow could result in increased constituent of concern concentrations due to reductions in dilution. If the constituent source is located upstream of a reservoir, an increase or decrease in flow due to changes in CVP/SWP operation would not reduce concentrations of constituents of concern.

The surface water quality analysis was conducted using the CalSim II model, as described in Appendix F, *Model Documentation*. The analysis simulated the operational assumptions of each alternative described in Chapter 3, *Alternatives*.

The modeling did not include certain actions, including the Shasta Dam Raise and water transfers. For the full list of actions not included in the CalSim II modeling, see Appendix F.

G.2.1.2 *Bay-Delta Region Specific Methods*

Section G.1.9, *Bay-Delta*, identifies numerous constituents or constituent categories present in the Delta, Suisun Bay, Suisun Marsh, or San Francisco Bay at levels that currently impair the water bodies' beneficial uses. Constituents of concern include: salinity-related constituents (i.e. EC, chloride, and TDS), temperature, mercury, selenium, trace metals, dissolved oxygen, pathogens, legacy contaminants (e.g., dioxin and furan compounds, PCBs, and PAHs), and pesticides. Thus, the project alternative evaluation of the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay water quality addresses effects on these constituents and constituent categories. The analysis addresses temperature within the context of the project alternatives' effects on dissolved oxygen.

In addition to addressing constituents currently known to impair beneficial uses, other constituents of concern for the Bay-Delta also were evaluated. Organic carbon is of concern because of the drinking water supply drawn from the Delta, and organic carbon's effect on food webs in the Delta, Suisun Bay, and San Francisco Bay. Bromide in Delta waters could also impact drinking water supplies. Nutrients levels in the Delta could potentially induce biostimulation, which can affect drinking water supplies and aquatic life. Nutrient levels are of concern in Suisun Bay, Suisun Marsh, and San Francisco Bay due to potential food web effects.

The following sections describe the approach to evaluating the project alternatives' project- and programmatic-level components' effects on water quality in the Delta, Suisun Bay and Marsh, and San Francisco Bay for constituents of concern.

The project-level evaluation of the project alternatives' effects on surface water quality in the Delta, Suisun Bay, and Suisun Marsh consisted of quantitative and qualitative analyses. Evaluations of the salinity-related parameters EC and chloride were conducted in a quantitative manner, utilizing modeling output from DSM2-QUAL. The mercury and selenium evaluations also utilized the DSM2-QUAL modeling output, coupled with bioaccumulation models. Evaluations of the effects of project alternatives on the other constituents of concern was conducted in a qualitative manner, considering the sources, of the constituents of concern and how the alternatives could affect the relative concentrations in Delta inflows and within the Bay-Delta.

The evaluation of each alternative's effect on surface water quality in San Francisco Bay used qualitative analyses and considered qualitative and quantitative analyses for the Delta and Suisun Bay, and Delta outflows as modeled by CalSim II (presented in Appendix F, Attachment 3-2, *Flow Results (CalSim II)*).

The following sections provide additional detail about the evaluation methods for the EC, chloride, bromide, mercury, and selenium evaluations.

G.2.1.2.1 <u>EC, Chloride, and Bromide</u>

The EC evaluation used monthly average EC output from DSM2-QUAL, which was modeled EC in the Delta for water years 1922 through 2003. The analysis summarized percent exceedances of monthly average EC for the 82-year simulation period in tables and plotted by month in exceedance plot format for the following locations:

- Sacramento River downstream of Steamboat Slough.
- Cache Slough at Ryer Island.
- Sacramento River downstream of Georgiana Slough.
- Sacramento River at Emmaton.

- Sacramento River at Rio Vista.
- San Joaquin River at Vernalis.
- San Joaquin River at Jersey Point.
- Old River at Rock Slough.
- Old River at Highway 4.
- Victoria Canal.
- San Joaquin River at Antioch.
- San Joaquin River at Mallard Slough.
- Sacramento River at Collinsville.
- Chipps Island North Channel.
- Chipps Island South Channel.
- Sacramento River at Port Chicago.
- Banks Pumping Plant.
- Jones Pumping Plant.

Appendix F, Attachment 3-6, *Salinity Modeling Results (DSM2)* presents the EC modeling results.

The discussion of EC levels under the project alternatives, as compared to the No Action Alternative, focuses on six assessment locations: the Sacramento River at Emmaton, San Joaquin River at Vernalis, San Joaquin River at Jersey Point, Sacramento River at Collinsville, Banks Pumping Plant, and Jones Pumping Plant. The Sacramento River at Emmaton, San Joaquin River at Vernalis and Jersey Point, and Banks and Jones pumping plants are Bay-Delta WQCP compliance locations for agricultural beneficial uses (SWRCB 2006). The San Joaquin River at Jersey Point and Sacramento River at Collinsville (located at the eastern edge of Suisun Marsh) are Bay-Delta WQCP compliance locations for fish and wildlife beneficial use protection (SWRCB 2006).

The analysis generated monthly average chloride concentrations, using monthly EC output from DSM2, for the following assessment locations, which are Bay-Delta WQCP compliance locations for municipal and industrial beneficial uses protection (SWRCB 2006):

- Contra Costa Pumping Plant #1.
- San Joaquin River at Antioch.
- Banks Pumping Plant.
- Jones Pumping Plant.
- Barker Slough at NBA Intake.

The analysis calculated chloride from the EC output using the two equations below:

$$Cl = (0.15 * EC - 12) \; and \; Cl = (0.285 * EC - 50) \begin{pmatrix} 0.15 * EC - 12 \\ 0.285 * EC - 50 \end{pmatrix}$$

In the equation above, Cl is the chloride concentration in mg/L, and EC is in µmhos/cm. The above equation is based on historical data for Mallard Island, Jersey Island, and Old River at Rock Slough (Contra Costa Water District 1997). Two regression equations are used to calculate chloride concentrations based on whether the location is riverine or seawater dominant. To be conservative, this assessment used the maximum chloride concentration calculated using the above two equations. The chloride modeling results are presented in Appendix F, *Salinity Modeling Results (DSM2)*.

The analysis compared each action alternative's modeled monthly average EC and chloride to the No Action Alternative in the summary tables and probability exceedance plots provided in Appendix F, *Salinity Modeling Results (DSM2)*. The analysis evaluated probability exceedance plots to determine how often the specified EC and chloride levels would be exceeded for the alternative as compared to what would occur for the No Action Alternative at the assessment locations. It compared modeled monthly average EC and chloride levels for each action alternative to those for the No Action Alternative at various Delta locations for the entire period of record modeled, and by water year type.

The qualitative bromide assessment is based on changes in EC and considered historical bromide concentrations in the Delta.

G.2.1.2.2 Methylmercury

The mercury assessment focuses on fish tissue concentrations of methylmercury, to be consistent with the Sacramento–San Joaquin Delta Estuary TMDL for methylmercury, which established waste load allocations and fish tissue objectives expressed as methylmercury. The assessment of the alternatives' effect on Delta methylmercury is based on modeled concentrations at specific Delta locations, as determined from DSM2 output. The analysis used the QUAL module of DSM2 to simulate source water fingerprinting, which identifies the relative contributions of water sources to the volume at the specified Delta location. The analysis input modeled methylmercury concentrations for the entire 82-year modeled period of water years 1922 through 2003 and the consecutive 5-year drought period of water years 1987 through 1991 into the Central Valley RWQCB TMDL model for the Delta to develop an estimate of fish tissue concentrations. Appendix G, Attachment 1, *Methylmercury Model Documentation* describes the methods for developing the modeled water and fish tissue concentrations in more detail.

The analysis evaluated project alternatives' effects on fish tissue methylmercury concentrations by comparing exceedances of the fish tissue water quality objective for methylmercury trophic level 4 fish of 0.24 mg/kg. The analysis determined exceedances of the fish tissue water quality objective by evaluating exceedance quotients (EQs), which are ratios of the modeled fish tissue concentration divided by the water quality objective of 0.24 mg/kg. Values over 1.0 indicate modeled tissue concentrations exceed the water quality objective. The analysis compared EQs for the project alternatives to the EQs for the No Action Alternative at various Delta locations to determine if the project alternatives would increase the potential for mercury bioaccumulation in fish within the Delta.

In 2017, the SWRCB approved *Part 2 of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California—Tribal and Subsistence Fishing Beneficial Uses and Mercury Provisions*, which established mercury limits to protect the state-designated beneficial uses associated with the consumption of fish by both people and wildlife. However, the mercury water quality objectives do not supersede the Central Valley RWQCB's site-specific numeric mercury water quality objectives established for the Delta (SWRCB 2017aq). Thus, the SWRCB water quality objectives were not applied in the methylmercury assessment.

For alternatives that include changes in the extent of tidal habitat, the assessment qualitatively addresses the potential to enhance mercury bioavailability and risk at a programmatic level.

G.2.1.2.3 Selenium

The selenium assessment evaluates changes to selenium concentrations in tissues that affect the health of fish, as well as wildlife and humans consuming fish in the Delta, using a suite of modeling tools. The analysis used the DSM2 QUAL module to simulate source water finger printing to quantify the relative contributions of water sources to the volume at specified Delta locations. The source water fingerprinting values (expressed as a % of each Delta source water) multiplied by source water concentrations determined annual average selenium concentrations in the Delta water column at specified locations. The analysis input modeled selenium concentrations for the entire 82-year modeled period of water years 1922 through 2003 and the consecutive 5-year drought period of water years 1987 through 1991 into the bioaccumulation models to estimate bioaccumulation in bird eggs and fish fillets, and to model selenium bioaccumulation in Sturgeon (*Acipenseridea*) living in the western Delta. Appendix G, Attachment 2, *Selenium Model Documentation* describes the methods for modeling water column concentrations and bioaccumulation are described in more detail.

The analysis evaluated the alternatives' effects on selenium bioaccumulation in biota by comparing exceedances of bird egg and fish tissue benchmarks. As described above for methylmercury, the analysis characterized exceedances of bird egg and fish tissue benchmarks using EQs. Values over 1.0 indicate modeled bird egg and fish tissue concentrations exceed the applicable toxicity benchmarks. The project alternatives' EQs compared to the EQs for the No Action Alternative, at various Delta locations, determined if the project alternatives would increase the potential for selenium bioaccumulation in bird eggs and fish within the Delta.

For alternatives that include changes in the extent of tidal habitat, the evaluation qualitatively addresses the potential to enhance selenium bioavailability and risk at a programmatic level.

G.2.1.3 *Programmatic-Level Assessment*

The qualitative water quality assessment of the alternatives' programmatic-level components considered the specific actions to be implemented by the programmatic component. It also considered if that action or component could contribute additional sources of water quality constituents of concern, or otherwise alter water quality. The analysis qualitatively addressed the water quality effects of programmatic components construction also, considering the anticipated construction activities that may be required and the materials that may be involved, as well as measures that would require implementation prior to initiating construction activities.

G.2.2 No Action Alternative

Potential changes in water quality

The No Action Alternative would generate no changes in CVP or SWP system operations, and as a result there would be no change in the limits on water supply deliveries currently in place. Given the lack of changes under the No Action Alternative to CVP and SWP operations there would also be no change to the water quality conditions. This includes water quality conditions within the study area that affect beneficial uses.

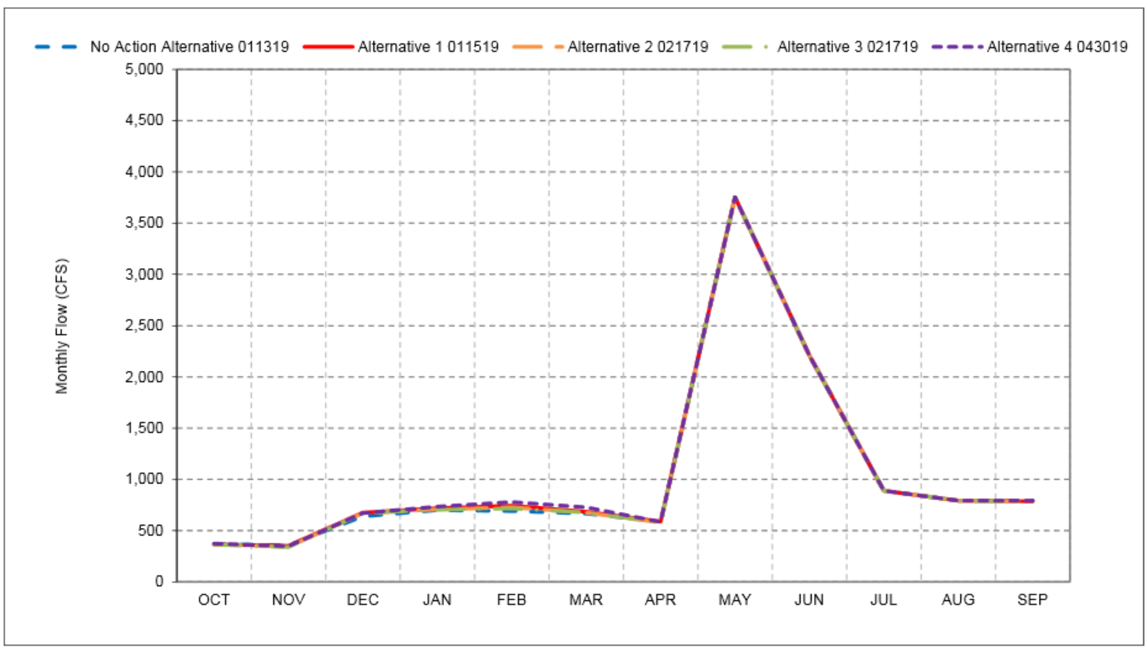
G.2.3 Alternative 1

G.2.3.1 *Project-Level Effects*

Potential changes in water quality

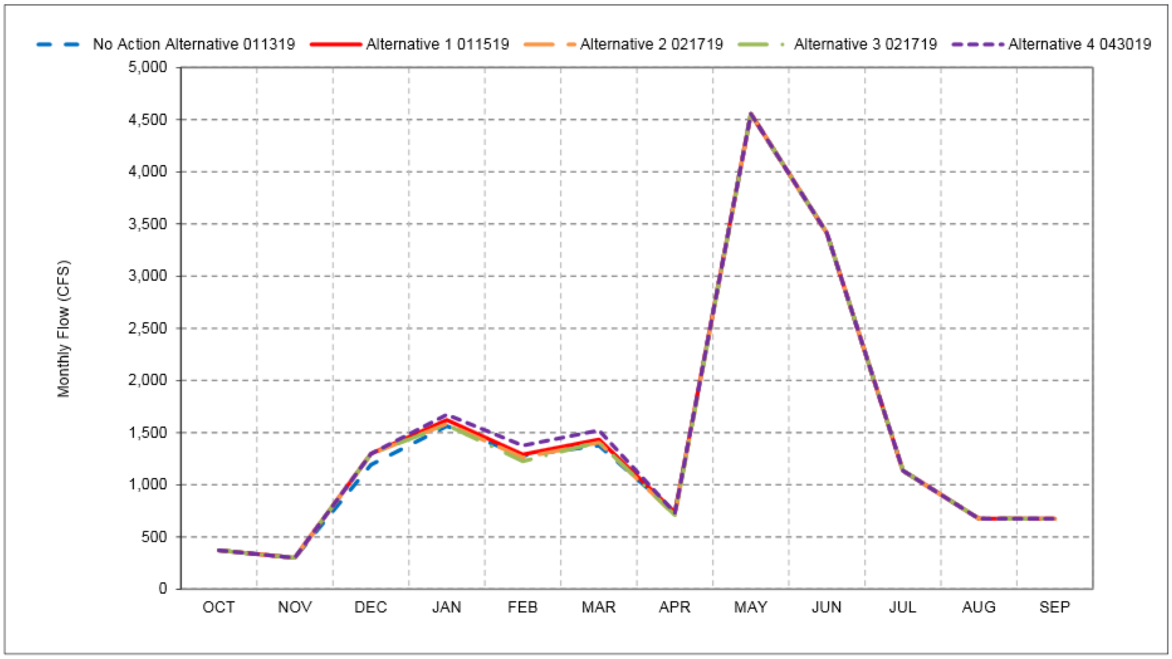
G.2.3.1.1 Trinity River

Operations in the Trinity River would remain similar to those under the No Action Alternative. The Trinity River Restoration Program Record of Decision controls Trinity River operations, and Reclamation would continue to release flows into the Trinity River as they do under the No Action Alternative. Figure G.2-1 through Figure G.2-6, illustrate flow changes for all water year types. Figure G.2-1, Trinity River Flow below Lewiston Dam, Long-Term Average Flow demonstrates that changes in long-term average flows under Alternative 1 are not expected to change by more than 8% compared to the No Action Alternative. Figure G.2-3, Trinity River Flow below Lewiston, Above Normal Year Average Flow, shows the largest change in flow is shown in where flows under Alternative 1 are expected to increase in February of above normal water years by approximately 58% compared to the No Action Alternative. Increasing and decreasing fluctuations in flow under Alternative 1 are expected to a lesser extent in other year types. Because Alternative 1 would have limited changes in flows on the Trinity River, changes in flows would have limited potential to affect water quality. Increases in flow would be considered beneficial based on the improvement of water quality through dilution of constituents of concern. The evaluation does not expect decreases in flow to be a large enough magnitude to affect water quality.



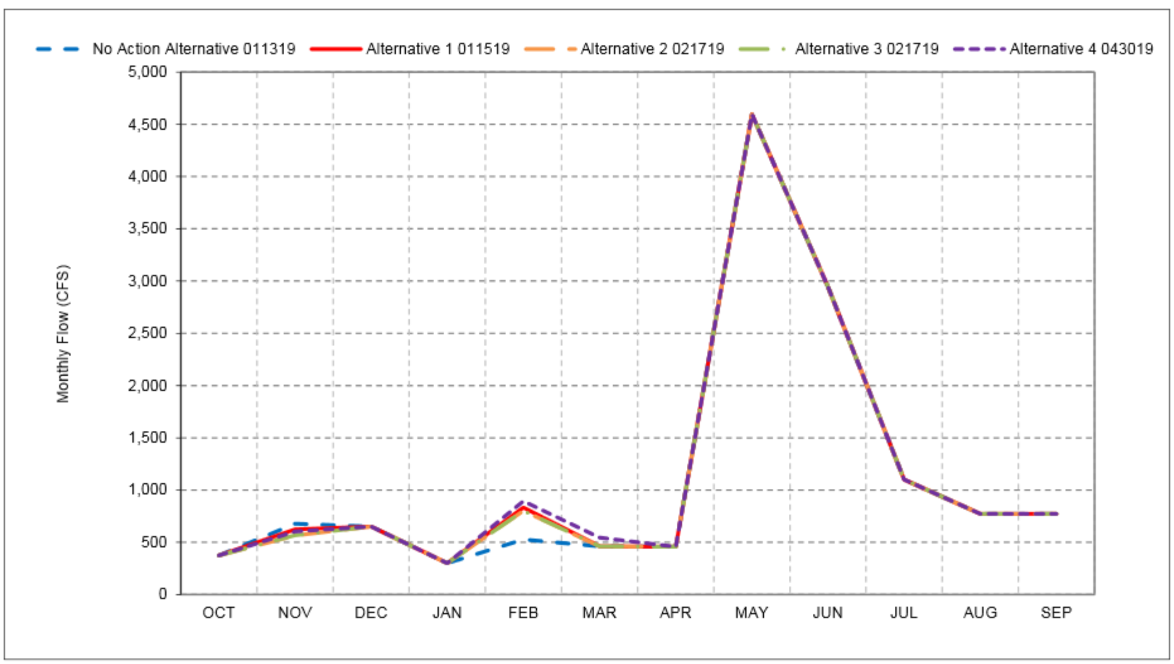
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-1. Trinity River Flow below Lewiston, Long-Term Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-2. Trinity River Flow below Lewiston, Wet Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
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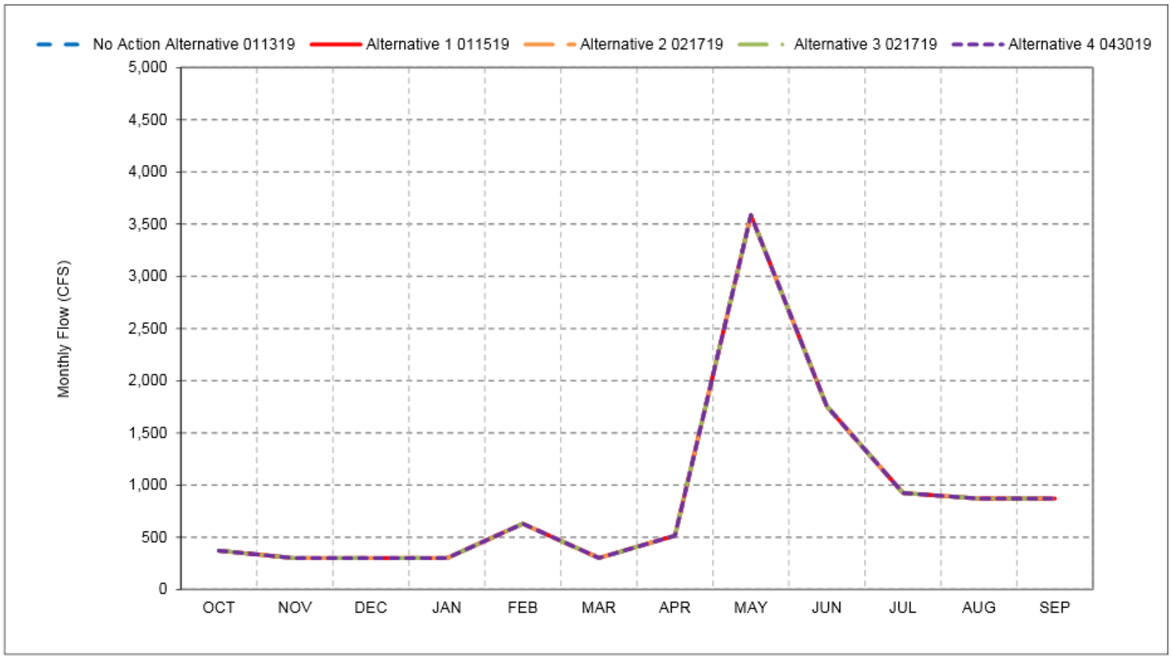
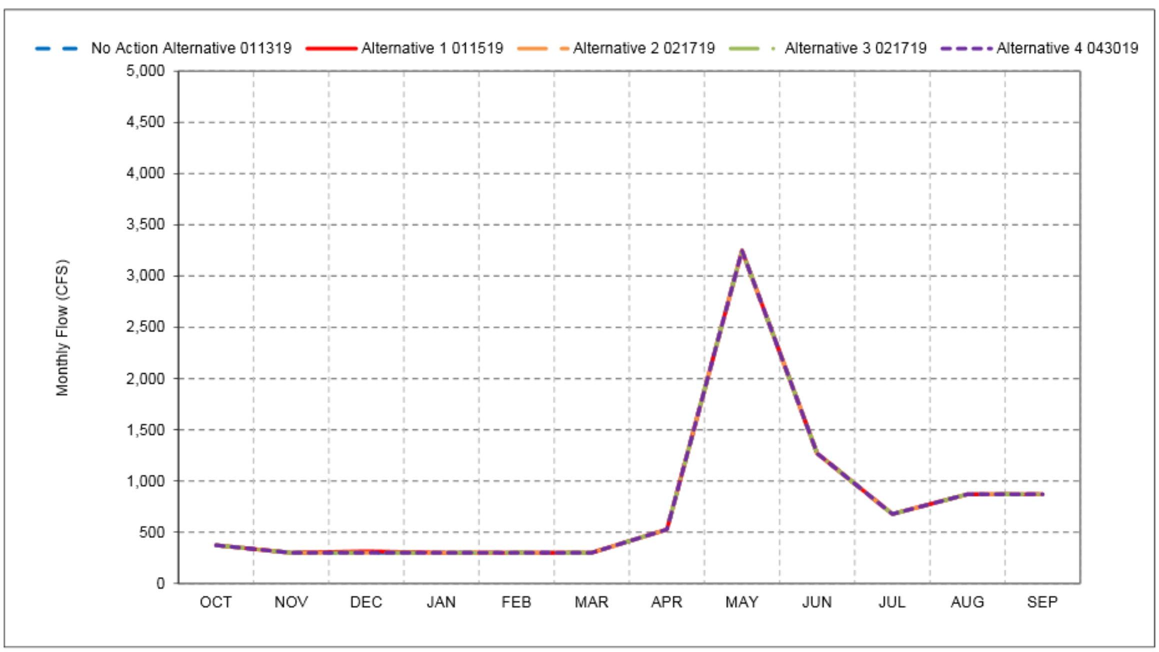
Figure G.2-3. Trinity River Flow below Lewiston, Above Normal Year Average Flow



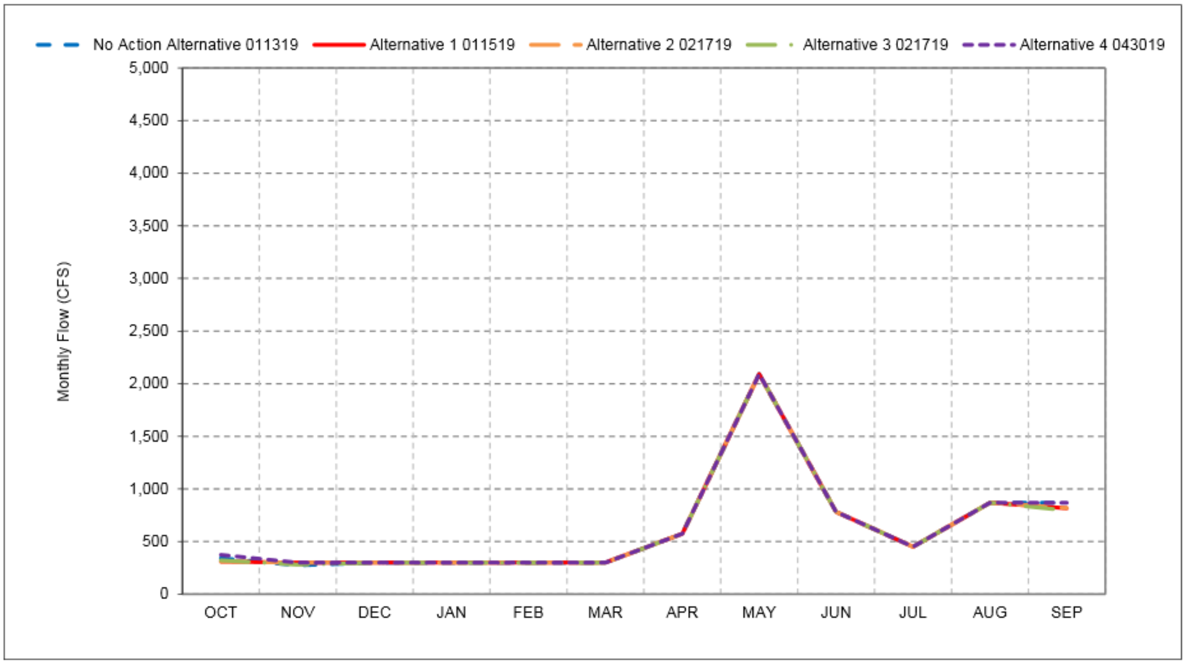
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-4. Trinity River Flow below Lewiston, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-5. Trinity River Flow below Lewiston, Dry Year Average Flow

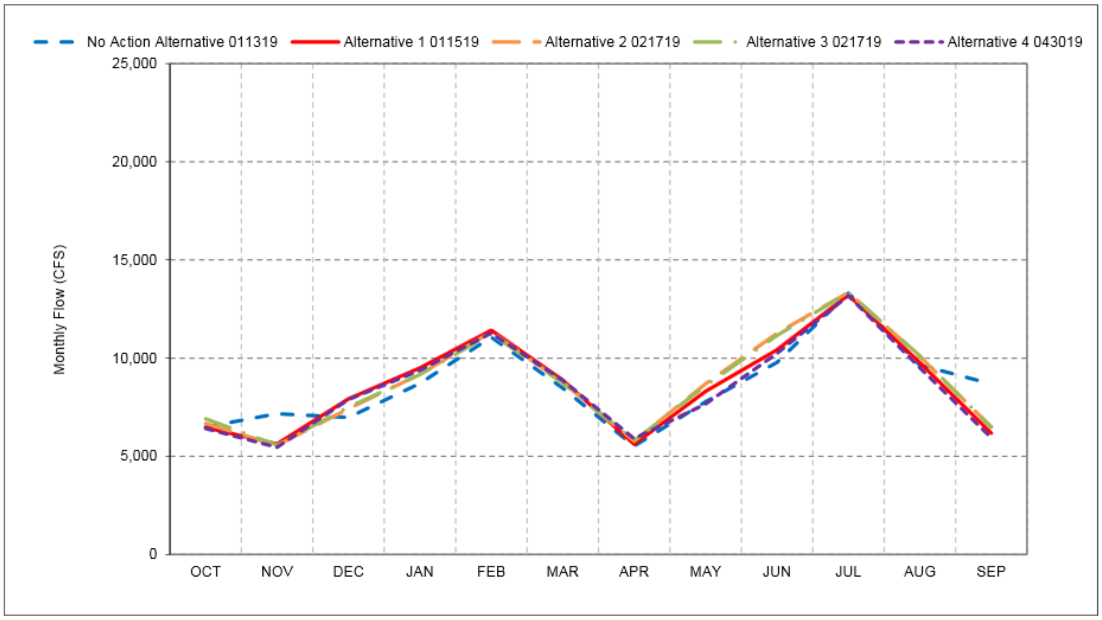


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-6. Trinity River Flow below Lewiston, Critical Year Average Flow

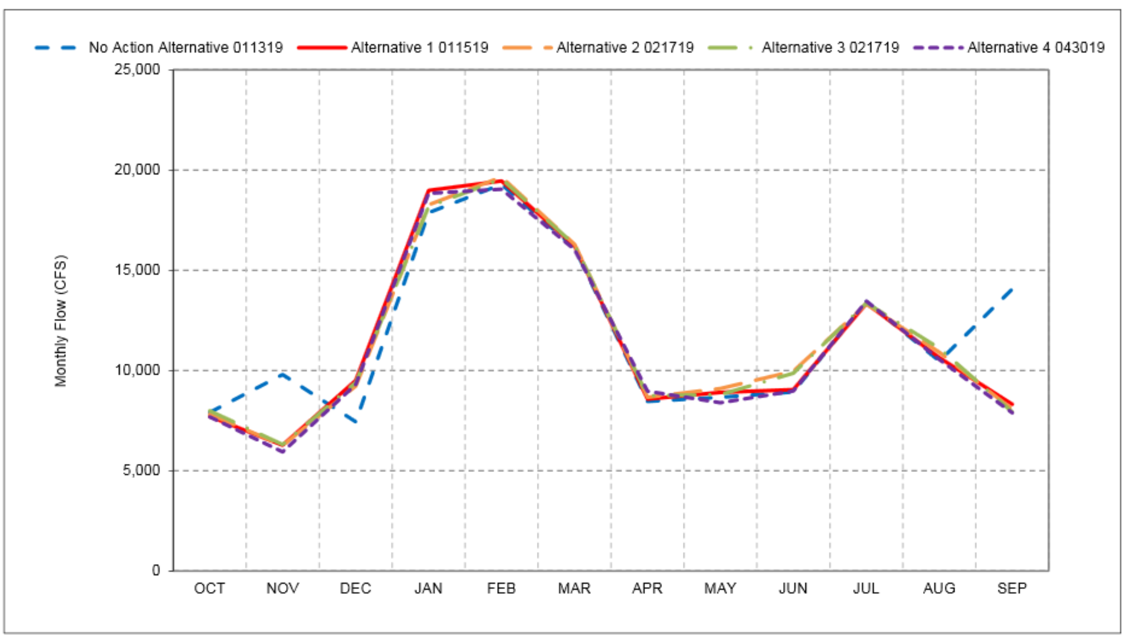
G.2.3.1.2 Sacramento River

Alternative 1 would cause flow changes in the Sacramento River from changes in spring pulse flows, cold water pool management, change in Delta fall requirements, and fall and winter refill. Flow changes could affect water quality in the Sacramento River because flows released from Keswick can dilute concentrations of constituents of concern that enter the river as it flows south. Figures G.2-7 through G.2-12 illustrate changes in flow on the Sacramento River downstream of Keswick Reservoir for different year types. Under Alternative 1, long-term average flow changes are not expected to deviate substantially from the No Action Alternative (see Figure G.2-7, Sacramento River Flow downstream of Keswick Reservoir, Long-Term Average Flow). The largest changes in flow under Alternative 1 are expected during the fall months of Wet and Above Normal Year Types (see Figures G.2-8 and G.2-9). The changes in flow come from changes to fall X2 requirements for Delta Smelt compared to the No Action Alternative. Under Alternative 1, reservoir releases would occur at different times, generally resulting in flow decreases during the fall and flow increases during winter and early spring, to regulate temperature management objectives and spring pulse flows. Substantial decreases in flow are expected only in wet and above normal water year types, in which case a decrease in flow is not expected to affect water quality due to higher base flows. Trends are similar for other sampling locations along the Sacramento River and can be viewed in Appendix F. While Alternative 1 would create flow changes, including decreases of up to 49%, in the Sacramento River, the flow changes would occur during wet and above normal water years when base flow is adequate and decreases in flow are not expected to cause violations of water quality standards. Overall, water quality would not be substantively affected by changes in flow under Alternative 1 and increased frequency of exceedances of water quality thresholds are not expected.



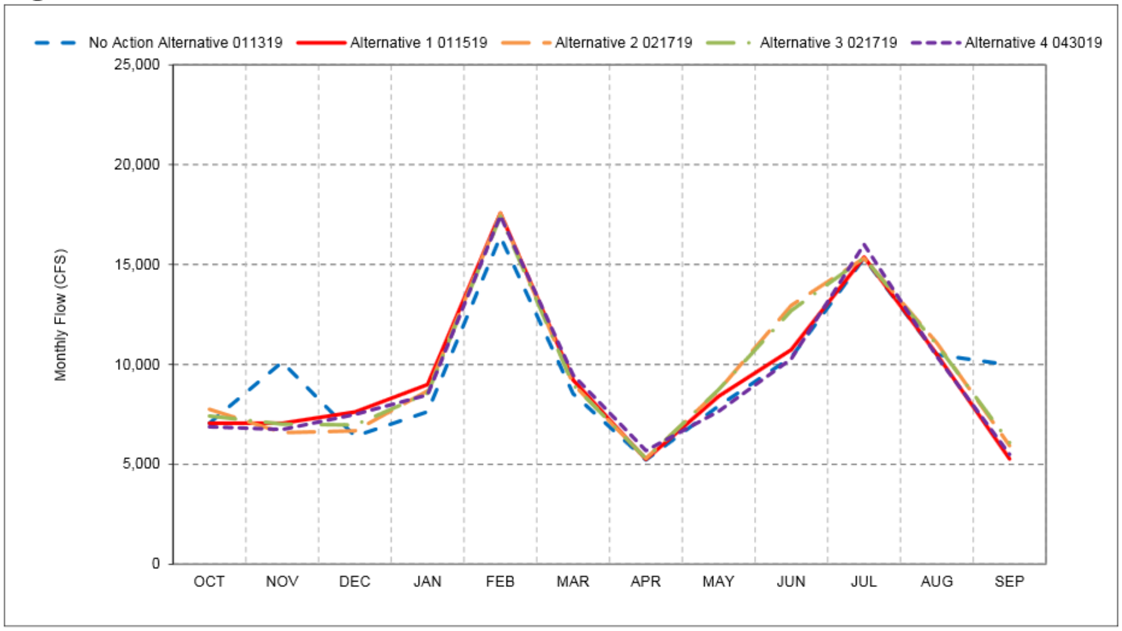
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-7. Sacramento River Flow downstream of Keswick Reservoir, Long-Term Average Flow



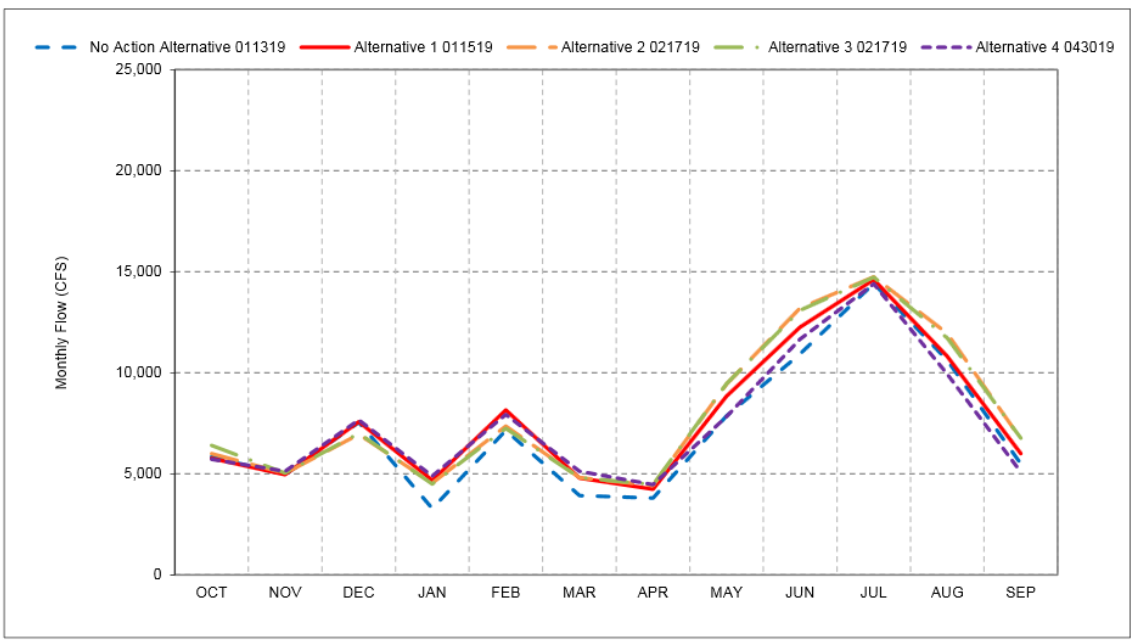
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-8. Sacramento River Flow downstream of Keswick Reservoir, Wet Year Average Flow



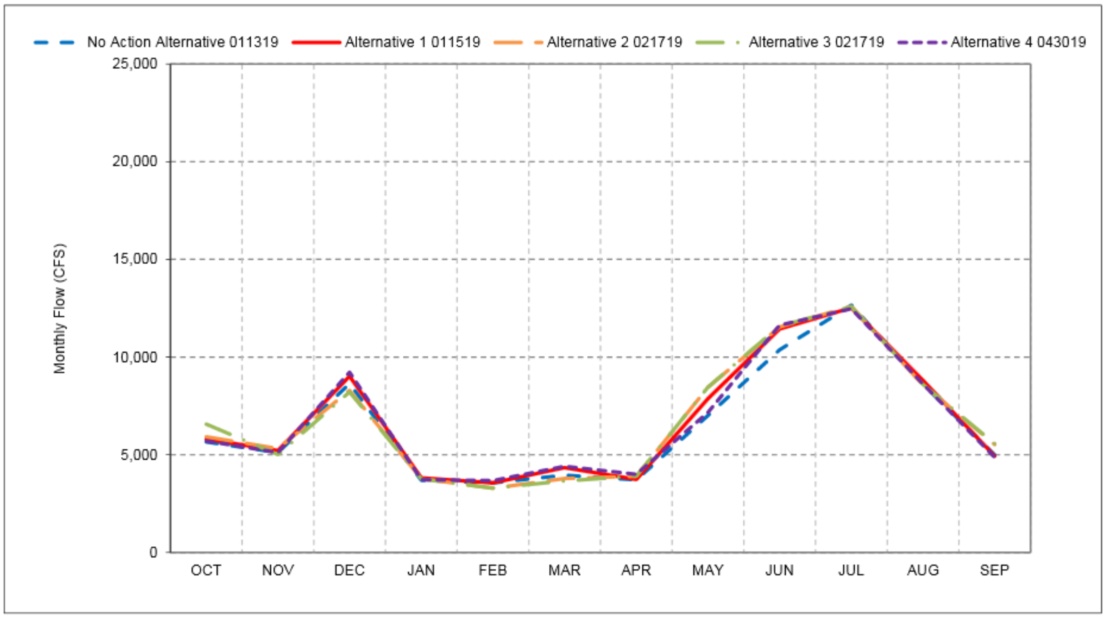
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-9. Sacramento River Flow downstream of Keswick Reservoir, Above Normal Year Average Flow



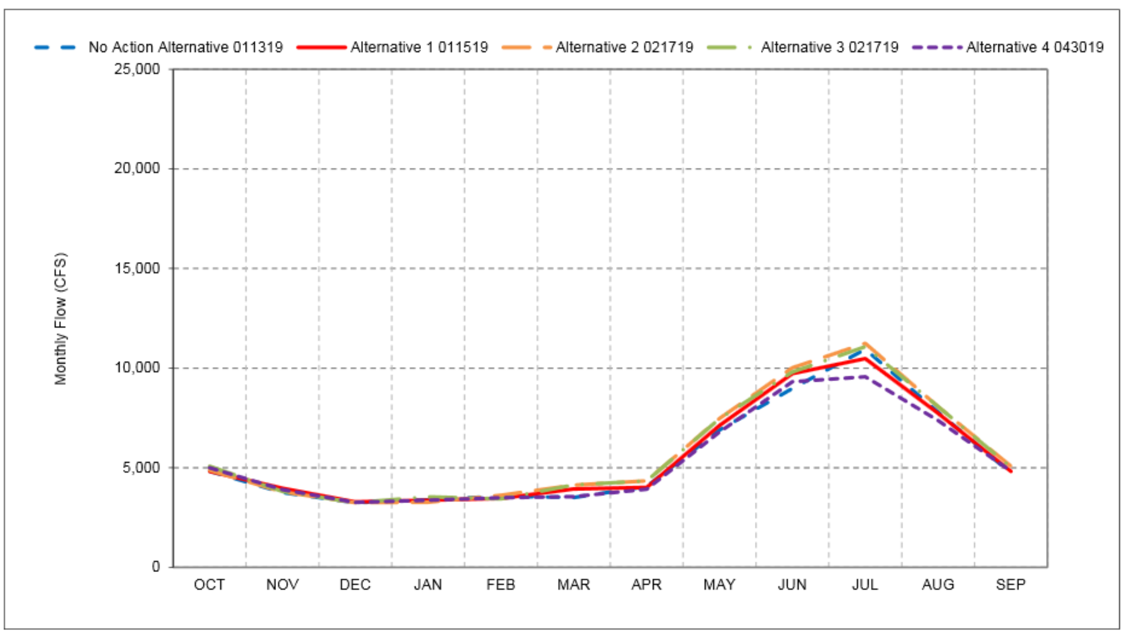
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-10. Sacramento River Flow downstream of Keswick Reservoir, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-11. Sacramento River Flow downstream of Keswick Reservoir, Dry Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

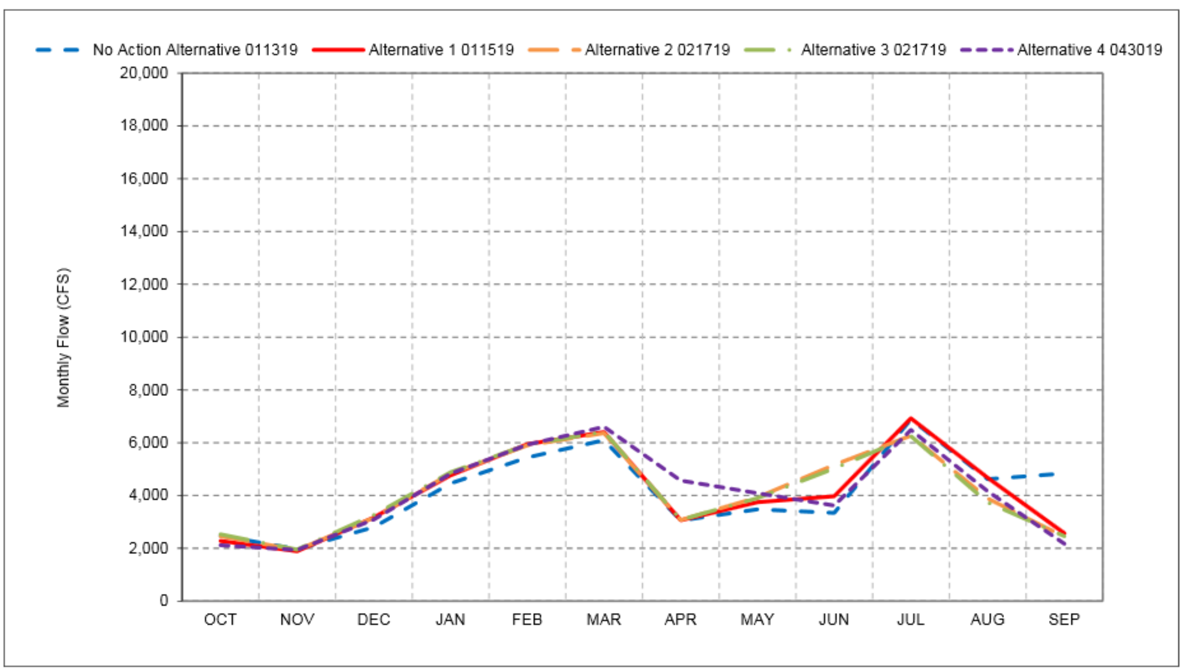
Figure G.2-12. Sacramento River Flow downstream of Keswick Reservoir, Critical Year Average Flow

G.2.3.1.3 Clear Creek

Flows in Clear Creek under Alternative 1 would increase compared to the No Action Alternative. The analysis considers flow increases beneficial to water quality by making more water available for dilution of constituents of concern (i.e., mercury), therefore no changes to existing water quality would occur.

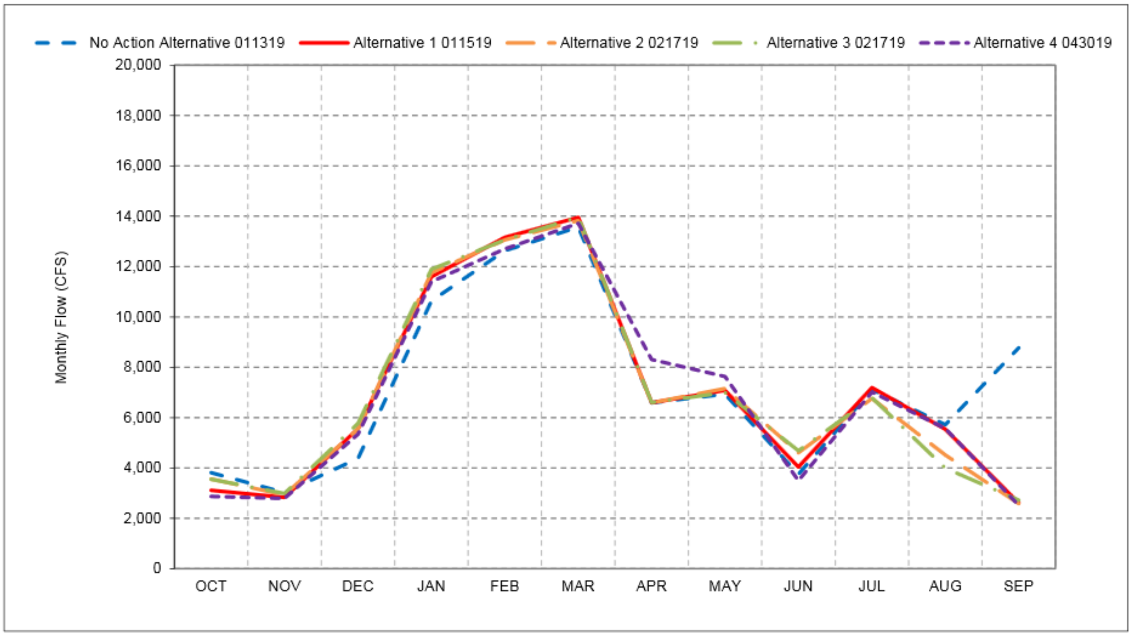
G.2.3.1.4 Feather River

The analysis modeled flows at two locations on the Feather River: the Sacramento River Confluence and downstream of Thermalito Afterbay. The Oroville complex operations are according to the FERC license under both the No Action Alternative and Alternative 1, but reservoir release changes somewhat because of changing Delta requirements. The largest flow decrease would be in September of wet water years and the largest flow increase would be in February of below normal water years for both locations. The flow decreases are generally in the fall of wet and above normal water years; similar to the Sacramento River, this change is caused by the change in fall X2 requirements in the Delta. The flow change moves reservoir releases to other periods. Figures G.2-13 through G.2-18 illustrate flow changes. Flow changes at the Sacramento River Confluence follow similar patterns, but have a smaller magnitude to those at Thermalito Afterbay. Similar to the Sacramento River, decreases in flow are expected only during wet and above normal water year types, when base flows are adequate to minimize impacts to water quality. Flow increases are expected in all water year types compared to the No Action Alternative, especially during Spring and Summer, which could improve water quality based on the dilution of constituents of concern. The evaluation does not expect overall changes in flow under Alternative 1 to cause water quality standard violations or to affect water quality along the Feather River.



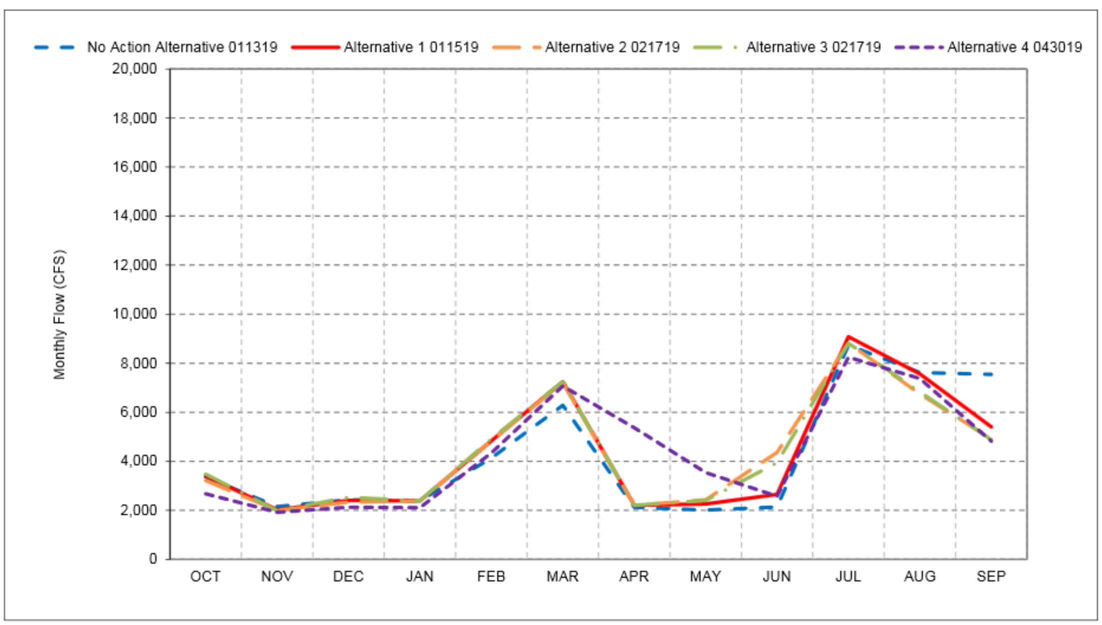
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-13. Feather River Flow downstream of Thermalito, Long-Term Average Flow



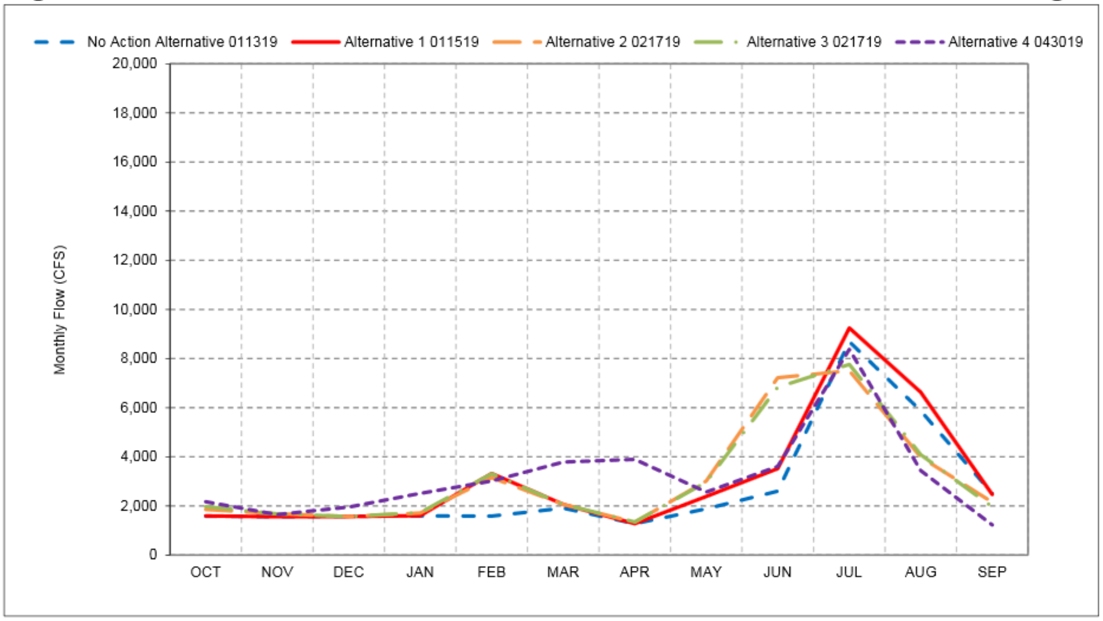
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-14. Feather River Flow downstream of Thermalito, Wet Year Average Flow



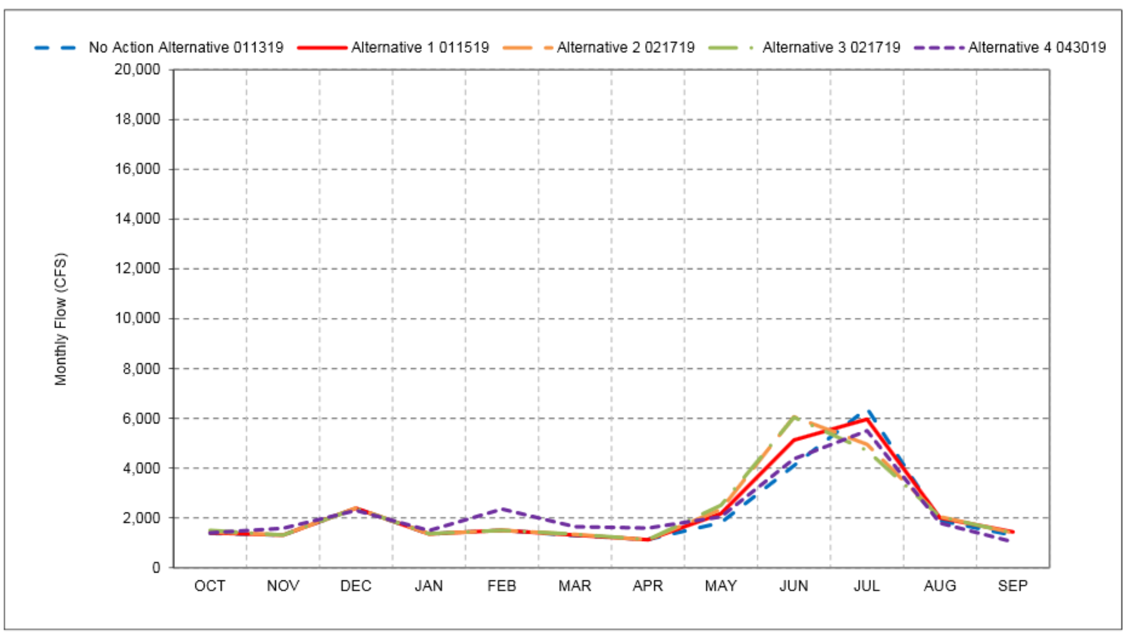
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-15. Feather River Flow downstream of Thermalito, Above Normal Year Average Flow



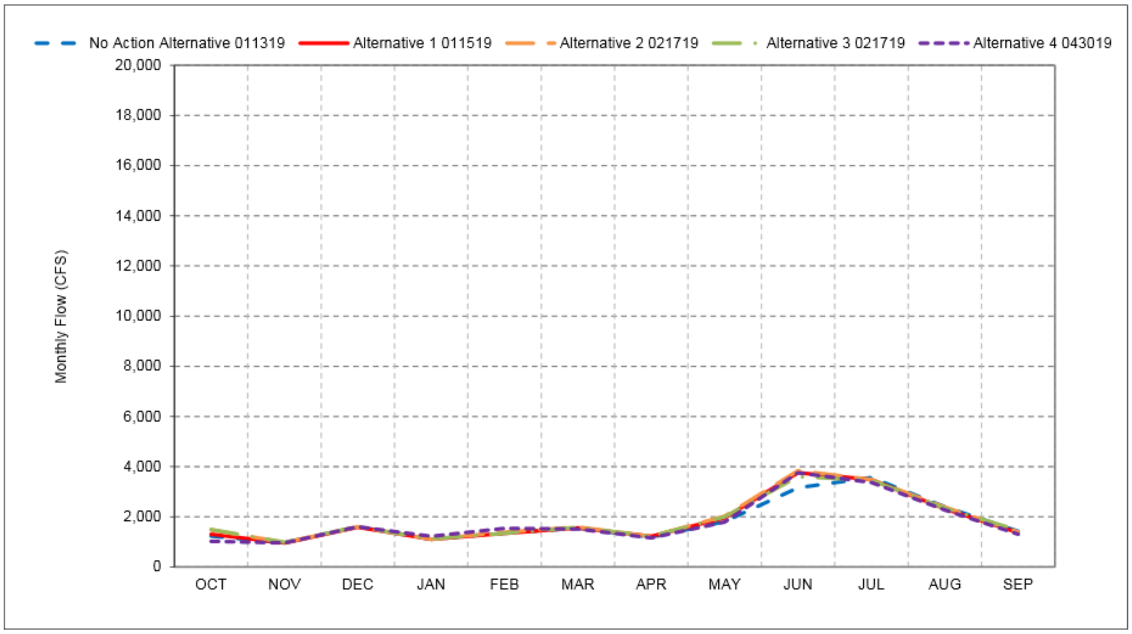
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-16. Feather River Flow downstream of Thermalito, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-17. Feather River Flow downstream of Thermalito, Dry Year Average Flow

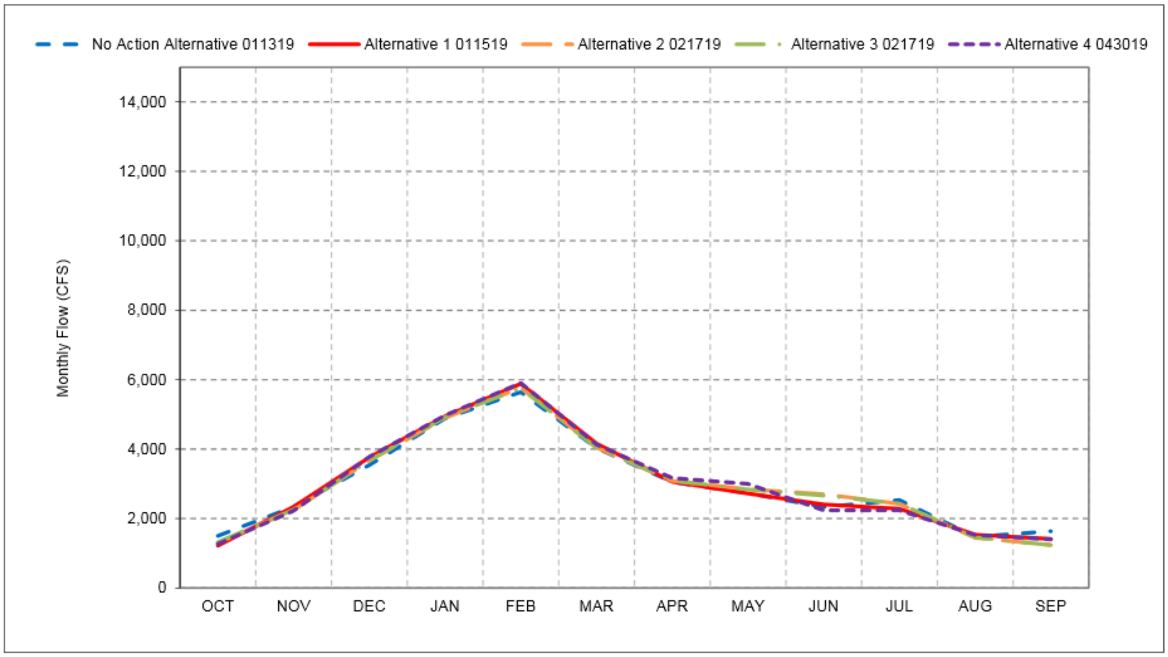


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-18. Feather River Flow downstream of Thermalito, Critical Year Average Flow

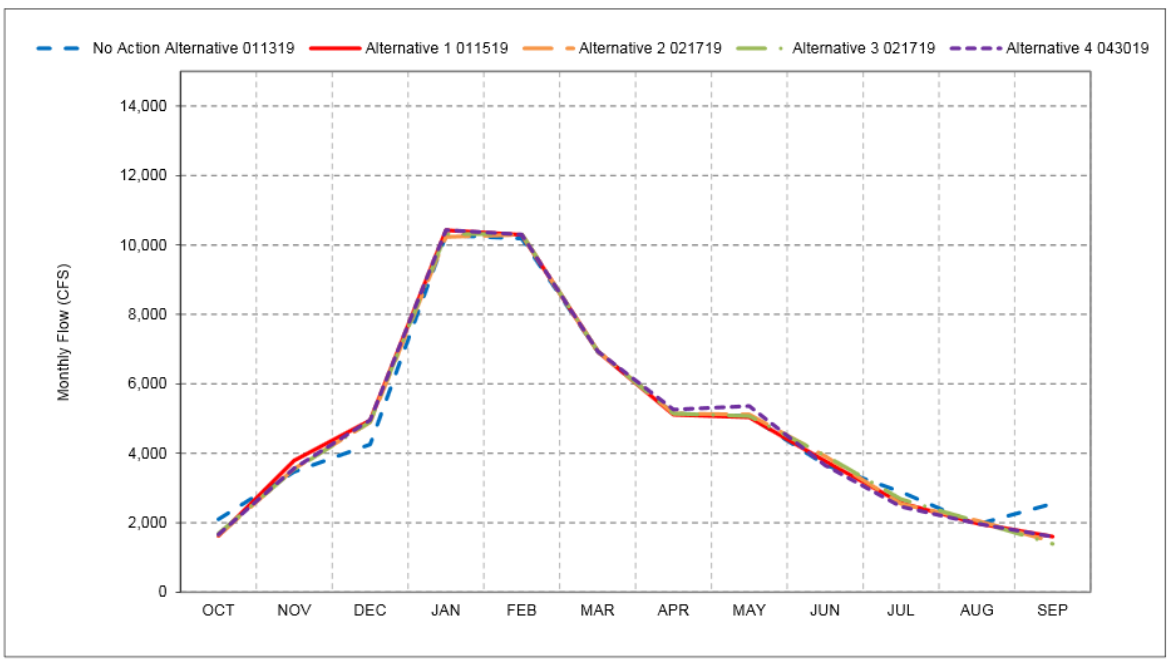
G.2.3.1.5 American River

The analysis modeled flows at two locations on the American River: H Street and below Nimbus Dam. Flows under Alternative 1 would be different from those under the No Action Alternative because Alternative 1 incorporates the 2017 Modified Flow Management Standard and would contribute to meeting different fisheries requirements in the Delta. Based on modeling, the maximum average increase in flows on the American River at H Street would be during February of critical water years, when flows are expected to increase by 46%. The maximum average decrease in flows would be during September of wet water years, when flows are expected to decrease by 37%. Figures G.2-19 through G.2-24 illustrate flow changes on the American River at H Street. Changes in flow below Nimbus Dam follow a similar trend but are generally smaller. While the evaluation considers a decrease in flows harmful to water quality due to the reduction of dilution of constituents of concern, changes in flows are small enough and at times of year that they would not be expected to result in adverse effects to water quality in the American River.



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-19. American River at H Street, Long-Term Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
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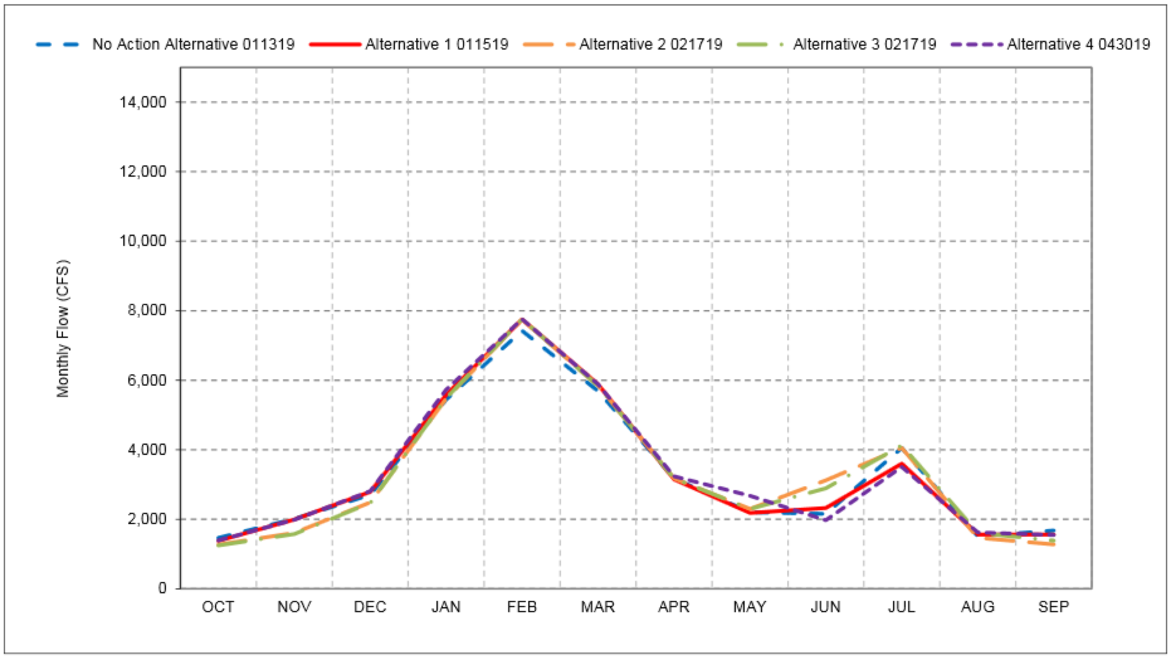
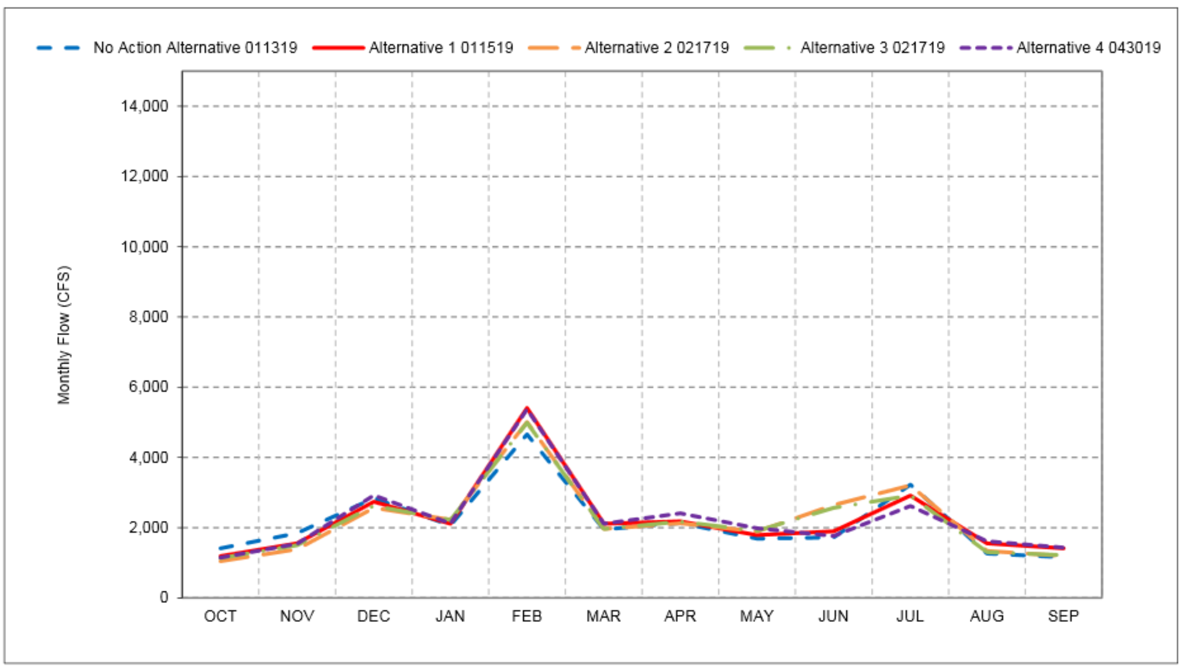
Figure G.2-20. American River at H Street, Wet Year Average Flow



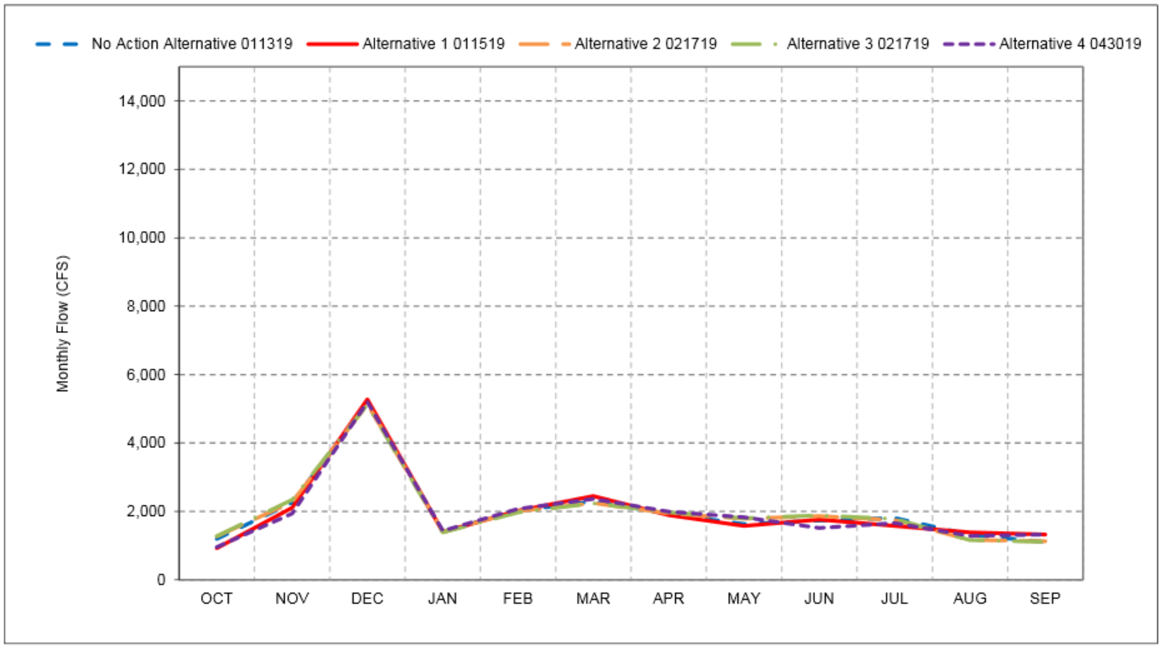
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-21. American River at H Street, Above Normal Year Average Flow



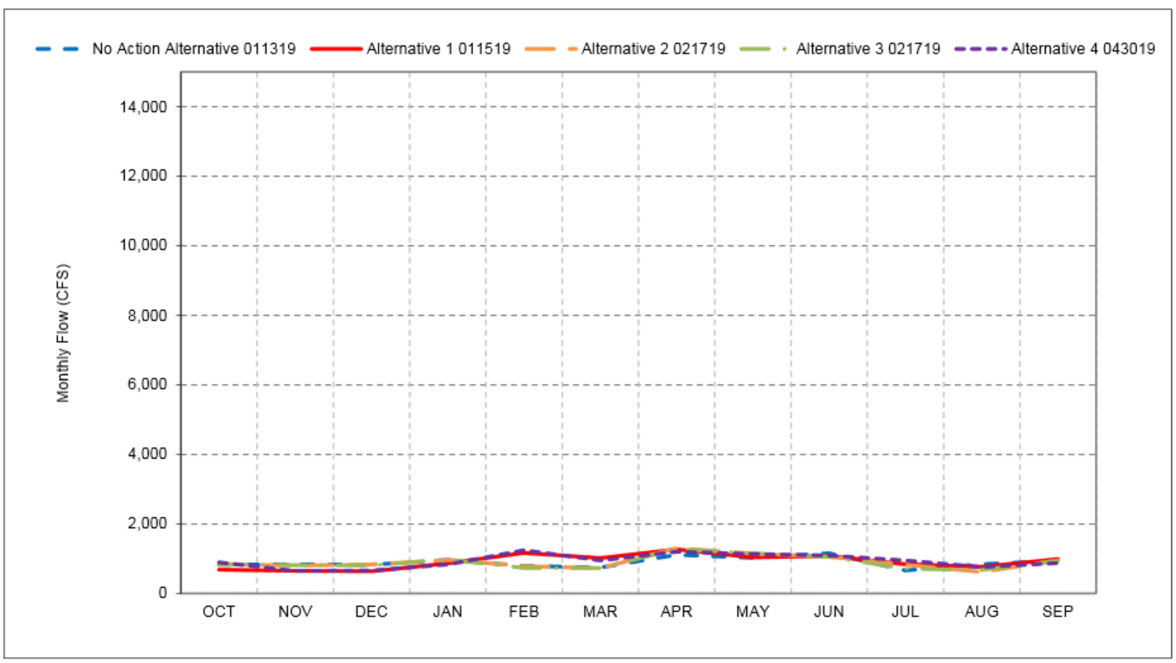
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-22. American River at H Street, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-23. American River at H Street, Dry Year Average Flow

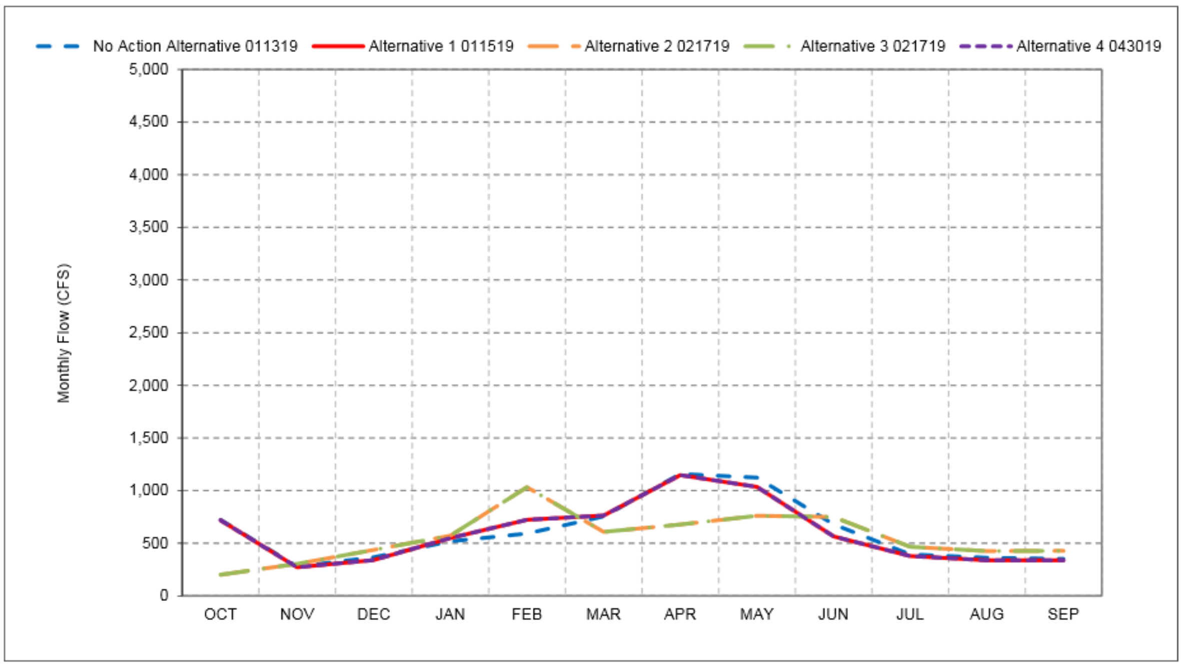


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-24. American River at H Street, Critical Year Average Flow

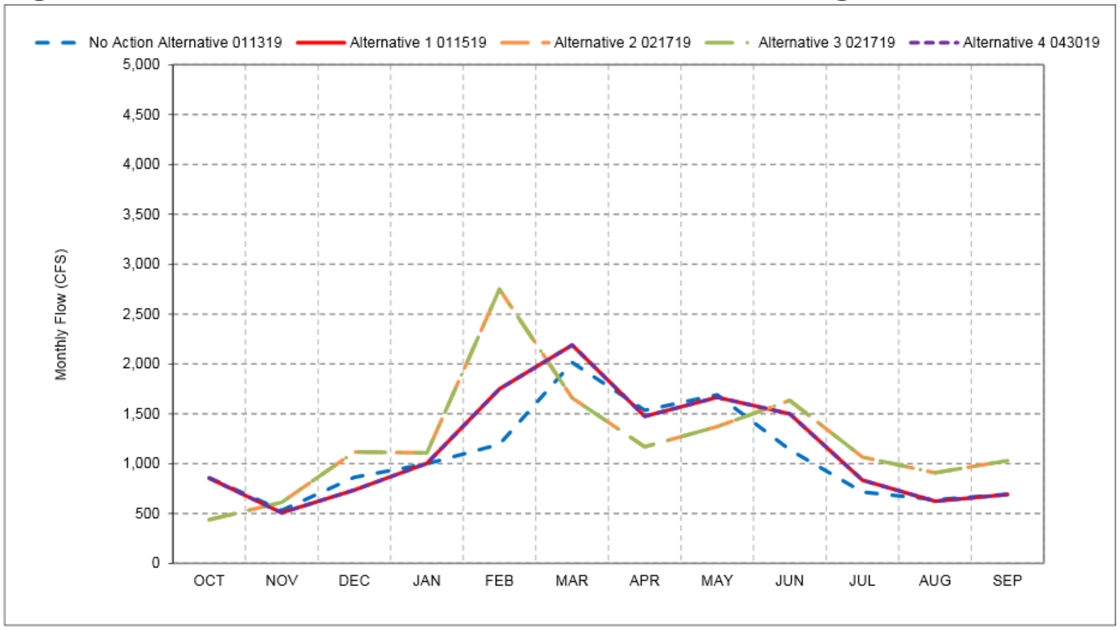
G.2.3.1.6 Stanislaus River

The analysis modeled flows at two locations on the Stanislaus River: at the mouth and below Goodwin Dam. Flow changes would be identical for both locations on the Stanislaus River. Alternative 1 would change flows on the Stanislaus River because it incorporates the Stepped Release Plan for New Melones Reservoir, which aims to create a release plan that is better able to meet the multiple reservoir purposes. The largest flow decrease would be in June of above normal water years and the largest flow increase would be in February of wet water years under Alternative 1. Stanislaus River flows below Goodwin Dam are expected to have a maximum increase of approximately 94% in January of below normal water years, and a maximum decrease by approximately 62% in June of above normal water years. Figures G.2-25 through G.2-30 show changes in flow below Goodwin Dam. While the evaluation considers a decrease in flows as harmful to water quality because it reduces dilution of constituents of concern, changes in flows are small enough and at times of year that they would not be expected to result in increased frequency of exceedances of water quality thresholds in Stanislaus River.



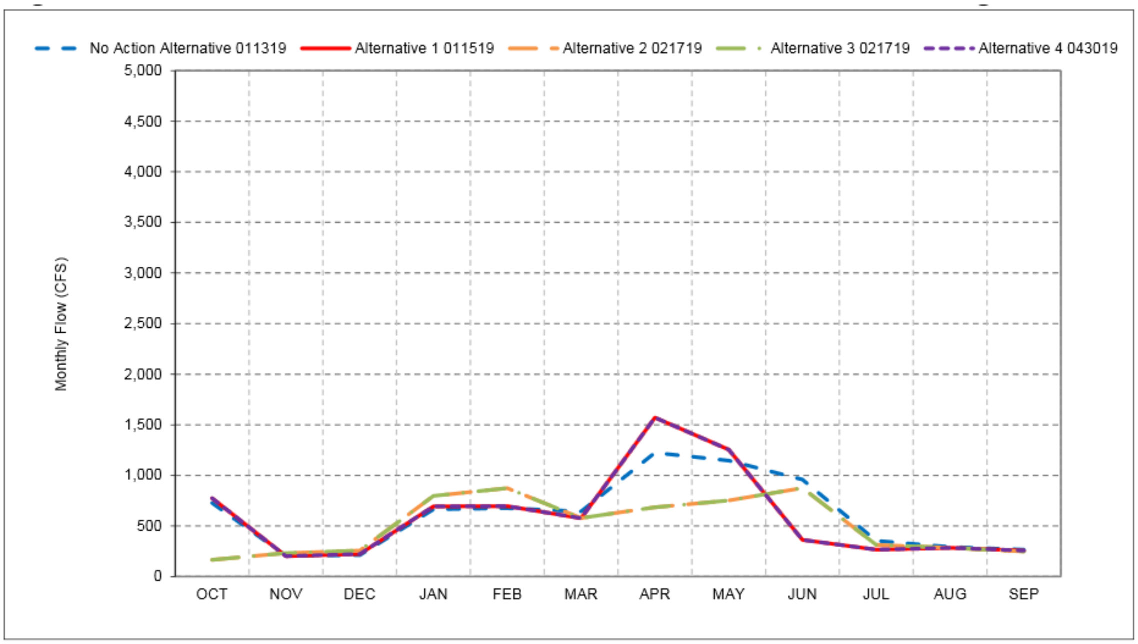
*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-25. Stanislaus River Flow below Goodwin, Long-Term Average Flow



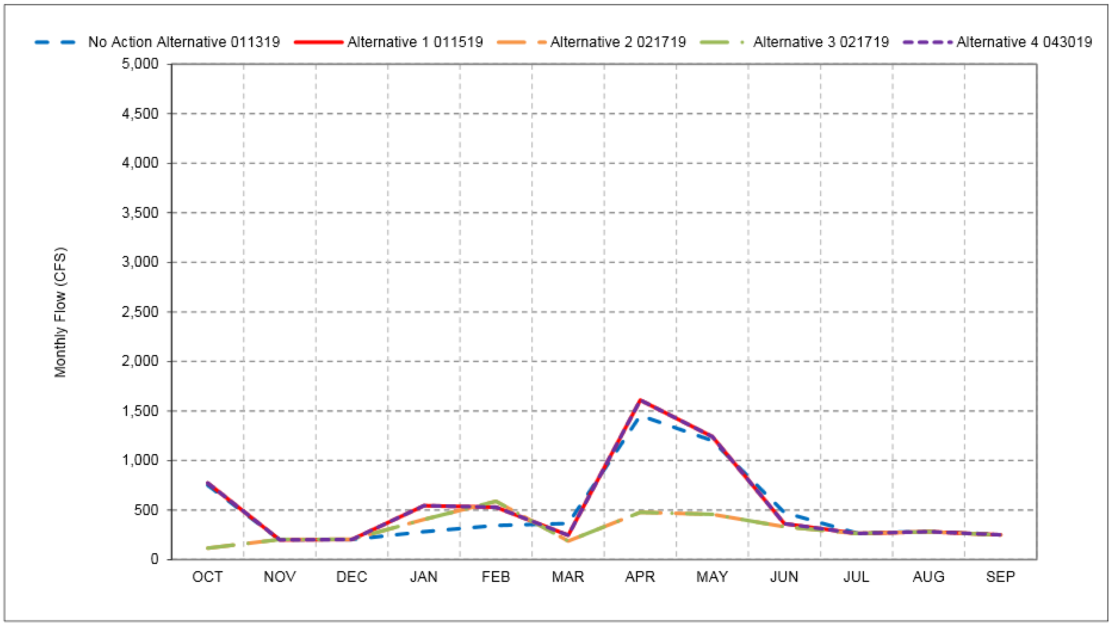
*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-26. Stanislaus River Flow below Goodwin, Wet Year Average Flow



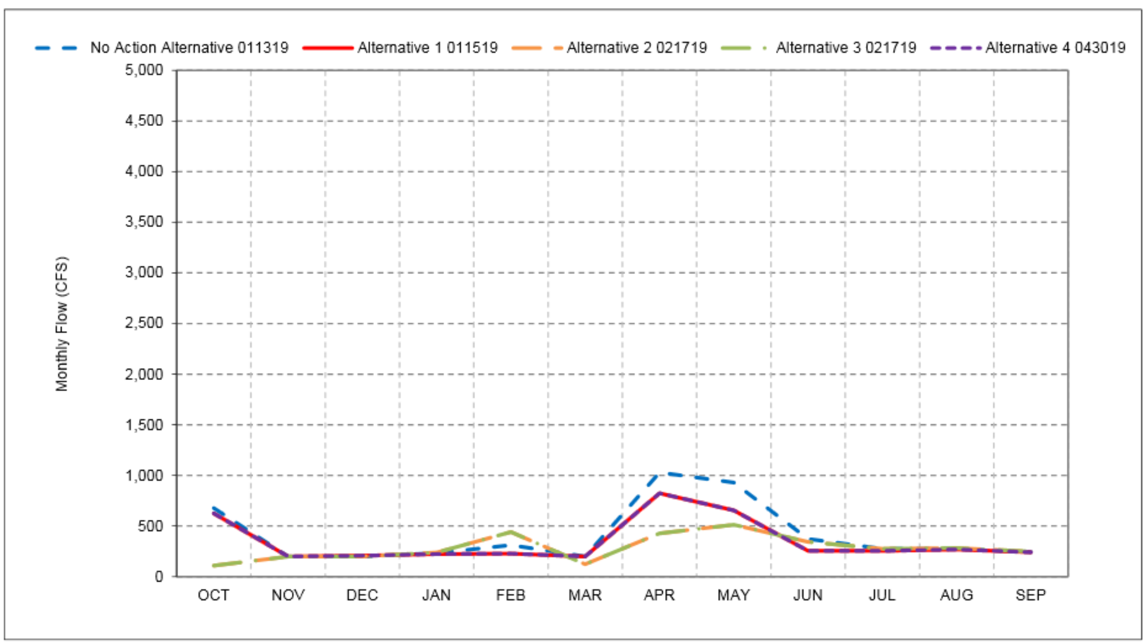
*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-27. Stanislaus River Flow below Goodwin, Above Normal Year Average Flow



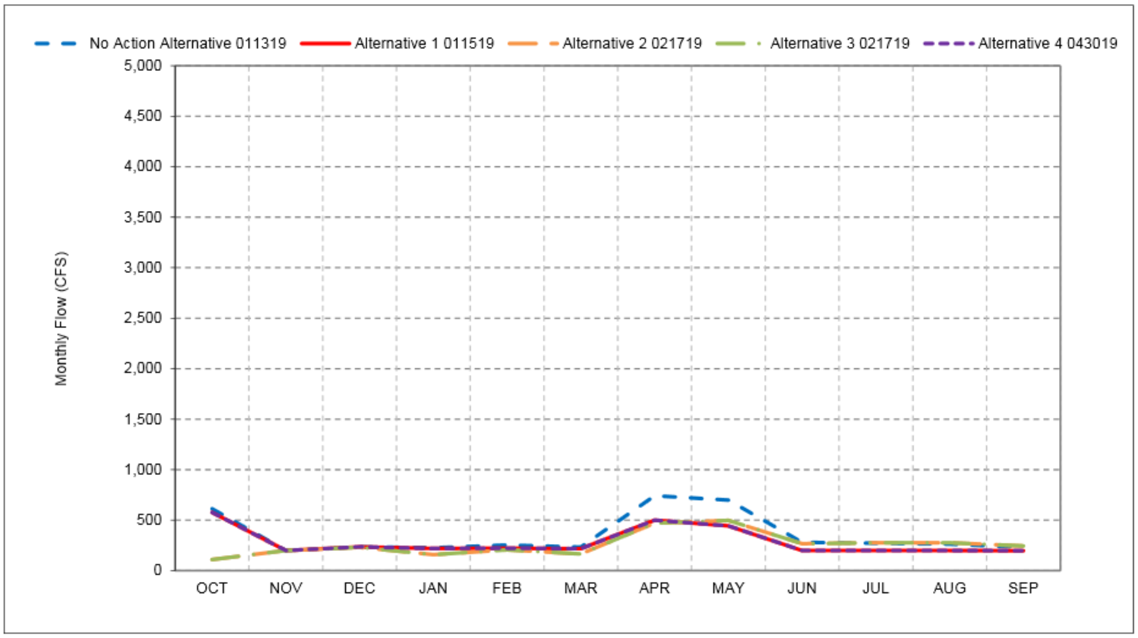
*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-28. Stanislaus River Flow below Goodwin, Below Normal Year Average Flow



*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-29. Stanislaus River Flow below Goodwin, Dry Year Average Flow

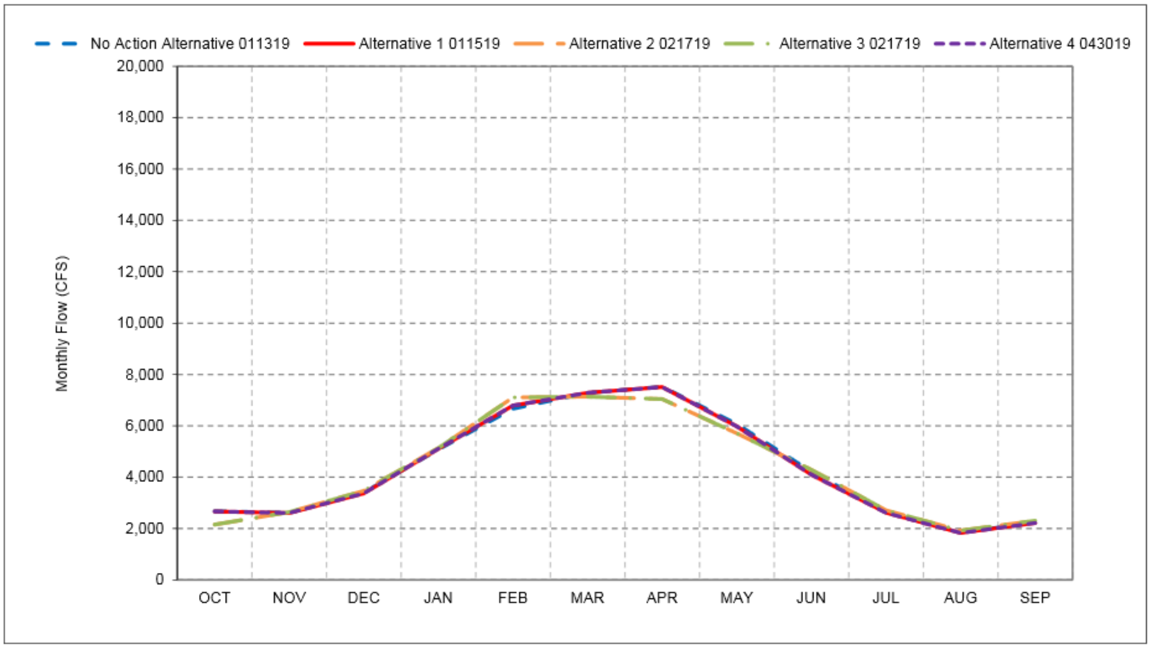


*As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.
*New Melones forecasts are used as the basis of water operations.

Figure G.2-30. Stanislaus River Flow below Goodwin, Critical Year Average Flow

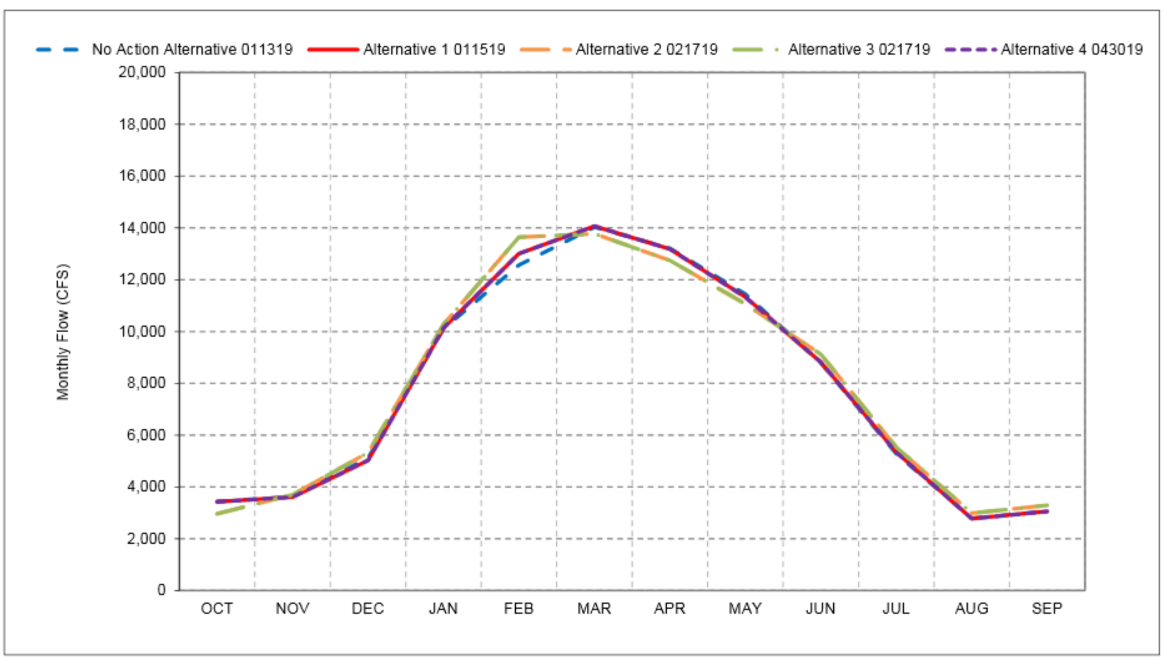
G.2.3.1.7 San Joaquin River

Flows in the San Joaquin River under Alternative 1 would remain similar to those under the No Action Alternative. The analysis modeled flows at four locations on the San Joaquin River: at Gravelly Ford, below the confluence with the Merced River, below Sack Dam, and at Vernalis. There would be no flow change at Gravelly Ford under Alternative 1 as compared to the No Action Alternative. Flow change below the confluence with the Merced River and below Sack Dam would be less than 1%. At Vernalis, Alternative 1 would result in a small decrease in flows for all water year types during October and spring months of March, April, and May. Figures G.2-31 through G.2-36 illustrate flow changes at Vernalis. The minimal change in flow under Alternative 1 would not likely result in increased frequency of exceedances of water quality thresholds in the San Joaquin River.



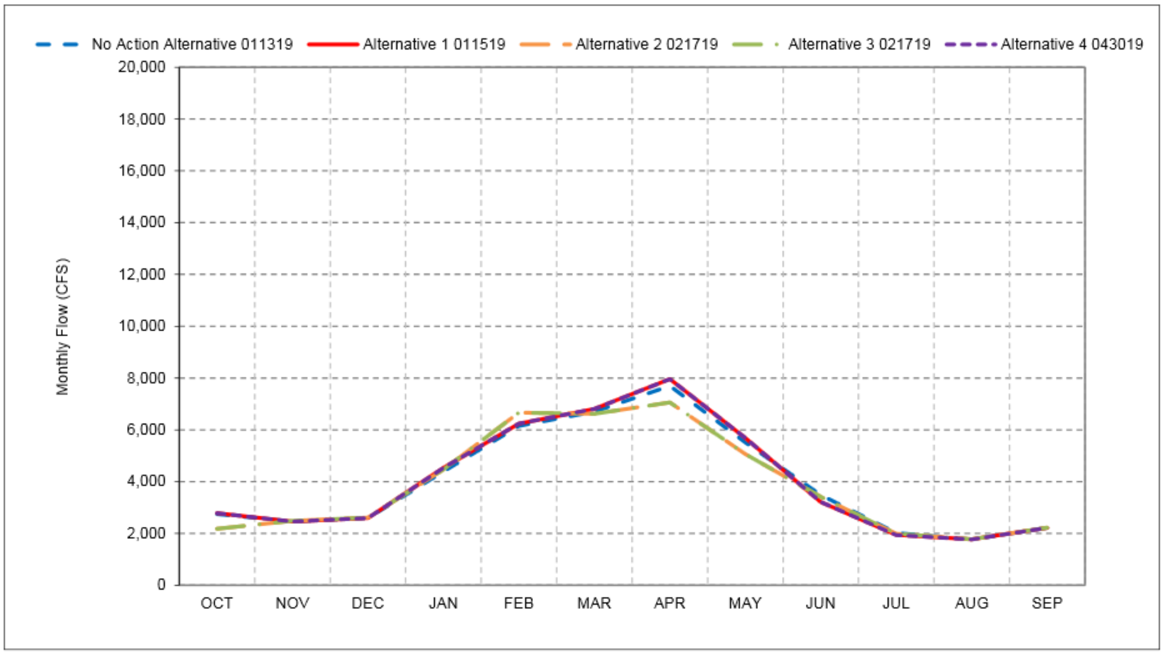
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-31. San Joaquin River at Vernalis, Long-Term Average Flow



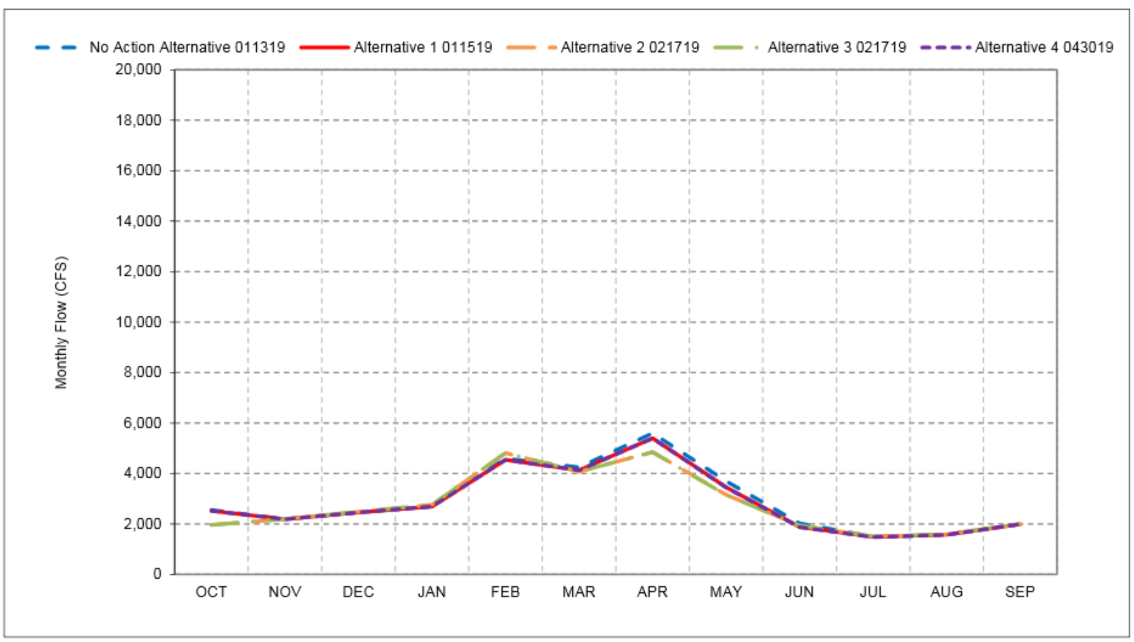
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-32. San Joaquin River at Vernalis, Wet Year Average Flow



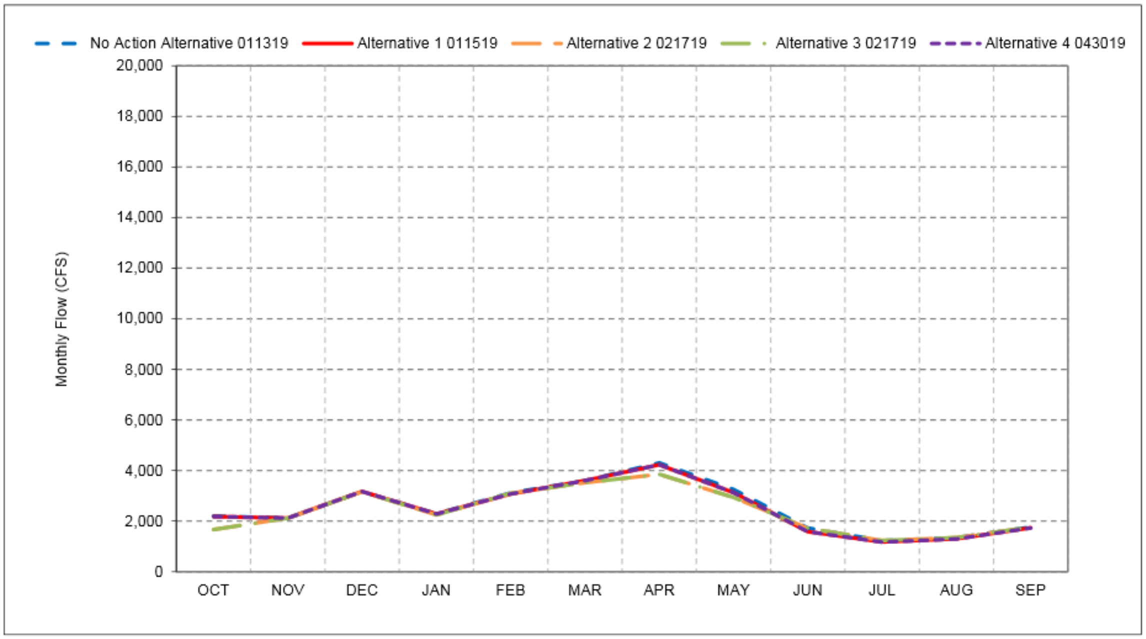
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-33. San Joaquin River at Vernalis, Above Normal Year Average Flow



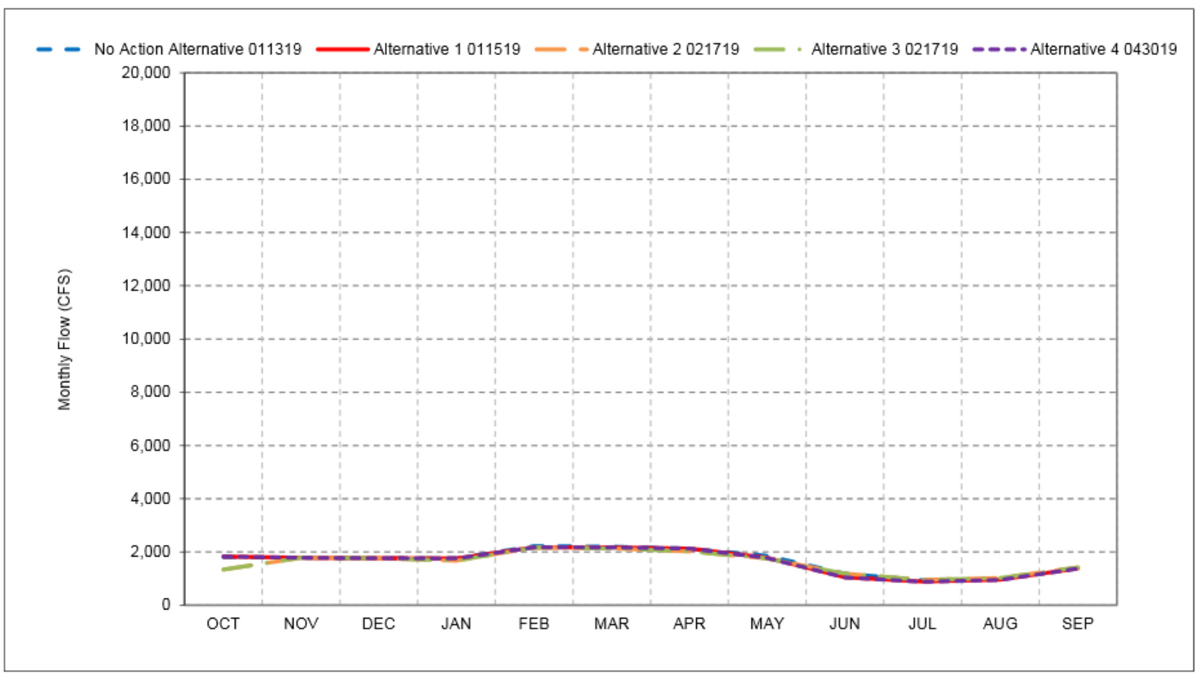
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-34. San Joaquin River at Vernalis, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-35. San Joaquin River at Vernalis, Dry Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-36. San Joaquin River at Vernalis, Critical Year Average Flow

G.2.3.1.8 CVP and SWP Service Area (south to Diamond Valley)

Alternative 1 would generally result in higher monthly average chloride concentrations in the months of September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, as compared to the No Action Alternative. Since this water is delivered to reservoirs for storage in the CVP/SWP reservoirs, reservoir chloride concentrations may increase. While there would be higher chloride concentrations under Alternative 1, relative to the No Action Alternative, in some months, the CVP/SWP would continue to be operated, in real-time, to meet the Bay-Delta WQCP objectives for chloride, which aim to protect municipal and industrial beneficial uses. In the months of September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 1 would not contribute to the impairment of municipal and industrial beneficial uses of the CVP/SWP service area.

G.2.3.1.9 Bay-Delta

Potential Changes in EC

Delta

Monthly average EC levels in the Sacramento River at Emmaton would often be substantially higher in September through December of wet and above normal water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, *Salinity Results (DSM2)*, Table 4-1, Sacramento River at Emmaton Salinity, Figures 4-1 through 4-6, and 4-15 through 4-18). Monthly average EC levels in January through August under Alternative 1 would be similar to No Action Alternative EC levels (Appendix F, Attachment 3-6, Table 4-1, Figures 4-7 through 4-14).

Monthly average EC levels in the San Joaquin River at Vernalis under Alternative 1 would, overall, be similar to levels occurring under the No Action Alternative (Appendix F, Attachment 3-6, Table 6-1, Figures 6-1 through 6-18). Somewhat higher monthly EC levels would occur in the months of April and May under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, Figures 6-10 and 6-11).

Monthly average EC levels in the San Joaquin River at Jersey Point, like the Sacramento River at Emmaton, would often be substantially higher in September through December of wet and above normal water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-1, Figures 7-2, 7-3, 7-15 through 7-18). Other months would also see somewhat higher EC levels under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-1, Figures 7-7 through 7-14).

Monthly average EC levels at the Banks and Jones pumping plants under Alternative 1, relative to the No Action Alternative, would be higher in September through January, most notably in wet and above normal water year types (Appendix F, Attachment 3-6, Tables 15-1 and 16-1, Figures 15-1 through 15-6 and 16-1 through 16-6). In February through August, monthly average EC levels under Alternative 1 would be similar to or lower than No Action Alternative EC levels (Appendix F, Attachment 3-6, Tables 15-1 and 16-1, Figures 15-8 through 15-14 and 16-8 through 16-14).

If the Summer-Fall Delta Smelt Habitat action under Alternative 1 includes a Fall X2 action, EC levels under Alternative 1 could be different than discussed above. The Fall X2 action could result in EC levels being lower than modeled, particularly in the western Delta, resulting in less of a difference between Alternative 1 and the No Action Alternative in the fall.

While there would be higher monthly average EC levels under Alternative 1 relative to the No Action Alternative, in some months, the CVP and SWP would continue to be operated, in real-time, to meet the Bay-Delta WQCP objectives for EC. The objectives are for protecting agricultural, and fish and wildlife beneficial uses. The western Delta EC objectives for the Sacramento River at Emmaton and San Joaquin River at Jersey Point for agricultural beneficial use protection apply from April through June, July, or August, depending on water year type (SWRCB 2006). The San Joaquin River at Jersey Point objective for fish and wildlife protection also applies during April and May (SWRCB 2006). During these months, the monthly average EC levels under Alternative 1 would be similar to the No Action Alternative (Appendix F, Attachment 3-6, Tables 4-1 and 7-1). The southern Delta EC objectives for the protection of agricultural uses for the San Joaquin River at Vernalis and the export area for Banks and Jones pumping plant apply year-round. Banks and Jones pumping plants would have higher EC levels in the fall, but lower monthly average EC in spring and summer, relative to the No Action Alternative (Appendix F, Attachment 3-6, Tables 15-1 and 16-1). Monthly average EC levels at Vernalis under Alternative 1 would be overall similar to the No Action Alternative (Appendix F, Attachment 3-6, Table 6-1). Thus, the differences in EC in the Delta under Alternative 1, relative to the No Action Alternative, would not contribute to agricultural or fish and wildlife beneficial use impairments in the Delta.

Suisun Marsh

In the Sacramento River at Collinsville, which is a Bay-Delta WQCP compliance location for the eastern portion of Suisun Marsh, monthly average EC levels would be substantially higher under Alternative 1, relative to the No Action Alternative, in September through December of wet and above normal water year types (Appendix F, Attachment 3-6, Table 11-1, Figures 11-2 and 11-3). The EC differences would occur primarily at the low end of the modeled EC range; there is little difference between the upper monthly average EC levels at Collinsville under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, Figures 11-15 through 11-18). Higher monthly average EC levels would also occur in December through May of all water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 11-1, Figures 11-1, 11-7 through 11-11, and 11-18).

One Alternative 1 component is to operate the Suisun Marsh Salinity Control Gates, in coordination with the Roaring River Distribution System west-side drain, during September and October following above normal and wet water years to achieve a target low salinity zone areal extent for the benefit of Delta Smelt. Another Alternative 1 component is increased Suisun Marsh Salinity Control Gates operation to direct more fresh water into Suisun Marsh. The component involves closing the gates on flood tides and opening the gates on ebb tides to reduce salinity within the marsh, potentially in late spring/summer of drier water years, depending on salinity conditions. Reclamation and DWR would coordinate monitoring the process to ensure that water operations are undertaken as necessary to minimize the potential for unintended salinity changes in the Suisun Bay and the Sacramento–San Joaquin River confluence area. Thus, the proposed operation of the SMSCG would not contribute to adverse effects to salinity parameters, such as the EC.

Suisun Bay and San Francisco Bay

Based on the modeling results discussed above, the EC of Delta outflow under Alternative 1 may be different than that which would occur under the No Action Alternative in certain months of certain water year types. Alternative 1 would result in lower Delta outflow rates, relative to the No Action Alternative, notably in the months of September, October, November, April, and May (Appendix F, Modeling, Attachment 3-2, *Flow Results* [CalSim II], Table 41-1). The differences in Delta EC and outflow could cause the freshwater-seawater salinity gradient within Suisun Bay and the northern portion of San Francisco Bay to be different between Alternative 1 and the No Action Alternative. The evaluation does not expect the differences to result in substantial changes in overall salinity conditions within Suisun Bay and San Francisco Bay, because seawater is the predominant source of salinity in the bays.

Potential Changes in Chloride

The discussion below provides an assessment of differences between chloride at the five assessment locations – Contra Costa Pumping Plant #1, San Joaquin River at Antioch, Banks and Jones pumping plants, and North Bay Aqueduct – under Alternative 1 as compared to the No Action Alternative. The assessment is based on modeling results presented in Appendix F, Attachment 3-10, *Salinity Results (DSM2)*.

Monthly average chloride concentrations at Contra Costa Pumping Plant #1 would often be substantially higher in October through December of wet and above normal water year types, and somewhat higher in September and January of all water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 19-1, Figures 19-1 through 19-18). In April and May of all water year types, chloride concentrations would be somewhat lower than would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-1, Figures 19-10 and 19-11). Monthly average chloride concentrations in the months of February, March, and June through August would be similar to concentrations under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-1, Figures 19-8, 19-9, and 19-12 through 19-14).

Monthly average chloride concentrations in the San Joaquin River at Antioch would often be substantially higher in September through December of wet and above normal water year types, and somewhat higher in these months in dry and critical water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 20-1, Figures 20-1 through 20-6). In the months of January through August, monthly average chloride concentrations would also be somewhat higher in all water year types (Appendix F, Attachment 3-10, Table 20-1, Figures 20-7 through 20-14).

Monthly average chloride concentrations at Banks and Jones pumping plants would be somewhat higher in the months of September through January of all water year types under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 21-1 and Table 22-1, Figures 21-1 through 21-6 and 22-1 through 22-6). In the months of February through August, monthly average chloride concentrations under Alternative 1 would be similar to or lower than those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 21-1 and Table 22-1, Figures 21-8 through 21-14, and 22-8 through 22-14).

Monthly average chloride concentrations in Barker Slough at the North Bay Aqueduct under Alternative 1 would be the same as concentrations that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 23-1, Figures 23-1 through 23-18).

If the Summer-Fall Delta Smelt Habitat action under Alternative 1 includes a Fall X2 action, chloride concentrations under Alternative 1 could be different than discussed above. The Fall X2 action could result in chloride concentrations being lower than modeled, particularly in the western Delta, resulting in less of a difference between Alternative 1 and the No Action Alternative in the fall.

In summary, Alternative 1 would generally result in higher monthly average chloride concentrations in the months of September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, as compared to the No Action Alternative. While there would be higher chloride concentrations under Alternative 1, relative to the No Action Alternative, in some months, the CVP and SWP would continue operate, in real-time, to meet the Bay-Delta WQCP objectives for chloride, which are for protection of municipal and industrial beneficial uses. In the months of September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006). Maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 1 would not contribute to the impairment of municipal and industrial beneficial uses of Delta waters.

Suisun Bay, Suisun Marsh, and San Francisco Bay waters are not designated for municipal and domestic supply uses, and other salinity-related effects in these waters are addressed above in the EC discussion.

Potential Changes in Bromide

Data correlates Delta bromide concentrations with Delta EC levels and chloride concentrations (DWR 2012; Denton 2015). The relationships between bromide and EC, and bromide and chloride vary by Delta location, season, hydrology, and Delta barrier operations (Denton 2015). During periods of low Delta outflow, such as the summer and fall, seawater can dominate at certain locations, making seawater the primary source of bromide to the Delta (Denton 2015). During periods of high outflow, agricultural return flow can be the primary source of bromide at certain locations (Denton 2015). A relationship developed by DWR (2012) for export locations in the Delta with less than 40% seawater expresses the concentration of bromide as a function of EC as follows:

$$CBr- = 0.0004EC - 0.0364$$

where EC is the monthly average electrical conductivity (µmhos/cm) level and CBr- is the monthly average bromide concentration (mg/L)

The EC modeling results show that EC, on average, would be higher at some Delta locations in some months under Alternative 1, relative to the No Action Alternative (Appendix F, Attachment 3-6). For example, in Old River at Rock Slough, long-term monthly average EC under Alternative 1 would be 93 to 264 µmhos/cm higher than under the No Action Alternative in September through December (Appendix F, Attachment 3-6, Table 8-1 and Figures 8-1 through 8-18). Based on the above equation, this corresponds to long-term monthly average bromide concentrations being between 37 and 105 µg/L higher than under the No Action Alternative. At the Banks and Jones pumping plants, the long-term monthly average EC would be 44 to 193 µmhos/cm higher than under the No Action Alternative in the months of September through December (Appendix F, Attachment 3-6, Tables 15-1 and 16-1, Figures 15-1 through 15-18, and Figures 16-1 through 16-18). This corresponds to long-term monthly average bromide concentrations being between 18 and 77 µg/L higher than under the No Action Alternative at the pumping plants. The months of September through December are generally when EC would be highest at these locations compared to other times of the year (Appendix F, Attachment 3-6, Tables 8-1, 15-1, and 16-1); thus, bromide concentrations would also expect to be highest in these months compared to other times of the year.

As described in Section G.1.9, there are not federal or state adopted water quality criteria for bromide applicable to the Delta. Bromide is a constituent of concern for drinking water treatment due to bromide being a precursor to the formation of bromate, bromoform, trihalomethanes, and other brominated disinfection byproducts when water containing bromide is treated for municipal drinking water supplies.

To meet current drinking water regulations for disinfection byproducts, CALFED (2007a) determined that bromide from 100 to 300 µg/l (and total organic carbon from 4 to 7 mg/L) is acceptable to provide users adequate flexibility in their choice of treatment method.

Historical monitoring data compiled for the CALFED *Water Quality Program Stage 1 Final Assessment* (CALFED 2007b) shows that bromide concentrations at drinking water intakes can be highly variable. Bromide concentrations at Banks and Jones pumping plants ranged from less than 50 to over 600 µg/L from 1990 to 2006, and at Old River and Rock Slough concentrations ranged from 50 to over 600 µg/L from 1990 to 2006 (CALFED 2007b). The CALFED Final assessment (2007b) estimated that running annual average concentrations of bromide range from 89 to 424 µg/L at Banks and Jones pumping plants, and 133 to 190 µg/L at Contra Costa Water District intakes on Old River and Rock Slough. Thus, concentrations of bromide at Delta drinking water intake locations are highly variable and have historically fallen outside of the range of 100 to 300 µg/l.

The potentially higher bromide concentrations under Alternative 1, relative to the No Action Alternative, could result in greater potential for disinfection byproduct formation in drinking water supplies that use Delta source waters, but the degree to which this would occur is uncertain. Treatment plants that use the Delta as a source for drinking water already experience highly variable bromide concentrations and, thus, must implement appropriate treatment technologies to ensure compliance with drinking water regulations for disinfection byproducts. Despite the potential for higher bromide concentrations under the Alternative 1, relative to the No Action Alternative, at specific times and locations, it is expected that Alternative 1 would not contribute to drinking water impairments related to bromide, relative to those that would occur under the No Action Alternative.

If the Summer-Fall Delta Smelt Habitat action under Alternative 1 includes a Fall X2 action, bromide concentrations under Alternative 1 could be different than discussed above. The Fall X2 action could result in bromide concentrations being lower, particularly in the western Delta, resulting in less of a difference between Alternative 1 and the No Action Alternative in the fall.

Because Suisun Bay and San Francisco Bay are not designated for municipal and domestic supply use, and seawater is the primary source of bromide in the western Delta, changes in bromide concentrations in the Delta outflow to the bays are not of concern in these water bodies relative to drinking water supplies or other beneficial uses.

Potential Changes in Methylmercury

Long-term average water column concentrations of methylmercury in the Delta under Alternative 1 would be the same as, or slightly (0.01 ng/L) lower than, those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2, Modeled Methylmercury Concentrations in Water). Thus, Alternative 1 would not contribute to higher concentrations of methylmercury in the Delta through changes in source water inflows.

All modeled fish tissue concentrations exceed the water quality objective of 0.24 mg/kg under the No Action Alternative and Alternative 1, as shown by fish tissue concentration results (Appendix G, Attachment 1, Tables G1.5-1, Methylmercury Concentrations in 350 millimeter Largemouth Bass Fillets for the No Action Alternative and G1.5-2, Methylmercury Concentrations in 350 millimeter Largemouth Bass Fillets for Alternative 1, and Comparison to No Action Alternative, and by the EQs plotted and provided in Appendix G, Attachment 1, Figures G1.5-1 and G1.5-2, Level of Concern Exceedance Quotients for Mercury Concentrations in 350 millimeter Largemouth Bass Fillets for All Years); all EQs are greater than 1.0. Under Alternative 1, fish tissue methylmercury concentrations would be from 1 to 4% lower at all modeled locations, except San Joaquin River at Stockton and Barker Slough at North Bay

Aqueduct Intake, where concentrations would be 1% higher, as compared to the No Action Alternative, for the entire period modeled (Appendix G, Attachment 1, Table G1.5-2). For the drought period modeled, fish tissue methylmercury concentrations would be from 1% to 7% lower at all modeled locations, except San Joaquin River at Stockton, where concentrations would be 2% higher, as compared to the No Action Alternative (Appendix G, Attachment 1, Table G1.5-2). Based on the overall lower methylmercury concentrations at almost all modeled Delta locations, water operations under Alternative 1 would not contribute to the additional water quality degradation with respect to methylmercury, or to increased health risks to wildlife or human consuming wildlife, as compared to the No Action Alternative. Thus, the differences in methylmercury in the Delta under Alternative 1, relative to the No Action Alternative, would not contribute to additional beneficial use impairments in the Delta.

Long-term average methylmercury concentrations in the western Delta under Alternative 1 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.5-2). Alternative 1 would result in lower Delta outflow rates, notably in the months of September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results* (CalSim II), Table 41-1). Thus, water operations under Alternative 1 would not contribute to the additional water quality degradation with respect to methylmercury or increased bioaccumulation in biota in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Selenium

Based on modeled Delta water concentrations, presented in Appendix G, Attachment 2, Table G2.2-1, Modeled Period Average Selenium Concentrations in Water for No Action Alternative and Alternatives 1 through 4, selenium concentrations in the Delta under Alternative 1 would be similar or lower than those occurring under the No Action Alternative. Long-term average selenium concentrations in the water column at the three western Delta locations under Alternative 1 would be identical to conditions under the No Action Alternative. Thus, Alternative 1 would not contribute to the additional water quality degradation with respect to selenium, as compared to the No Action Alternative.

Modeled selenium concentrations in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 1 are similar to those modeled for the No Action Alternative, as shown in Appendix G, Attachment 2, Table G2.3-1, Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative and Alternative 1. EQs computed for the applicable toxicity benchmarks show that selenium concentrations in biota under both the No Action Alternative and Alternative 1 would be below the thresholds identified for ecological risk (Appendix G, Attachment 2, Tables G2.3-5, Summary Table for Selenium Concentrations in Biota, and Comparisons for No Action Alternative to Benchmarks, and G2.3-6, Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 1 to No Action Alternative and Benchmarks, Figures G2.3-1 through G2.3-4). Thus, Alternative 1 would not result in increased health risks to wildlife or human consuming wildlife associated with whole-body fish, bird eggs (invertebrate diet), bird eggs (fish diet), and fish fillets, as compared to the No Action Alternative.

Modeled selenium concentrations in whole-body Sturgeon (*Acipenseridae*) in the western Delta under Alternative 1 also are similar to or slightly lower than those modeled for the No Action Alternative (Appendix G, Attachment 2, Tables G2.3-10, Summary of Period Average Selenium Concentrations in whole-body Sturgeon, and G2.3-12, Percent Change in Selenium Concentrations in Whole Body Sturgeon Relative to No Action Alternative). Low Toxicity Threshold EQs are less than 1.0 for the entire 82-year period modeled and slightly exceed 1.0 for the drought period modeled (Appendix G, Attachment 2, Table G2.3-11, Comparison of Annual Average Selenium Concentrations in Whole-body Sturgeon to Toxicity Thresholds, and Figure G2.3-5, Low Toxicity Threshold Exceedance Quotients for Selenium Concentrations in Whole-body Sturgeon for Drought Years), and Alternative 1 numbers are similar to the

No Action Alternative. Modeled EQs for the High Toxicity Threshold at all locations are less than 1.0 for the entire period modeled and the drought period modeled, and Alternative 1 numbers are similar to the No Action Alternative. Thus, Alternative 1 would not result in increased health risks to wildlife or human consuming wildlife associated with sturgeon, as compared to the No Action Alternative.

Long-term average water column selenium concentrations in the western Delta under Alternative 1 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Alternative 1 would result in lower Delta outflow rates, notably in the months of September, October, November, April, and May (Appendix F*,* Attachment 3-2, *Flow Results* (CalSim II), Table 41-1). Thus, Alternative 1 would not contribute to additional water quality degradation with respect to selenium or increased bioaccumulation in biota in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Trace Metals

Trace metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, silver, and zinc, occur naturally in the river inflows to the Delta. Trace metals concentrations in the Sacramento and San Joaquin rivers, the primary inflows that would be affected by Alternative 1, are below applicable water quality objectives/criteria and this below impairment levels (SWRCB 2017aq). In general, concentrations of trace metals within the Delta are at levels that do not cause beneficial use impairments (SWRCB 2017aq). The trace metals-related impairments in the Delta include arsenic in the western Delta, copper in the portion of Bear Creek in the eastern portion of the Delta, and copper and zinc in the portion of the lower Mokelumne River within the Delta (SWRCB 2017aq; Section G.1.8). The Delta inflows from the Sacramento River and San Joaquin River that would occur under Alternative 1 would not affect these impairments due to trace metals. The Sacramento River and San Joaquin River inflows that would occur under Alternative 1 would not result in additional impairments in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative, because trace metals conditions within these rivers are applicable water quality objectives and thus below impairment levels.

Potential Changes in Nutrients

The primary nutrients considered in this analysis include ammonium, nitrate, and phosphorus. The two main anthropogenic sources of these nutrients in the Delta are urban point sources (wastewater effluent), and agricultural non-point sources (agricultural runoff and return flows of fertilizers mixed in irrigation water). Nutrient removal projects by two major wastewater treatment plants that discharge into the Sacramento and San Joaquin rivers watersheds and the Delta (i.e., Sacramento Regional Wastewater Treatment Plant and Stockton Regional Wastewater Control Facility) will be complete by 2025. Agricultural non-point source discharges are regulated under the Central Valley RWQCB's *Irrigated Lands Regulatory Program Waste Discharge Requirements*, which mandates nutrient monitoring in the major agricultural reaches, implementing best management practices (BMPs) to reduce nutrient discharges to streams, and controlling fertilizer application and management.

Alternative 1 would result in some differences in Delta inflow rates from the Sacramento River and San Joaquin River, relative to the No Action Alternative. Alternative 1 could create differences in the proportion of Sacramento River and San Joaquin River water at various Delta locations, which may result in differences in nutrient distributions relative to the No Action Alternative at various Delta locations. The analysis anticipates that any difference in nutrient distributions under Alternative 1, relative to the No Action Alternative, would be minimal. Nutrient loadings would be reduced throughout the entire Delta by the regulatory processes described above by 2025. Thus, the evaluation does not expect river inflows under Alternative 1 to contribute to differences in Delta nutrient concentrations or in nutrient distributions that would result in adverse effects to beneficial uses or substantially degrade the water quality, relative to the nutrient conditions that would occur under the No Action Alternative.

Because nutrient concentrations in the Delta under Alternative 1 are not expected to be substantially different from those that would occur under the No Action Alternative, this evaluation does not expect substantial differences in nutrient concentrations in Delta outflow to Suisun Bay and Marsh, and San Francisco Bay. However, there could be some nutrient loading differences from the Delta to Suisun Bay and Marsh, and San Francisco Bay because of Delta outflow differences. Alternative 1 would result in lower Delta outflow rates, relative to the No Action Alternative, notably in the months of September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-1). Thus, it is possible that nutrient loading to Suisun Marsh, Suisun Bay, and San Francisco Bay may be slightly lower under Alternative 1, relative to the No Action Alternative, in September, October, November, April, and May, when Delta outflow would be lower.

The evaluation does not expect any potential lower nutrient loading from the Delta to Suisun Bay and Marsh, and San Francisco Bay due to different outflow patterns under Alternative 1, relative to the No Action Alternative, to adversely impact primary productivity in these embayments for several reasons. First, there are numerous drivers of primary productivity throughout Suisun Bay and Marsh, and San Francisco Bay. They include high turbidity (light limitation), strong tidal mixing (breaks down stratification and reduces light availability), and abundant grazing (removes phytoplankton from the water column). These factors, not nutrients, currently limit algal production within the embayments (references within SFEI 2016). Thus, any minor change to nutrient loading that may occur under Alternative 1, relative to the No Action Alternative, would not result in lower primary productivity rates in these areas. Second, although Suisun Bay and San Francisco Bay have been nutrient enriched for many years, there is evidence that current nutrient levels are starting to cause adverse effects to the phytoplankton community. Recent observations indicate a shifting phytoplankton community composition away from healthy assemblages towards algal species that form harmful algae blooms (Senn and Novick 2014 and references within). As such, the potential for slightly lower nutrient loadings during certain months of the year due to a change in Delta outflows may be beneficial to Suisun Bay and Marsh, and San Francisco Bay. Finally, the only postulated effect of changes in phosphorus loads to Suisun and San Francisco Bays is related to the influence of nutrient stoichiometry on primary productivity. However, any changes to phosphorus loads under Alternative 1 would be proportional to changes to nitrogen loads, thus the ratios of these two nutrients are expected to change negligibly, if at all. In addition, any effect on phytoplankton community composition would likely be small compared to the effects of grazing from introduced clams and zooplankton in the estuary (Senn and Novick 2014; Kimmerer and Thompson 2014). Therefore, this evaluation does not expect the differences in total nitrogen and phosphorus loading that would occur in Delta outflow to Suisun Bay and Marsh, and San Francisco Bay, relative to the No Action Alternative, to result in water quality degradation with regard to nutrients that would result in adverse effects to beneficial uses or the further impairment of Suisun Bay and Marsh, or San Francisco Bay.

Potential Changes in Dissolved Oxygen

Dissolved oxygen levels in Delta, Suisun Bay and Marsh, and San Francisco Bay waters are primarily affected by water temperature, flow velocities, nutrients (e.g., phosphorus and nitrogen), and the photosynthesis, respiration, and decomposition of aquatic organisms. The sediment oxygen demand of organic material deposited in the low velocity channels also affects dissolved oxygen levels in Delta waters.

The potential for differences in these factors and dissolved oxygen decreases to occur under Alternative 1, relative to the No Action Alternative, are addressed below.

- *Temperature:* Atmospheric exchange processes primarily drive Delta, Suisun Marsh, and Suisun Bay water temperatures on both short and long timescales (Kimmerer 2004; Wagner et al. 2011; Vroom et al. 2017; Enright et al. 2013). Ocean inflow primarily drives Northern San Francisco Bay water temperature (Vroom et al. 2017). Thus, the differences in Delta inflows that would occur under Alternative 1, relative to the No Action Alternative, would not result in water temperature differences what would lead to lower dissolved oxygen levels.
- *Channel Velocities:* The relative degree of tidal exchange, flows, and turbulence that contributes to exposure of Delta, Suisun Bay and Marsh, and San Francisco Bay waters to the atmosphere for reaeration would not be substantially different from the No Action Alternative. The water bodies would continue to experience the daily ebb and flood tides that contribute to water movement within the channels, which contributes to the water column's reaeration.
- *Nutrients:* The primary oxygen-demanding nutrient is ammonium. The major ammonium sources to the Delta are wastewater treatment plant discharges, and treatment plant modifications have been or are being implemented to reduce ammonia discharges (Section G.1.8). Nutrients can also affect dissolved oxygen by promoting aquatic plants biostimulation. However, as described above, the evaluation does not expect Alternative 1 to result in changes in nutrient levels within Delta, Suisun Marsh and Bay, and San Francisco Bay waters, relative to the No Action Alternative, that would encourage additional biostimulation of algae or aquatic plants.
- *Sediment Oxygen Demand:* The differences in Delta inflows that would occur with Alternative 1, relative to the No Action Alternative, would not result in higher concentrations of organic material in the Delta, Suisun Bay and Marsh, and San Francisco Bay sediments that would lead to higher oxygen demand.

Section 303(d) lists some waterways in the eastern, southern, and western Delta as impaired by low oxygen levels (Section G.1.8). A TMDL has been approved for the Stockton Deep Water Ship Channel in the eastern Delta to control the discharge of oxygen-demanding substances, and aerators operated by the Port of Stockton improved dissolved oxygen conditions within the channel. Alternative 1 would not result in changes in Delta inflows, relative to the No Action Alternative, that would make the impairment worse. Alternative 1 would not make the other dissolved oxygen impairments in the Delta worse, relative to the No Action Alternative.

Operations of the managed wetlands and associated discharges cause the current Suisun Marsh dissolved oxygen impairments (Section G.1.8). Therefore, changes in Delta flows into the marsh that could occur under Alternative 1 would not make this impairment worse, relative to the No Action Alternative.

Potential Changes in Pathogens

Delta pathogens levels are more closely related to what happens in the proximity of a particular Delta location than to what happens in the larger watershed where substantial travel time and concomitant pathogen die-off can occur (Section G.1.8). Thus, the differences in Delta inflows under Alternative 1, relative to the No Action Alternative, would not contribute to higher pathogens levels within the Delta.

Potential Changes in Legacy Contaminants

The Delta is on the SWRCB's CWA Section 303(d) list as impaired by dioxin and furan compounds, PCBs, and PAHs (Section G.1.8). It lists Suisun Bay and San Francisco Bay for dioxin and furan compounds, and PCBs. Dioxin and furan compounds, PCBs, and PAHs are identified as "legacy contaminants" because of their persistence in the environment long after use.

River inflows are not the primary sources of dioxin and furan compounds, PCBs, and PAHs in the Delta (Section G.1.9). The Delta's primary source of dioxin and furan compounds and PAHs in watersheds in atmospheric deposition, which, in turn, enters water bodies via stormwater runoff. The Delta's primary source of PCBs is the suspension and transport of Bay suspended sediment into the western Delta on flood tides. Dioxin and furan compounds, PCBs, and PAHs deposition and transport would continue to occur independent of CVP/SWP operation. Thus, changes in river inflows to the Delta due to Alternative 1 implementation would not substantially affect concentrations of dioxin and furan compounds, PCBs, and PAHs in the Delta, relative to the No Action Alternative. For these same reasons, Suisun Bay and San Francisco Bay concentrations of dioxin and furan compounds, and PCBs would not be substantially affected by Alternative 1, relative to the No Action Alternative.

Potential Changes in Pesticides

Effects from CVP/SWP Operation

Pesticide concentrations in the Delta, Suisun Bay and Marsh, and San Francisco Bay waters are primarily affected by surface water and stormwater discharges from agricultural and urban land use areas (Central Valley RWQCB 2006, 2014, 2017b). Applications by structural pest control professionals and over-the-counter pesticide use can be among the greatest contributors of pesticides in urban runoff (San Francisco Bay RWQCB 2005). Pyrethroid insecticide use in urban areas is relatively consistent throughout the year, while agricultural pyrethroid use is highest in the winter (Central Valley RWQCB 2017b). Individual pesticide use and the resulting concentrations in receiving waters can vary seasonally, by source, and depend on weather patterns that influence runoff and river flows.

Differences in the Sacramento River and San Joaquin River inflows to the Delta between Alternative 1 and the No Action Alternative could lead to differing pesticide concentrations within Delta waterways, or in the Delta outflow to Suisun Marsh and Bay, and San Francisco Bay. The difference would depend on the relative presence and concentrations of pesticides in the inflows of these rivers, and the relative contributions from other Delta inflows and in-Delta sources.

Several factors affect the presence of pesticides in Delta inflows. Pesticides must be used in a location with hydrologic connectivity to surface water and in amounts that are not easily diluted in the environment. The pesticide must be transportable, which is largely determined by its individual chemical properties, such as water solubility, vaporization, and soil sorption. The pesticide must be sufficiently stable in the environment, so that residues of the applied pesticide or its degradates, which can also adversely affect beneficial uses, are present during runoff events. If transported to surface waters, sufficient amounts of pesticide must be present so that, once diluted by surface water flows, the resulting concentration is a magnitude that can elicit a measurable effect on beneficial uses. Alternatively, pesticides that are transported in the water column can sorb to particles and settle into the sediment, where they can also affect beneficial uses (Central Valley RWQCB 2017b). Factors unrelated to the pesticide are also important, including substrate erosivity, precipitation amount, irrigation and runoff rates, and time elapsed from application to runoff.

Several pesticide control programs and monitoring efforts in the Delta watershed aim to address past pesticide-related impairments and prevent potential future impairments. The Central Valley RWQCB (2005, 2006, 2014) adopted TMDLs for diazinon and chlorpyrifos for several Section 303(d)-listed segments of the Sacramento River, San Joaquin River, and Delta, as well as to address impairments related to these pesticides. Likewise, the Central Valley RWQCB (2017b) adopted a Basin Plan

Amendment for the control of pyrethroids in the entirety of the Sacramento River and San Joaquin River basins. The Central Valley RWQCB's Delta RMP includes a program to describe the status and trends of pesticide concentrations in the Delta, aiming to support future regulatory and management decisions about pesticides control. Monitoring data may indicate the effectiveness of control programs and identify additional pesticides causing toxicity that may need to be the focus of future regulatory actions. The Central Valley RWQCB Irrigated Lands Regulatory Program aims to prevent agricultural runoff containing pesticides from impairing surface waters (Section G.1.8).

Considering the factors described above, Alternative 1 would not result in substantially higher pesticide concentrations in the Delta in a way that would increase the risk of water quality degradation or pesticide-related toxicity to aquatic life, as compared to conditions that would occur under the No Action Alternative. Several primary factors external to CVP/SWP operation affect pesticide presence and concentrations in Delta inflows and throughout the Delta. The Central Valley RWQCB's external regulatory actions to monitor future pesticide presence in the Delta watershed surface waters and adopt TMDLs and water quality objectives, mean that pesticide conditions in the Delta under Alternative 1 and the No Action Alternative would likely be similar. For the same reasons, this evaluation would expect pesticide conditions in Suisun Bay and Marsh, and San Francisco Bay under Alternative 1 to be similar to No Action Alternative conditions.

Effects due to Clifton Court Forebay Weed Removal Program

The Clifton Court Forebay Weed Removal Program would potentially involve using copper-based herbicides and algaecides to control aquatic weeds and algal blooms in the forebay. Herbicides and algaecides application in Clifton Court Forebay would require coverage under the *Statewide General National Pollutant Discharge Elimination System (NPDES) Permit for Residual Aquatic Pesticide Discharges to Waters of the United States from Algae and Aquatic Weed Control Applications (*General Pesticide Permit; NPDES No. CAG990005; Water Quality Order No. 2013-0002-DWQ, as amended by Orders 2014-0078-DWQ and 2015-0029-DWQ) (SWRCB 2016b). The General Permit covers pesticide applications using products containing 2,4-D, acrolein, calcium hypochlorite, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, sodium hypochlorite, and triclopyr-based algaecides and aquatic herbicides, and adjuvants containing ingredients represented by the surrogate nonylphenol (SWRCB 2016b). To obtain General Permit coverage, the applicant must submit an Aquatic Pesticides Application Plan that includes, among other requirements, BMPs for applying herbicides at an appropriate rate, preventing spill, coordinating with water diverters so beneficial water uses are not impacted, and preventing fish kill, and a monitoring program. Considering that BMP implementation would be required for the General Permit, the Clifton Court Forebay Weed Removal Program would not contribute to additional beneficial use impairments in the Delta related to herbicide applications, as compared to the No Action Alternative.

Potential Changes in Organic Carbon

Delta inflows are a notable source of organic carbon to the Delta, followed by in-Delta sources (Section G.1.8). Alternative 1 would result in some changes in Delta inflow rates from the Sacramento River and San Joaquin River, relative to the No Action Alternative, which could result in changes in the proportion of Sacramento River and San Joaquin River water at various Delta locations. The water proportion changes may result in organic carbon concentration differences relative to the No Action Alternative at various Delta locations.

Source water with total organic carbon between 4 and 7 mg/L is believed sufficient to meet currently established drinking water criteria for disinfection byproducts, depending on the amount of Giardia inactivation required (CALFED 2007a). Sacramento River monthly average total organic carbon concentrations tend to be 3 mg/L or less (Tetra Tech, Inc. 2006). San Joaquin River monthly average total organic carbon concentrations are generally 5 mg/L or less, with the exception of September and October, when concentrations are up to 10 mg/L are more likely (Tetra Tech, Inc. 2006). Considering the relative Sacramento River, San Joaquin River, and in-Delta contributions of total organic carbon to the Delta, this evaluation does not expect that higher San Joaquin River flows to the Delta in September and October would result in contributions to total organic carbon concentrations at Delta drinking water intake locations to be above 7 mg/L more frequently under Alternative 1, relative to the No Action Alternative. In other months, higher San Joaquin River inflows, relative to the No Action Alternative, may contribute to an increased frequency of total organic carbon concentrations being above 4 mg/L at Delta drinking water intake locations, but would not contribute an increased frequency above 7 mg/L, because total organic carbon concentrations tend to be 7 mg/L or less in the other months. Thus, while Sacramento River and San Joaquin River inflow rates to the Delta under Alternative 1 would differ from the No Action Alternative, the river inflow difference would not contribute to Delta total organic carbon concentrations that would negatively affect drinking water treatment operations for Delta waters users.

In Suisun Marsh, managed wetlands followed by watershed stormwater contributions are the primary sources of organic carbon (Section G.1.8). Thus, this evaluation would not expect changes in total organic carbon concentrations in the Delta outflow to Suisun Marsh under Alternative 1, relative to the No Action Alternative, to contribute to adverse effects on organic enrichment conditions within the marsh.

Suisun Bay and San Francisco Bay are not designated for municipal and domestic supply use, thus changes in organic carbon concentrations in the Delta outflow to the bays are not of concern in these water bodies relative to drinking water supplies. However, total organic carbon is an important component of the food web in these water bodies; the Delta provides 68% of the total organic carbon to Suisun Bay and the northern portion of San Francisco Bay (Section G.1.8; Jassby et al. 1993). The Delta also provides the majority of dissolved organic carbon to Suisun Bay and the northern portion of San Francisco Bay, but this is generally less bioavailable to the food web base compared with total organic carbon and/or carbon from primary production (Stepanauskas et al. 2005; Tetra Tech, Inc. 2006).

Alternative 1 would result in lower Delta outflow rates, relative to the No Action Alternative, notably in the months of September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-1). The lower outflow rates could potentially result in reduced total organic carbon and dissolved organic carbon loads to Suisun Bay and San Francisco Bay during those months. A lower dissolved organic carbon load to Suisun and San Francisco Bay would not be expected to adversely affect food webs because dissolved organic carbon is generally less available to the base of the food web compared with particulate organic carbon or carbon from primary production (Tetra Tech, Inc. 2006). Thus, lower dissolved organic carbon inputs under Alternative 1, relative to the No Action Alternative, are unlikely to directly affect the food web (Tetra Tech, Inc. 2006).

Much of the organic carbon transported from the Delta to Suisun Bay and San Francisco Bay is in the form of detritus (Durand 2015). However, total organic carbon contained in freshwater phytoplankton from the Delta represents most of the total organic carbon actually used in the Suisun and northern San Francisco Bay food webs (Kimmerer 2004). Alterations to the Delta's seasonal flow schedule could change how total organic carbon (e.g., phytoplankton) is transported to Suisun Bay and the San Francisco Bay (Kimmerer 2004). This could potentially reduce food availability to consumers in Suisun Bay and the northern portion of the San Francisco Bay during the months flows are lower under Alternative 1, relative to the No Action Alternative (Jassby and Cloern 2000). However, the relationship between flows and total organic carbon inputs may not be linear. For example, phytoplankton in the Delta may bloom primarily when freshwater flow rates are low and residence times are high (references within Kimmerer 2004). As such, it is difficult to ascertain exactly how food webs in Suisun Bay and the northern San Francisco Bay would be affected by the lower Delta outflows and total organic carbon loading under Alternative 1, relative to the No Action Alternative.

G.2.3.2 *Program-Level Effects*

Under Alternative 1, program-level effects would include effects from intake lowering, tidal habitat restoration, increased aquatic weed removal in the Delta, the introduction of dredge material for turbidity, and construction activities associated with facility improvements.

G.2.3.2.1 Tidal Habitat Restoration

The tidal habitat restoration would largely focus on the Delta region. Newly created tidal habitat restoration areas can potentially affect mercury and selenium bioaccumulation, and dissolved organic carbon. The construction of tidal habitat areas and facility improvements are addressed below in Section G.2.3.2.4, *Construction-Related Activities*.

Mercury

Newly created tidal habitat areas have the potential to become new sources of methylmercury to the Delta (Alpers et al. 2008). Methylmercury production is highest in high elevation marshes subjected to wet and dry periods occurring during the highest monthly tidal cycles, as compared to lower elevation marshes not subjected to dry periods (Alpers et al. 2008). Floodplains and seasonally flooded agricultural lands also have relatively high rates of methylmercury production (Alpers et al. 2008). Water and sediment properties determine mercury methylation rates in tidal habitats, including sediment grain size, pH, binding constituent availability (e.g., iron, sulfur, organic matter), and factors influencing the success of the microbes responsible for the methylation process (e.g., nutrients and dissolved oxygen) (Alpers et al. 2008).

DWR is conducting a study of methylmercury import to and export from tidal wetlands in the Delta, Yolo Bypass, and Suisun Marsh (DWR 2015). The study evaluated several hypotheses, including: (1) tidal wetlands are a net source of total methylmercury on an annual basis; (2) tidal wetlands are a net source of total mercury on an annual basis; (3) tidal wetlands have higher total and dissolved methylmercury exports during the warmer, summer months; (4) tidal wetlands are a net source of dissolved mercury and a sink for particulate methylmercury and total mercury on an annual basis; and (5) organic carbon concentrations and methylmercury concentrations are positively correlated. Preliminary results from a tidal wetland in the Yolo Wildlife Area showed the area was a sink for total methylmercury and more often a sink for dissolved methylmercury than a source (DWR 2015). Study of other tidal wetlands is ongoing.

Some habitat restoration activities would likely occur on lands in the Delta formerly used for irrigated agriculture. In-Delta irrigated agriculture can be a substantial source of methylmercury (Central Valley RWQCB 2010a). Thus, the new tidal habitat would not necessarily be a new source of methylmercury to the Delta.

The degree to which new tidal habitat areas may be future sources of methylmercury to the aquatic environment of the Delta is uncertain. The new tidal habitat's specific siting and design would affect the potential for methylmercury generation and transport. However, the amount of tidal habitat restoration area proposed for Alternative 1 is the same as what would occur under the No Action Alternative. Therefore, the new tidal habitat areas would not present additional sources of organic carbon or pose additional risk to fish, wildlife, and humans, relative to the No Action Alternative.

Selenium

Conversion of lands within the Delta to tidal habitat has the potential to result in localized increased water residence times. Water would flow in and out of the restored tidal habitat areas, thus residence times would not increase without bound and water column selenium concentrations would not build up and be recycled in sediments and organisms, as may be the case within a closed system. If increases in fish tissue or bird egg selenium concentrations were to occur, the increases would be of concern primarily where fish tissue or bird egg selenium concentrations are already near or above toxicity benchmarks. Where biota concentrations are currently low and not approaching toxicity benchmarks (which, as discussed in the Project-Levels effect analysis of selenium, is the case throughout the Delta, except for sturgeon in the western Delta), changes in residence time alone would not be expected to cause biota concentrations that approach or exceed toxicity benchmarks. The western Delta and Suisun Bay may have areas where biota tissue concentrations would be high enough that additional bioaccumulation in sturgeon would be a concern.

Several TMDLs were adopted and implemented to address selenium impairments within the Central Valley and San Francisco Bay regions (Section G.1.9). TMDL implementation led to declining selenium contributions to the Delta and within San Francisco Bay, and implementation would continue independent of Alternative 1. Thus, while there is the potential for increased selenium bioaccumulation in biota associated with development of tidal habitat restoration areas, with ongoing implementation of selenium TMDLs, a substantial increase in selenium bioaccumulation in biota would not be expected above that which would occur with the No Action Alternative in a way that would increase risk to fish, wildlife, or humans.

Organic Carbon

Newly-created tidal habitat could potentially lead to new substantial sources of localized total and dissolved organic carbon loading within the Delta. New tidal habitat established in areas presently used for agriculture, which also is a source of total and dissolved organic carbon loading, also could result in a substitution and temporary increase in localized total and dissolved organic carbon loading. Preliminary results from the ongoing DWR study in the Delta found that the tidal habitat in the Yolo Wildlife Area was a sink for both total and dissolved organic carbon (DWR 2015). The degree to which new tidal habitat areas may be future sources of organic carbon to the aquatic environment of the Delta is uncertain. The specific siting and design of the new tidal habitat would likely affect the potential for organic carbon generation and transport. The amount of tidal habitat restoration area proposed for Alternative 1 is the same as what would occur under the No Action Alternative. Therefore, the new tidal habitat areas would not present additional sources of organic carbon to the Delta, Suisun Bay and Marsh, and San Francisco Bay, relative to the No Action Alternative.

G.2.3.2.2 Increased Aquatic Weed Removal

Implementing an aquatic weed removal program that involves herbicides could result in exposing the aquatic system to potentially toxic conditions if not properly managed. Pesticide application would require coverage under the General Pesticide Permit, which would require submittal of an Aquatic Pesticides Application Plan that includes BMPs for applying herbicides at an appropriate rate, preventing spill, coordinating with water diverters so that beneficial uses of water are not impacted, and measures to prevent fish kill (SWRCB 2016b). Considering that implementation of BMPs would be required as part of the General Pesticide Permit requirements, the Increased Aquatic Weed Removal program would not contribute to additional beneficial use impairments related to herbicide applications, as compared to the No Action Alternative.

G.2.3.2.3 Introduce Dredge Material for Turbidity

The program to introduce dredge material to the Delta would be targeted to increase turbidity at specific locations within the Delta for beneficial habitat effects. The sediment augmentation program would be designed for consistency with Central Valley RWQCP objectives for turbidity, i.e., except for periods of storm runoff, turbidity of Delta waters not exceeding 50 Nephelometric Turbidity Units in the Central Delta waters and 150 Nephelometric Turbidity Units in other Delta waters. Thus, the introduction of dredge material to increase turbidity at specific Delta locations is not expected to cause turbidity-related impairments to Delta waters' beneficial uses.

G.2.3.2.4 Construction-Related Activities

Construction activities necessary to implement various facility improvements and tidal habitat restoration areas could result in the direct discharge of contaminants to adjacent Delta waters, due to the work to Delta waterways. Construction activities could include clearing vegetation; grading, excavation and soil placement; and in-channel work, such as dredging. Due to the direct connectivity with Delta channels, these construction activities have the potential to result in direct discharge of eroded soil and construction-related contaminants. The construction activity intensity, along with the fate and transport characteristics of the chemicals used, would largely determine the magnitude, duration, and frequency of construction-related discharges and the resulting concentrations and degradation associated with the specific constituents of concern.

Land surface grading and excavation activities, or the exposure of disturbed sites immediately following construction, but prior to stabilization, could result in rainfall-related soil erosion, runoff, and offsite sedimentation in surface water bodies. Soil erosion and runoff could also result in increased concentrations and loading of organic matter, nutrients (nitrogen and phosphorus), and other contaminants contained in the soil (such as trace metals, pesticides, or animal-related pathogens). Graded and exposed soils also could be compacted by heavy machinery, resulting in reduced infiltration of rainfall and runoff, thus increasing the rate of contaminated runoff to downstream water bodies.

Construction activities would be expected to involve transporting, handling, and using a variety of hazardous substances and non-hazardous materials that may adversely affect water quality if discharged inadvertently to construction sites or directly to water bodies. Typical construction-related contaminants include petroleum products for refueling and machinery maintenance (e.g., fuel, oils, solvents), concrete, paints and other coatings, cleaning agents, debris and trash, and human wastes. Contaminants released or spilled on bare soil also may result in groundwater contamination. Dewatering operations may contain elevated levels of suspended sediment or other constituents that could cause water quality degradation.

The SWRCB's NPDES stormwater program requires permits for discharges from construction activities that disturb one or more acres. SWRCB adopted a general NPDES permit for stormwater discharges associated with construction activity (Construction General Permit) in Order No. 2009-0009-DWQ, which became effective on July 1, 2010 (as amended by revised orders 2010-0014-DWQ and 2012-006-DWQ). The Construction General Permit includes specific requirements based on the site's "risk level." Three different risk levels are dependent on two factors: (1) project sediment runoff risk; and (2) receiving water risk. Obtaining coverage under the Construction General Permit requires filing a Notice of Intent and preparing and implementing a stormwater pollution prevention plan (SWPPP), which specifies BMPs to reduce or eliminate sediment and other pollutants in stormwater as well as non-stormwater discharges. The Construction General Permit requires implementing BMPs that control pollutant discharges using best available technology economically achievable for toxic contaminants, best conventional technology for conventional contaminants, and any other necessary BMPs to meet water quality standards. The Construction General Permit contains technology-based numeric action levels for pH and turbidity, and requires visual monitoring for potential contaminant runoff at all sites, and effluent monitoring at all risk level 2 and 3 sites, with follow-up actions required for exceedances of numeric action levels. Risk level 2 and 3 sites also must prepare and implement Rain Event Action Plans for all storm events forecast to have measurable precipitation. The Construction General Permit specifies runoff reduction requirements for all sites not covered by a municipal NPDES permit, to minimize post-construction stormwater runoff impacts. Implementing the necessary BMPs, as required by the Construction General Permit, would reduce potential adverse discharge effects of constituents of concern.

Facility improvements also may require additional environmental permits, such as CWA Section 401 water quality certifications from the RWQCB, California Department of Fish and Wildlife Streambed Alteration Agreements, and USACE CWA Section 404 dredge and fill permits. These other permit processes may include requirements to implement additional action-specific BMPs to reduce potential adverse discharge effects of constituents of concern associated with construction activities.

While program-level activities could have short-term effects on water quality, implementation of Mitigation Measures WQ-1, WQ-2, WQ-3, and WQ-4, described below in Section G.2.7, *Mitigation Measures*, would reduce the severity of these effects. Adverse impacts to water quality and violations of water quality standards are not expected as a result of program-level activities.

G.2.4 Alternative 2

G.2.4.1 *Project-Level Effects*

Potential changes in water quality

G.2.4.1.1 Trinity River

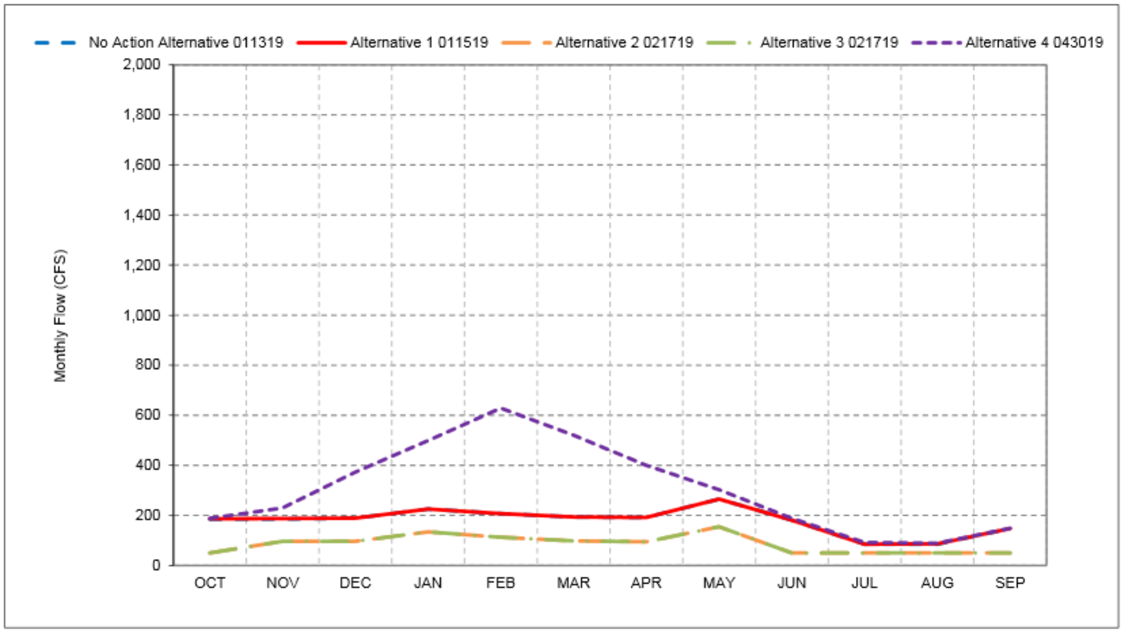
Operations in the Trinity River under Alternative 2 would remain similar to those under the No Action Alternative. The maximum average change in flows is modeled during February of above normal water year types, when flows are expected to increase by approximately 52%. Figures G.2-1 through G.2-6 illustrate flow changes. Increases in flows would be beneficial to water quality; therefore, no violations of existing water quality standards would occur.

G.2.4.1.2 Sacramento River

Changes in flow under Alternative 2 compared to the No Action Alternative in the Sacramento River increase in late winter and early spring and decrease during late fall and early winter. Under Alternative 2, trends in flow would be similar to those shown under Alternative 1, and average flows could decrease a maximum of 44% compared to the No Action Alternative. The decrease in flow would occur at Wilkins Slough during wet water year types. Increases in flow are also expected under Alternative 2 during some months, especially during dry and critical water years, but not to the extent of the decrease in flows. Figures G.2-7 through G.2-12 illustrate flow changes. As flow increases are beneficial to water quality because it dilutes constituents of concern, flow decreases are not expected to be large enough to negatively impact water quality and increase the frequency of exceedances of water quality thresholds in the Sacramento River.

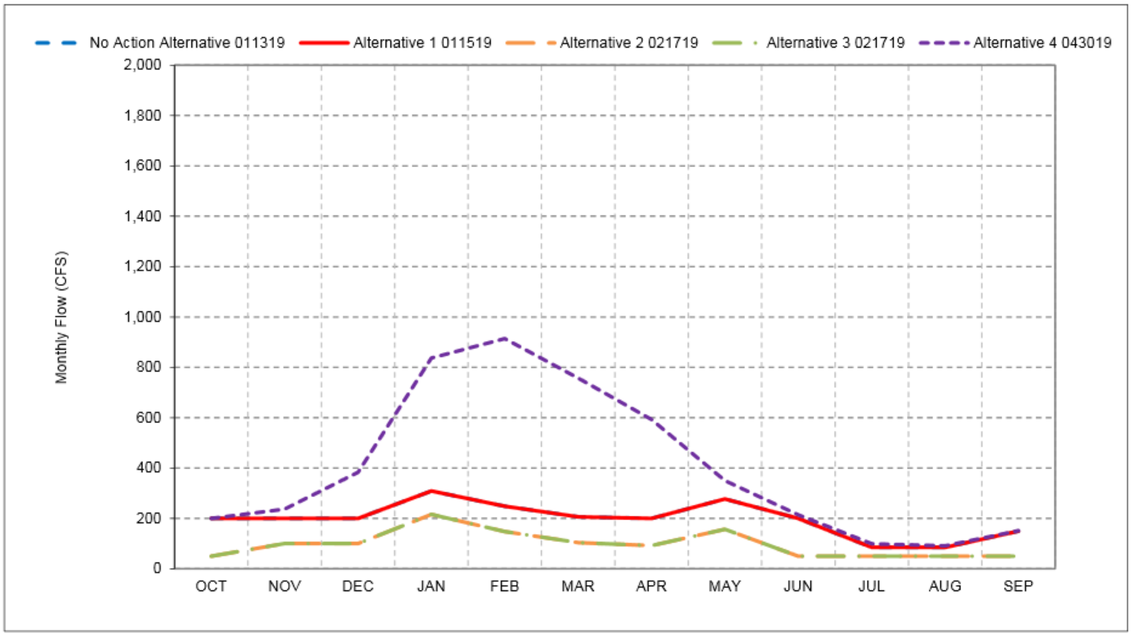
G.2.4.1.3 Clear Creek

Flows in Clear Creek under Alternative 2 would decrease as compared to the No Action Alternative because Alternative 2 does not include flows in Clear Creek from the National Marine Fisheries Service (NMFS) BO Action I.1.1 and CVPIA 3406(b)(2) flows. The maximum average change in flows is modeled during October and June of wet and above normal water years, when flows are expected to decrease by approximately 75%. Figures G.2-37 through G.2-42 illustrate changes in flow under Alternative 2. As mentioned in Section G.1.4.1, *Mercury*, gold mining activity occurred within the Clear Creek watershed between Whiskeytown Lake and the confluence with the Sacramento River during the Gold Rush era (USGS 2005), resulting in mercury contamination of Clear Creek and Whiskeytown Lake that currently persist. Reductions in flow due to changes in the operations of CVP/SWP under Alternative 2 could result in less dilution causing increased concentrations of mercury within Clear Creek compared to the No Action Alternative.



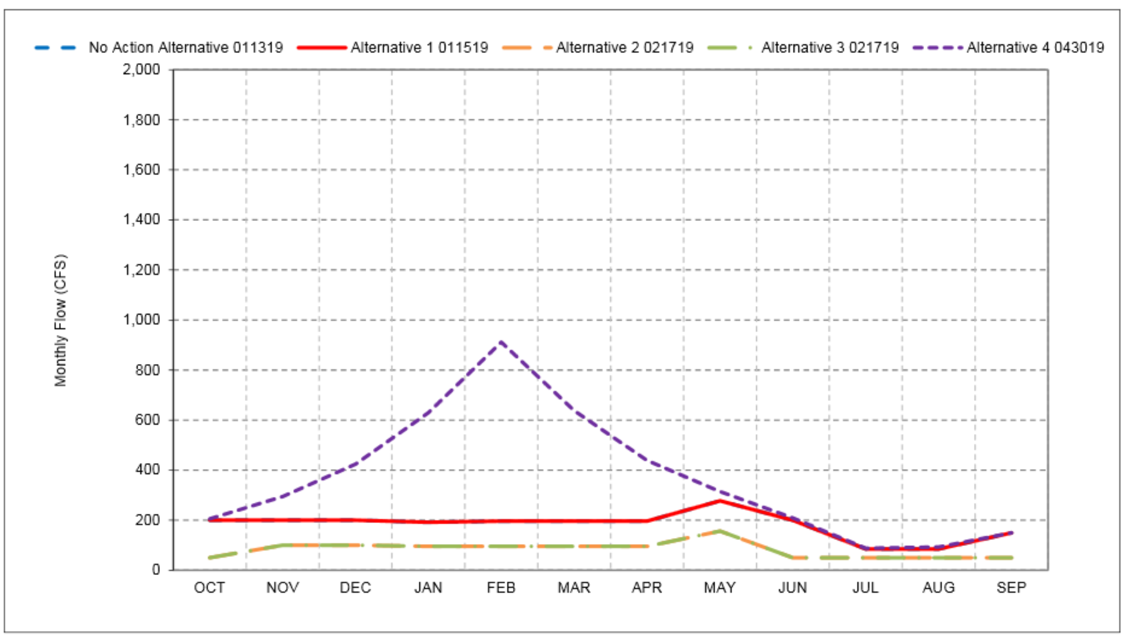
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-37. Clear Creek below Whiskeytown Dam Flow, Long-Term Average Flow



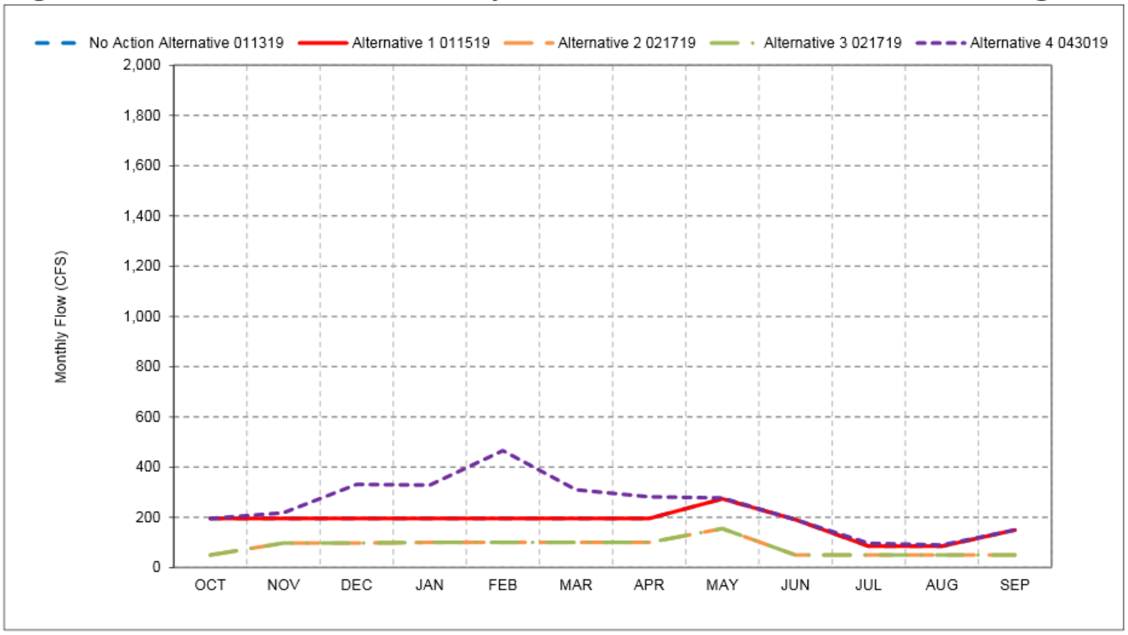
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-38. Clear Creek below Whiskeytown Dam Flow, Wet Year Average Flow



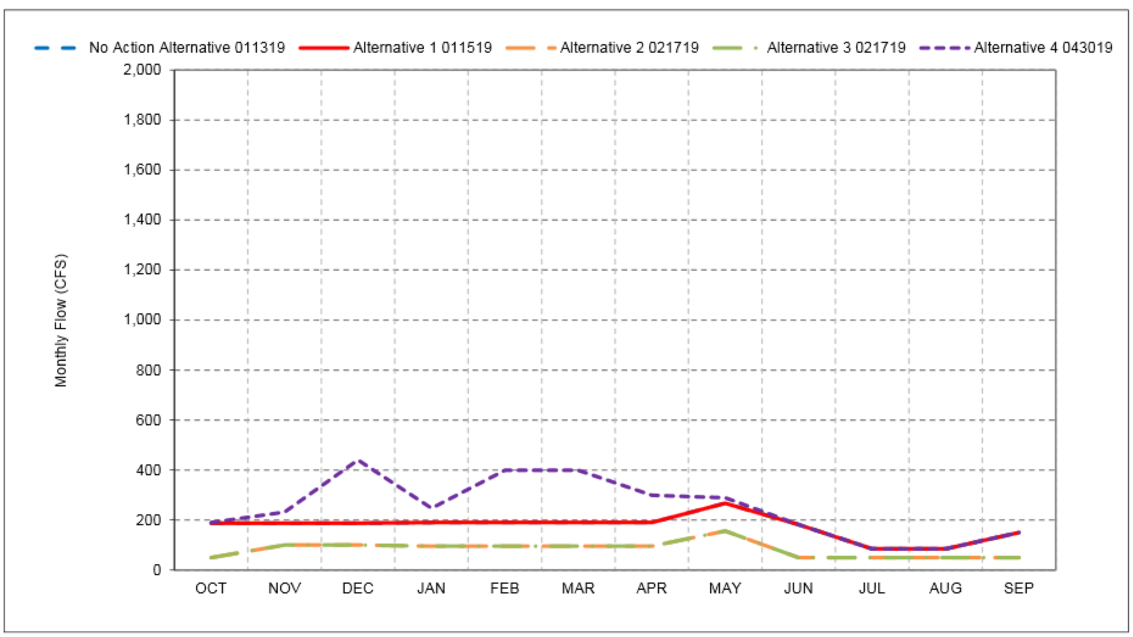
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-39. Clear Creek below Whiskeytown Dam Flow, Above Normal Year Average Flow



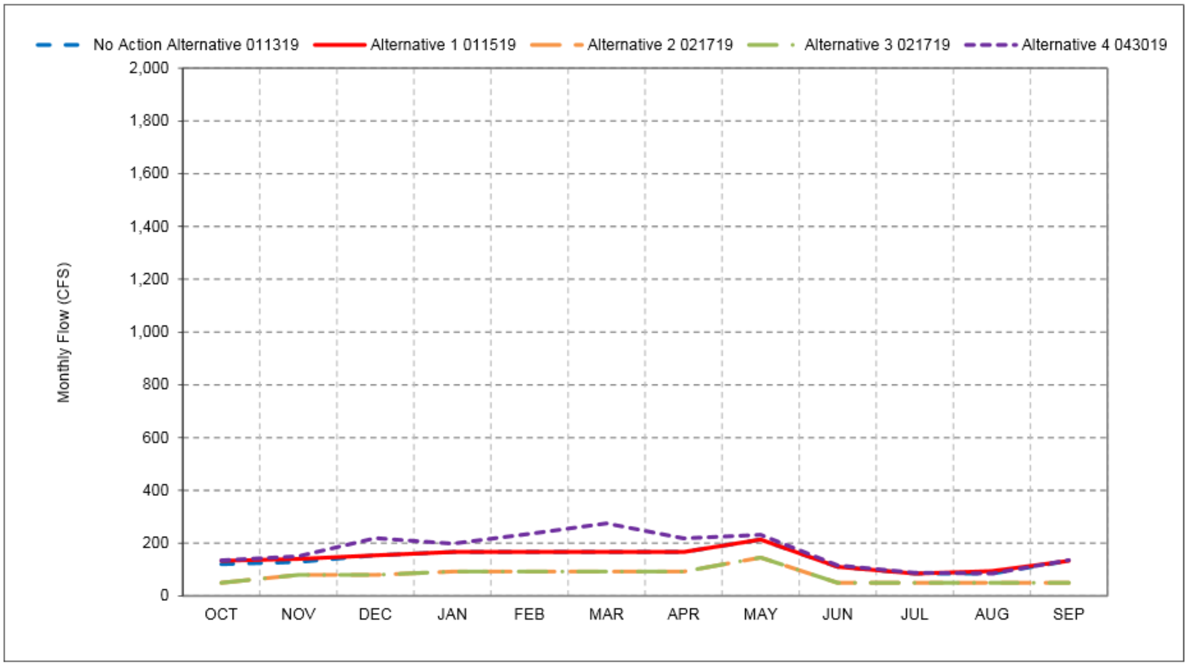
*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-40. Clear Creek below Whiskeytown Dam Flow, Below Normal Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-41. Clear Creek below Whiskeytown Dam Flow, Dry Year Average Flow



*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft results meant for qualitative analysis and are subject to revision.

Figure G.2-42. Clear Creek below Whiskeytown Dam Flow, Critical Year Average Flow

G.2.4.1.4 Feather River

Alternative 2 would require fewer releases from Lake Oroville to meet Delta standards, so the flows within the Feather River would shift to different times of year. The largest decrease in flows would be in September of wet water years and the largest increase in flows are expected in June of below normal water years under Alternative 2. Changes in flow would be similar for both locations on the Feather River. Feather River flows at the Sacramento River Confluence would have the largest increase of approximately 130% and largest decrease of approximately 57%. Feather River flows downstream of Thermalito Afterbay would have the largest increase of approximately 177% and largest decrease of approximately 71%. Figures G.2-13 through G.2-18 illustrate monthly changes in Feather River flow for all water year types under Alternative 2 compared to the No Action Alternative. Flow increases are considered beneficial to water quality because they dilute constituents of concern, and flow decreases are expected when water conditions are wet or above normal water years and have less impact on water quality. Frequency increases of exceedances of water quality standards in the Feather River are not expected.

G.2.4.1.5 American River

Under Alternative 2, Reclamation would operate Folsom Reservoir, making releases according to the 2006 American River Flow Management Standard, which is also included in the No Action Alternative. However, Reclamation would not release water to meet NMFS BO Action II.1 and other Delta standards, which would shift the timing of releases from Folsom. The largest flow decreases would be in September of wet water years and the largest flow increases would be in June of above normal water years. Flow changes would be similar for both locations on the American River. American River flows at H Street and below Nimbus Dam would have a maximum increase of approximately 48% and a maximum decrease of approximately 43%. Figures G.2-19 through G.2-24 present monthly changes in American River flow at H Street for all Water Year types under Alternative 2 compared to the No Action Alternative. Flow increases are beneficial to water quality because they dilute constituents of concern, and flow decreases, expected when conditions are wet or above normal, have a minor impact on water quality. Frequency increases of exceedances of water quality standards in the American River are not expected.

G.2.4.1.6 Stanislaus River

Like Alternative 1, changes in flow would be identical for both locations (at Mouth and below Goodwin) on the Stanislaus River. The largest flow decrease would be in April of below normal water years and the largest flow increase would be in February of wet water years under Alternative 2. Stanislaus River flows below Goodwin Dam would have a maximum increase of approximately 130% and a maximum decrease of approximately 85%. Figures G.2-25 through G.2-30 present monthly changes in Stanislaus River flow for all water year types under Alternative 2 compared to the No Action Alternative. As described in Section G.1.7.2, pesticides are a constituent of concern in the Lower Stanislaus River, largely caused by urban and agricultural runoff. At times when flow increases, water quality could improve as more water is available to dilute pesticide runoff in the Stanislaus River. Flow decreases during spring and summer months of all water year types could cause water quality degradation because less water would be available to dilute pesticide concentrations.

G.2.4.1.7 San Joaquin River

The greatest flow change in the San Joaquin River would be at Vernalis, where flows would decrease by a maximum of 26%. Figures G.2-31 through G.2-36 show changes in the San Joaquin River at Vernalis. The small change in flow under Alternative 2 would not likely result in adverse effects on water quality nor an increase in frequency of exceedances of water quality thresholds in the San Joaquin River.

G.2.4.1.8 CVP and SWP Service Area (south to Diamond Valley)

Alternative 2 would generally result in higher monthly average chloride concentrations at Banks and Jones Pumping Plants in the months of September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, as compared to the No Action Alternative. Since this water is delivered to reservoirs for storage in CVP/SWP reservoirs, chloride concentrations in these reservoirs may increase. While there would be higher chloride concentrations under Alternative 2, relative to the No Action Alternative, in some months, the CVP/SWP would continue operation, in real-time, to meet the Bay-Delta WQCP objectives for chloride, which aim to protect municipal and industrial beneficial uses. In September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 2 would not contribute to municipal and industrial beneficial uses CVP/SWP service area impairment.

G.2.4.1.9 Bay-Delta

Potential Changes in EC

Delta

Monthly average EC levels in the Sacramento River at Emmaton would often be substantially higher in September through December of wet and above normal water year types under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 4-2, Figures 4-2, 4-3, 4-15 through 4-18). Monthly average EC levels in January of below normal, dry, and critical water year types also would be substantially higher relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 4-2, Figure 4-7). Monthly average EC levels in February through August under Alternative 2 would be similar to or lower than the No Action Alternative EC levels (Appendix F, Attachment 3-6, Table 4-2, Figures 4-8 through 4-14).

Monthly average EC levels in the San Joaquin River at Vernalis under Alternative 2 would, overall, be similar to levels that would occur under the No Action Alternative, except in October, when EC levels would be substantially higher than the No Action Alternative (Appendix F, Attachment 3-6, Table 6-2, Figures 6-1 through 6-18). Somewhat higher monthly EC levels would occur in the months of March through June under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 6-2, Figures 6-9 and 6-12).

Monthly average EC levels in the San Joaquin River at Jersey Point, like the Sacramento River at Emmaton, would often be substantially higher in September through December of wet and above normal water year types under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-2, Figures 7-2, 7-3, 7-15 through 7-18). February, March, April, May, and June would also see somewhat higher EC levels under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-2, Figures 7-8 through 7-12).

Monthly average EC levels at the Banks and Jones pumping plants under Alternative 2, relative to the No Action Alternative, would be higher in September through January, most notably in wet and above normal water year types (Appendix F, Attachment 3-6, Tables 15-2 and 16-2, Figures 15-2, 15-3, 16-2, 16-3). In February through August, monthly average EC levels under Alternative 2 would be similar to or lower than No Action Alternative EC levels (Appendix F, Attachment 3-6, Tables 15-2 and 16-2, Figures 15-8 through 15-14 and 16-8 through 16-14).

While there would be higher monthly average EC levels under Alternative 2 relative to the No Action Alternative, in some months, the CVP/SWP would continue to operate, in real-time, to meet the Bay-Delta WQCP objectives for EC to protect agricultural and fish and wildlife beneficial uses. The western Delta EC objectives for the Sacramento River at Emmaton and San Joaquin River at Jersey Point for agricultural beneficial use protection apply from April through June, July, or August, depending on water year type (SWRCB 2006). The San Joaquin River at Jersey Point objective for fish and wildlife protection also applies during April and May (SWRCB 2006). During these months, the monthly average EC levels under Alternative 2 would be similar to the No Action Alternative (Appendix F, Attachment 3-6, Tables 4-2 and 7-2). The southern Delta EC objectives to protect agricultural uses for the San Joaquin River at Vernalis and the export area for Banks and Jones pumping plant apply year-round. Banks and Jones pumping plants would have higher EC levels in the fall, but lower monthly average EC in spring and summer, relative to the No Action Alternative (Appendix F, Attachment 3-6, Tables 15-2 and 16-2). Monthly average EC levels at Vernalis under Alternative 2 would overall be similar to the No Action Alternative, except in October, when EC levels would be somewhat higher than the No Action Alternative (Appendix F, Attachment 3-6, Table 6-2). Thus, the differences in EC in the Delta under

Alternative 2, relative to the No Action Alternative, would not contribute to agricultural or fish and wildlife beneficial use impairments in the Delta.

Suisun Marsh

In the Sacramento River at Collinsville, which is a Bay-Delta WQCP compliance location for the eastern portion of Suisun Marsh, monthly average EC levels would be substantially higher under Alternative 2, relative to the No Action Alternative, in September through December of wet and above normal water year types (Appendix F, Attachment 3-6, Table 11-2, Figures 11-2 and 11-3). The EC differences would occur primarily at the low end of the modeled EC range; there is little difference between the upper monthly average EC levels at Collinsville under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Figures 11-15 through 11-18). Higher monthly average EC levels would also occur in December through May of all water year types under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 11-2, Figures 11-1, 11-7 through 11-11, and 11-18).

Suisun Bay and San Francisco Bay

Based on the modeling results discussed above, the EC of Delta outflow under Alternative 2 may be different than what would occur under the No Action Alternative in certain months of certain water year types. Also, Alternative 2 would result in lower Delta outflow rates relative to the No Action Alternative (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-2). The differences in Delta EC and outflow could cause the freshwater-seawater salinity gradient within Suisun Bay and the northern portion of San Francisco Bay to be different between Alternative 2 and the No Action Alternative. These differences are not expected to result in substantial changes in overall salinity conditions within Suisun Bay and San Francisco Bay, because seawater is the predominant source of the bays' salinity.

Potential Changes in Chloride

The discussion below assesses the differences between chloride at the five assessment locations – Contra Costa Pumping Plant #1, San Joaquin River at Antioch, Banks and Jones pumping plants, and North Bay Aqueduct – under Alternative 2 as compared to the No Action Alternative. The assessment is based on modeling results presented in Appendix F, Attachment 3-10, *Salinity Results (DSM2)*.

Monthly average chloride concentrations at Contra Costa Pumping Plant #1 would often be substantially higher in October through December of wet and above normal water year types, and somewhat higher in September, January, and February of all water year types under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 19-2, Figures 19-1 through 19-18). In April and May of all water year types, chloride concentrations would be somewhat lower than would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-2, Figures 19-10 and 19-11). Monthly average chloride concentrations in March, and June through August would be similar to concentrations under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-2, Figures 19-9, and 19-12 through 19-14).

Monthly average chloride concentrations in the San Joaquin River at Antioch would often be substantially higher in September through December of wet and above normal water year types under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 20-2, Figures 20-2 and 20-3). In the months of December through May, and August, monthly average chloride concentrations also would be somewhat higher in all water year types (Appendix F, Attachment 3-10, Table 20-2, Figures 20-1, 20-7 through 20-11, 20-14, and 20-18).

Monthly average chloride concentrations in all water year types at Banks and Jones pumping plants would be somewhat higher in the months of September through January under Alternative 2, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 21-2 and Table 22-2, Figures 21-1 through 21-6 and 22-1 through 22-6). In the months of February through August, monthly average chloride concentrations under Alternative 2 would be similar to or lower than those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Tables 21-2 and 22-2, Figures 21-8 through 21-14 and 22-8 through 22-14).

Monthly average chloride concentrations in Barker Slough at the North Bay Aqueduct under Alternative 2 would be the same as concentrations that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 23-2, Figures 23-1 through 23-18).

In summary, Alternative 2 would generally result in higher monthly average chloride concentrations in the months of September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, compared to the No Action Alternative. While there would be higher chloride concentrations under Alternative 2, relative to the No Action Alternative, in some months, the CVP/SWP would continue operation, in real-time, to meet the Bay-Delta WQCP chloride objectives, which aim to protect municipal and industrial beneficial uses. In September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006:12). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 2 would not contribute to the impairment of Delta waters' municipal and industrial beneficial uses.

Suisun Bay, Suisun Marsh, and San Francisco Bay waters are not designated for municipal and domestic supply uses, and other salinity-related effects in these waters are addressed above in the discussion for EC.

Potential Changes in Bromide

As discussed for Alternative 1, based on the EC levels modeled for Alternative 2, monthly average bromide concentrations at Delta drinking water intakes could be higher than those that would occur under the No Action Alternative, particularly in the fall. However, for the reasons provided for Alternative 1, it is expected that Alternative 2 would not contribute to drinking water impairments related to bromide, relative to those that would occur under the No Action Alternative.

Potential Changes in Methylmercury

Methylmercury concentrations in the Delta, and thus Suisun Bay and Marsh, and San Francisco Bay, could be affected by Alternative 2 through CVP/SWP operation. Unlike Alternative 1, this alternative does not include tidal habitat restoration.

Long-term average water column concentrations of methylmercury in the Delta under Alternative 2 would be the same as, or slightly (0.01 ng/L) lower than, those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Thus, Alternative 2 would not contribute to higher concentrations of methylmercury in the Delta through changes in source water inflows to the Delta.

All modeled fish tissue concentrations exceed the water quality objective of 0.24 mg/kg under the No Action Alternative and Alternative 2, as shown by fish tissue concentration results presented in Appendix G, Attachment 1, Table G1.5-3, Methylmercury Concentrations in 350 millimeter Largemouth Bass Fillets for Alternative 2, and Comparison to No Action Alternative, and by the EQs plotted and provided in Appendix G, Attachment 1, Figures G1.5-1 and G1.5-2; all EQs are greater than 1.0. Under Alternative 2, fish tissue methylmercury concentrations would be from 1% to 7 % lower at all modeled locations, except San Joaquin River at Stockton and Barker Slough at North Bay Aqueduct Intake, where concentrations would be 1% higher than the No Action Alternative, for the entire period modeled (Appendix G, Attachment 1, Table G1.5-3). For the drought period modeled, fish tissue methylmercury concentrations would be from 1 to 10% lower at all modeled locations, except San Joaquin River at Stockton, where concentrations would be 1% higher than the No Action Alternative (Appendix G, Attachment 1, Table G1.5-3). Based on the overall lower methylmercury concentrations at almost all modeled Delta locations, water operations under Alternative 2 would not contribute to additional water quality degradation with respect to methylmercury, or increased health risks to wildlife or human consuming wildlife, as compared to the No Action Alternative. Thus, the differences in methylmercury in the Delta under Alternative 2, relative to the No Action Alternative, would not contribute to additional beneficial use impairments in the Delta.

Long-term average methylmercury concentrations in the western Delta under Alternative 2 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Alternative 2 would result in lower Delta outflow rates, notably in the months of September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-2). Thus, water operations under Alternative 2 would not contribute to additional water quality degradation with respect to methylmercury or increased bioaccumulation in biota in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Selenium

Based on modeled Delta water concentrations, selenium concentrations in the Delta under Alternative 2 would be similar to or lower than those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Further, long-term average selenium concentrations in the water column at the three western Delta locations under Alternative 2 would be identical to conditions under the No Action Alternative. Thus, Alternative 2 would not contribute to additional water quality degradation with respect to selenium, as compared to the No Action Alternative.

Modeled selenium concentrations in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 2 are similar to those modeled for the No Action Alternative, as shown in Appendix G, Attachment 2, Table G2.3-2, Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative and Alternative 2. EQs computed for the applicable toxicity benchmarks show that selenium concentrations in biota under both the No Action Alternative and Alternative 2 would be below the thresholds identified for ecological risk (Appendix G, Attachment 2, Tables G2.3-5, Summary Table for Selenium Concentrations in Biota, and Comparisons for No Action Alternative to Benchmarks, and G2.3-7, Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 2 to No Action Alternative and Benchmarks, and Figures G2.3-1 through G2.3-4). Thus, Alternative 2 would not result in increased health risks to wildlife or human consuming wildlife associated with whole-body fish, bird eggs (invertebrate diet), bird eggs (fish diet), and fish fillets, as compared to the No Action Alternative.

Modeled selenium concentrations in whole-body Sturgeon in the western Delta under Alternative 2 also are similar to or slightly lower than those modeled for the No Action Alternative (Appendix G, Attachment 2, Table G2.3-10, *Summary of Period Average Selenium Concentrations in Whole-body*

Sturgeon, and G2.3-12*, Percent Change in Selenium Concentrations in Whole Body Sturgeon Relative to No Action Alternative*). Low Toxicity Threshold EQs are less than 1.0 for entire 82-year period modeled and slightly exceed 1.0 for drought period modeled (Appendix G, Attachment 2, Table G2.3-11, Comparison of Annual Average Selenium Concentrations in Whole-body Sturgeon to Toxicity Thresholds, and Figure G2.3-5, Low Toxicity Threshold Exceedance Quotients for Selenium Concentrations in Whole-body Sturgeon for Drought Years), but are similar for Alternative 2 and the No Action Alternative. Modeled EQs for the High Toxicity Threshold at all locations are less than 1.0 for the entire period modeled and the drought period modeled, and are also similar for Alternative 2 and the No Action Alternative. Thus, Alternative 2 would not result in increased health risks to wildlife or human consuming wildlife associated with sturgeon, as compared to the No Action Alternative.

Long-term average water column selenium concentrations in the western Delta under Alternative 2 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Alternative 2 would result in lower Delta outflow rates, notably in the months of September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-2). Thus, Alternative 2 would not contribute to additional water quality degradation with respect to selenium or increased bioaccumulation in biota in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Trace Metals

For the same reasons described for Alternative 1, Alternative 2 would not affect existing Delta impairments related to trace metals, and would not result in additional trace metals-related impairments in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Nutrients

For the same reasons described for Alternative 1, Alternative 2 would not contribute to different Delta nutrient concentrations or nutrient distributions that would result in adverse effects to beneficial uses or substantially degrade the water quality, relative to nutrient conditions that would occur under the No Action Alternative. Further, any potential differences in total nitrogen and phosphorus loading that would occur in Delta outflow to Suisun Bay and Marsh, and San Francisco Bay, relative to the No Action Alternative, are not expected to result in water quality degradation with regard to nutrients that would result in adverse effects to beneficial uses or the further impairment of Suisun Bay and Marsh, or San Francisco Bay.

Potential Changes in Dissolved Oxygen

For the same reasons described for Alternative 1, Alternative 2 would not substantially affect dissolved oxygen concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, or make existing dissolved oxygen impairments in the Delta and Suisun Marsh worse, relative to the No Action Alternative.

Potential Changes in Pathogens

For the same reasons described for Alternative 1, Alternative 2 would not substantially affect pathogen levels in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Legacy Contaminants

For the same reasons described for Alternative 1, Alternative 2 would not substantially affect levels of legacy contaminants (e.g., dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Pesticides

For the same reasons described for Alternative 1, Alternative 2 would not substantially affect pesticide concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative. Note that under Alternative 2, the Clifton Court Aquatic Weed program discussed in the Alternative 1 pesticides assessment would not be implemented.

Potential Changes in Organic Carbon

For the same reasons described for Alternative 1, Alternative 2 would not result in differences in organic carbon concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative, that would adversely affect beneficial uses.

G.2.4.2 *Program-Level Effects*

Alternative 2 does not include program-level components. Thus, there would be no program-level effects to water quality under Alternative 2.

G.2.5 Alternative 3

G.2.5.1 *Project-Level Effects*

Potential Changes in water quality

Alternatives 2 and 3 have almost identical flow changes compared to the No Action Alternative (Figures G.2-1 through G.2-36). The difference between the alternatives is related to the habitat restoration actions included in the program-level analysis. The analysis of project-level impacts for Alternative 2 in the Trinity River, Sacramento River, Clear Creek, Feather River, American River, Stanislaus River, and CVP/SWP service areas is the same as described above for Alternative 2. The analysis below focuses on the Bay-Delta region.

G.2.5.1.1 Bay Delta

Potential Changes in EC

Delta

Monthly average EC levels in the Sacramento River at Emmaton would often be substantially higher in September through December of wet and above normal water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 4-3, Figures 4-2, 4-3, 4-15 through 4-18). Monthly average EC levels in January of below normal, dry, and critical water year types also would be substantially higher relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 4-3, Figure 4-7). Monthly average EC levels in February through August under Alternative 3 would be similar to or lower than the No Action Alternative EC levels (Appendix F, Attachment 3-6, Table 4-3, Figures 4-8 through 4-14).

Monthly average EC levels in the San Joaquin River at Vernalis under Alternative 3 would, overall, be similar to levels that would occur under the No Action Alternative, except in October, when EC levels would be substantially higher than the No Action Alternative (Appendix F, Attachment 3-6, Table 6-3, Figures 6-1 through 6-18). Somewhat higher monthly EC levels would occur in March through June under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 6-3, Figures 6-9 and 6-12).

Monthly average EC levels in the San Joaquin River at Jersey Point, like the Sacramento River at Emmaton, would often be substantially higher in September through December of wet and above normal water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-3, Figures 7-2, 7-3, 7-15 through 7-18). February, March, April, May, and June would also see somewhat higher EC levels under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-3, Figures 7-8 through 7-12).

Monthly average EC levels at the Banks and Jones pumping plants under Alternative 3, relative to the No Action Alternative, would be higher in September through December, most notably in wet and above normal water year types (Appendix F, Attachment 3-6, Tables 15-3 and 16-3, Figures 15-2, 15-3, 16-2, and 16-3). In February through August, monthly average EC levels under Alternative 3 would be similar to or lower than No Action Alternative EC levels (Appendix F, Attachment 3-6, Tables 15-3 and 16-3, Figures 15-8 through 15-14 and 16-8 through 16-14).

While there would be higher monthly average EC levels under Alternative 3 relative to the No Action Alternative, in some months, the CVP/SWP would continue operation, in real-time, to meet the Bay-Delta WQCP EC objectives, which aim to protect agricultural and fish and wildlife beneficial uses. The western Delta EC objectives for the Sacramento River at Emmaton and San Joaquin River at Jersey Point for agricultural beneficial use protection apply from April through June, July, or August, depending on water year type (SWRCB 2006). The San Joaquin River at Jersey Point objective for fish and wildlife protection also applies during April and May (SWRCB 2006). During these months, the monthly average EC levels under Alternative 3 would be similar to the No Action Alternative (Appendix F, Attachment 3-6, Tables 4-3 and 7-3). The southern Delta EC objectives for the protection of agricultural uses for the San Joaquin River at Vernalis and the export area for Banks and Jones pumping plant apply year-round. Banks and Jones pumping plants would have higher EC levels in the fall, but lower monthly average EC in spring and summer, relative to the No Action Alternative (Appendix F, Attachment 3-6, Tables 15-3 and 16-3), and monthly average EC levels at Vernalis under Alternative 3 would overall be similar to the No Action Alternative, except in October, when EC levels would be somewhat higher than the No Action Alternative (Appendix F, Attachment 3-6, Table 6-3). Thus, the differences in EC in the Delta under Alternative 3, relative to the No Action Alternative, would not contribute to agricultural or fish and wildlife beneficial use impairments in the Delta.

Suisun Marsh

In the Sacramento River at Collinsville, a Bay-Delta WQCP compliance location for the eastern portion of Suisun Marsh, monthly average EC levels would be substantially higher under Alternative 3, relative to the No Action Alternative, in September through December of wet and above normal water year types (Appendix F, Attachment 3-6, Table 11-3, Figures 11-2 and 11-3). The EC differences would occur primarily at the low end of the modeled EC range; there is little difference between the upper monthly average EC levels at Collinsville under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Figures 11-15 through 11-18). Higher monthly average EC levels would also occur in December through May of all water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 11-3, Figures 11-7 through 11-11, and 11-18).

Suisun Bay and San Francisco Bay

Based on the modeling results discussed above, the EC of Delta outflow under Alternative 3 may be different than what would occur under the No Action Alternative in certain months of certain water year types. Also, Alternative 3 would result in lower Delta outflow rates, relative to the No Action Alternative (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-3). These differences in Delta EC and outflow could cause the freshwater-seawater salinity gradient within Suisun Bay and the northern portion of San Francisco Bay to differ between Alternative 3 and the No Action Alternative. These differences are not expected to result in substantial changes in overall salinity conditions within Suisun Bay and San Francisco Bay, because seawater is the bays' predominant salinity source.

Potential Changes in Chloride

The discussion below assesses the differences between chloride at the five assessment locations – Contra Costa Pumping Plant #1, San Joaquin River at Antioch, Banks and Jones pumping plants, and North Bay Aqueduct – under Alternative 3 as compared to the No Action Alternative. The assessment is based on modeling results presented in Appendix F, Attachment 3-10, *Salinity Results (DSM2)*.

Monthly average chloride concentrations at Contra Costa Pumping Plant #1 would often be substantially higher in October through December of wet and above normal water year types, and somewhat higher in September, January, and February of all water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 19-3, Figures 19-1 through 19-18). In April and May of all water year types, chloride concentrations would be somewhat lower than would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-3, Figures 19-10 and 19-11). Monthly average chloride concentrations in the months of March and June through August would be similar to concentrations under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-3, Figures 19-9, and 19-12 through 19-14).

Monthly average chloride concentrations in the San Joaquin River at Antioch would often be substantially higher in September through December of wet and above normal water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 20-3, Figures 20-2 and 20-3). In the months of December through May, monthly average chloride concentrations would also be somewhat higher in all water year types (Appendix F, Attachment 3-10, Table 20-3, Figures 20-7 through 20-11 and 20-18).

Monthly average chloride concentrations at Banks and Jones pumping plants would be somewhat higher in September through January of all water year types under Alternative 3, relative to the No Action Alternative (Appendix F, Attachment 3-10, Tables 21-3 and 22-3, Figures 21-1 through 21-18 and 22-1 through 22-18). In February through August, monthly average chloride concentrations under Alternative 3 would be similar to or lower than those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Tables 21-3 and 22-3, Figures 21-8 through 21-14 and 22-8 through 22-14).

Monthly average chloride concentrations in Barker Slough at the North Bay Aqueduct under Alternative 3 would be slightly lower than those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 23-3, Figures 23-1 through 23-18).

In summary, Alternative 3 would generally result in higher monthly average chloride concentrations in the months of September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, as compared to the No Action Alternative. While there would be higher chloride concentrations under Alternative 3 relative to the No Action Alternative, in some months, the CVP/SWP would operate in real-time to meet the Bay-Delta WQCP chloride objectives, which aim to protect municipal and industrial beneficial uses. In September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 3 would not contribute to municipal and industrial beneficial uses of Delta waters impairment.

Suisun Bay, Suisun Marsh, and San Francisco Bay waters are not designated for municipal and domestic supply uses, and other salinity-related effects in these waters are addressed above in the EC discussion.

Potential Changes in Bromide

As discussed for Alternative 1, based on the EC levels modeled for Alternative 3, monthly average bromide concentrations at Delta drinking water intakes could be higher than those that would occur under the No Action Alternative, particularly in the fall. However, for the reasons provided for Alternative 1, Alternative 3 would not be expected to contribute to drinking water impairments related to bromide, relative to those that would occur under the No Action Alternative.

Potential Changes in Methylmercury

Long-term average water column methylmercury concentrations in the Delta under Alternative 3 would be the same as, or slightly (0.01 ng/L) lower than, those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Thus, Alternative 3 would not contribute to higher methylmercury concentrations in the Delta through changes in source water inflows.

All modeled fish tissue concentrations exceed the water quality objective of 0.24 mg/kg under the No Action Alternative and Alternative 3, as shown by fish tissue concentration results presented in Appendix G, Attachment 1, Table G1.5-4, Methylmercury Concentrations in 350 millimeter Largemouth Bass Fillets for Alternative 3, and Comparison to No Action Alternative, and the EQs plotted and provided in Appendix G, Attachment 1, Figures G1.5-1 and G1.5-2; all EQs are greater than 1.0. Under Alternative 3, fish tissue methylmercury concentrations would be from 0% to 12% lower at all modeled locations, except San Joaquin River at Stockton, where concentrations would be 0.2% higher, as compared to the No Action Alternative, for the entire period modeled (Appendix G, Attachment 1, Table G1.5-4). For the drought period modeled, fish tissue methylmercury concentrations would be from 0% to 15% lower at all modeled locations, except San Joaquin River at Stockton, where the concentration would be 1% higher, as compared to the No Action Alternative (Appendix G, Attachment 1, Table G1.5-4). Based on the overall lower methylmercury concentrations at almost all modeled Delta locations, water operations under Alternative 3 would not contribute to additional water quality degradation with respect to methylmercury, or in increased health risks to wildlife or humans consuming wildlife, as compared to the No Action Alternative. Thus, the differences in methylmercury in the Delta under Alternative 3, relative to the No Action Alternative, would not contribute to additional beneficial use impairments in the Delta.

Long-term average water column methylmercury concentrations in the western Delta under Alternative 3 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Alternative 3 would result in lower Delta outflow rates, notably in September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-3). Thus, water operations under Alternative 3 would not contribute to additional water quality degradation with respect to methylmercury or increased biota bioaccumulation in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Selenium

Based on modeled Delta water concentrations, selenium concentrations in the Delta under Alternative 3 would be similar to or lower than those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Long-term average selenium concentrations in the water column at the three western Delta locations under Alternative 3 would be the same as or lower than those that would occur under the No Action Alternative. Thus, Alternative 3 would not contribute to additional water quality degradation with respect to selenium, as compared to the No Action Alternative.

Modeled selenium concentrations in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 3 are similar to those modeled for the No Action Alternative, as shown in Appendix G, Attachment 2, Table G2.3-3, Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative and Alternative 3. Also, EQs computed for the applicable toxicity benchmarks show that selenium concentrations in biota under both the No Action Alternative and Alternative 3 would be below the thresholds identified for ecological risk (Appendix G, Attachment 2, Tables G2.3-5, Summary Table for Selenium Concentrations in Biota, and Comparisons for No Action Alternative to Benchmarks, and G2.3-8, Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 3 to No Action Alternative and Benchmarks, and Figures G2.3-1 through G2.3-4). Thus, Alternative 3 would not result in increased health risks to wildlife that consuming wildlife associated with whole-body fish, bird eggs (invertebrate diet), bird eggs (fish diet), and fish fillets, as compared to the No Action Alternative.

Modeled selenium concentrations in whole-body sturgeon in the western Delta under Alternative 3 also are similar to or slightly lower than those modeled for the No Action Alternative (Appendix G, Attachment 2, Tables G2.3-10 and G2.3-12). Low Toxicity Threshold EQs are less than 1.0 for entire 82-year period modeled and slightly exceed 1.0 for drought period modeled (Appendix G, Attachment 2, Table G2.3-11, Figure G2.3-5), but are similar for Alternative 3 and the No Action Alternative. Modeled EQs for the High Toxicity Threshold at all locations are less than 1.0 for the entire period modeled and the drought period modeled, and are similar for Alternative 3 and the No Action Alternative. Thus, Alternative 3 would not result in increased health risks to wildlife or human consuming wildlife associated with sturgeon, as compared to the No Action Alternative.

Long-term average water column selenium concentrations in the western Delta under Alternative 3 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Alternative 3 would result in lower Delta outflow rates, notably in September, October, November, April, and May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-3). Thus, Alternative 3 would not contribute to additional water quality degradation with respect to selenium or increased biota bioaccumulation in Suisun Bay and San Francisco Bay, as compared to the No Action Alternative.

Potential Changes in Trace Metals

For the same reasons described for Alternative 1, Alternative 3 would not affect existing Delta impairments related to trace metals, and would not result in additional trace metals-related impairments in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Nutrients

For the same reasons described for Alternative 1, Alternative 3 would not contribute to different Delta nutrient concentrations or nutrient distributions that would adversely affect beneficial uses or substantially degrade the water quality, relative to the nutrient conditions that would occur under the No Action

Alternative. Further, any potential differences in total nitrogen and phosphorus loading that would occur in Delta outflow to Suisun Bay and Marsh, and San Francisco Bay, relative to the No Action Alternative, are not expected to degrade water quality with regard to nutrients that would create adverse effects to beneficial uses or further impair Suisun Bay and Marsh, or San Francisco Bay.

Potential Changes in Dissolved Oxygen

For the same reasons described for Alternative 1, Alternative 3 would not substantially affect dissolved oxygen concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, or make existing dissolved oxygen impairments in the Delta and Suisun Marsh worse, relative to the No Action Alternative.

Potential Changes in Pathogens

For the same reasons described for Alternative 1, Alternative 3 would not substantially affect pathogen levels in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Legacy Contaminants

For the same reasons described for Alternative 1, Alternative 3 would not substantially affect legacy contaminants levels (e.g., dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Pesticides

For the same reasons described for Alternative 1, Alternative 3 would not substantially affect pesticide concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative. Note that under Alternative 3, the Clifton Court Aquatic Weed program discussed in the Alternative 1 pesticides assessment would not be implemented.

Potential Changes in Organic Carbon

For the same reasons described for Alternative 1, Alternative 3 would not result in organic carbon concentration differences in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative, that would adversely affect beneficial uses.

G.2.5.2 *Program-Level Effects*

Under Alternative 3, program level effects would include effects from intake lowering, habitat restoration, increased aquatic weed removal, the introduction of dredge material for turbidity, and construction activities associated with facility improvements. The Alternative 3 program-level components that would be implemented with the potential to affect water quality are primarily the same as those described for Alternative 1. The one difference is that the tidal habitat restoration area would be larger, thus the potential for methylmercury and organic carbon generation could be greater than the No Action Alternative, depending on the siting and design of the tidal habitat. Construction-related effects to water quality from the facility improvements and habitat restoration construction activities would be similar. While these could have short-term effects on water quality, including increased sedimentation and turbidity, the implementation of Mitigation Measures WQ-1, WQ-2, WQ-3, and WQ-4, described below in Section G.2.7, would reduce or eliminate the effects on water quality. Adverse effects on water quality and violations to water quality standards are not expected from program-level activities.

G.2.6 Alternative 4

G.2.6.1 *Project-Level Effects*

Potential Changes in water quality

G.2.6.1.1 Trinity River

Operations in the Trinity River under Alternative 4 would remain similar to those under the No Action Alternative, but flows may change in the spring of some years because Alternative 4 would increase flow targets on the Sacramento River system. The maximum average change in flows is modeled during February of above normal water year types, when flows are expected to increase by approximately 69%. Figures G.2-1 through G.2-6 illustrate flow changes. Increases in flows would be beneficial to water quality; therefore, no violations of existing water quality standards would occur.

G.2.6.1.2 Sacramento River

Changes in flow under Alternative 4 compared to the No Action Alternative in the Sacramento River would be similar to those seen under Alternatives 1-3, with increases in late winter and early spring and decreases during late fall and early winter. Under Alternative 4, average flows could decrease a maximum of 46% compared to the No Action Alternative. This decrease in flow would occur at Wilkins Slough during above normal water year types. Increases in flow are also expected under Alternative 4 during some months, especially during dry and critical water years. Figures G.2-7 through G.2-12 illustrate flow changes. Flow increases are beneficial to water quality because they dilute constituents of concern. Flow decreases would be relatively small or occur at times when they would not negatively affect water quality and increase the frequency of water quality thresholds exceedances in the Sacramento River.

G.2.6.1.3 Clear Creek

Flows in Clear Creek under Alternative 4 would increase as compared to the No Action Alternative. Under all water year types, flows are expected to increase substantially in the winter and spring. During above normal water years, the maximum average change in flows is expected to increase by approximately 365%. These increases in flow are expected because the flow targets include increased releases from Whiskeytown Lake into Clear Creek. Figures G.2-37 through G.2-42 illustrate changes in flow under Alternative 4. The analysis considers flow increases beneficial to water quality because they make more water available to dilute constituents of concern (i.e., mercury), therefore, no negative changes to existing water quality would occur.

G.2.6.1.4 Feather River

Alternative 4 would include flow targets that change the timing and quantity of the Lake Oroville release for the Feather River below the Thermalito outlet. Increases in flow compared to the No Action Alternative are expected during spring months of all water year types at both Feather River modeling locations. Increases in flow may be as high as 205% in April of below normal water years downstream of Thermalito Afterbay. Similar trends in spring increases in flow are apparent at the Sacramento River confluence, but to a lesser magnitude. Decreases in flow are expected in the summer and early fall, with a maximum decrease of 71% in September of wet water years. Decreases in flow in other water year types are expected to occur in late summer and fall to a lesser magnitude. Figures G.2-13 through G.2-18 illustrate monthly changes in Feather River flow. Flow increases are considered beneficial to water quality because they dilute constituents of concern, and flow decreases are expected when water conditions are wet or above normal and have less impact on water quality. Increased frequency of exceedances of water quality thresholds in the Feather River are not expected.

G.2.6.1.5 American River

In addition to the assumptions outlined under Alternative 1, the flow targets under Alternative 4 would cause changes in flow on the American River due to changes in Folsom Lake release. While decreases in flow are expected to be similar, if not identical to those under Alternative 1, increases in flow would be of greater magnitude than those seen under Alternative 1. Flows are expected to increase to a maximum of 56% during February of critical water years. Figures G.2-19 through G.2-24 present monthly changes in American River flow at H Street for all water year types under Alternative 4 compared to the No Action Alternative. Flow increases are beneficial to water quality because they dilute constituents of concern, and flow decreases would have a minor effect on water quality because they would occur when conditions are wet or above normal. Water quality standards in the American River are not expected to be exceeded with increased frequency.

G.2.6.1.6 Stanislaus River

Changes in flow under Alternative 4 would be identical to those seen under Alternative 1 because Alternative 4 includes the same Stepped Release Plan for the Stanislaus River. Stanislaus River flows at the mouth and below Goodwin Dam are expected to have a maximum increase of approximately 92% and a maximum decrease by approximately 62% compared to the No Action Alternative. Figures G.2-25 through G.2-30 show changes in flow below Goodwin Dam. While the evaluation considers a decrease in flows harmful to water quality because it reduces the dilution of constituents of concern, changes in flows are small enough and at times of year that they would not be expected to result in more water quality thresholds exceedances in Stanislaus River.

G.2.6.1.7 San Joaquin River

Flows in the San Joaquin River under Alternative 4 would be identical to those seen under Alternative 1. Flow change below the confluence with the Merced River and below Sack Dam would be less than 1%. At Vernalis, Alternative 4 would result in a small decrease in flows for all water year types, primarily during the summer months, May through September. Figures G.2-31 through G.2-36 illustrate flow changes at Vernalis. The minimal change in flow under Alternative 4 would not likely increase the frequency of water quality threshold exceedances in the San Joaquin River.

G.2.6.1.8 CVP and SWP Service Area (south to Diamond Valley)

Alternative 4 would generally result in higher monthly average chloride concentrations from September through January, particularly in wet and above normal water year types, and similar or lower concentrations in the remaining months, as compared to the No Action Alternative. Since this water is delivered to reservoirs for storage in the CVP/SWP reservoirs, reservoir chloride concentrations may increase. However, in some months, the CVP/SWP would continue to be operated in real-time to meet the Bay-Delta WQCP objectives for chloride, which aim to protect municipal and industrial beneficial uses. In September through January, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006). Thus, Alternative 4 would not impair municipal and industrial beneficial uses of the CVP/SWP service area.

G.2.6.1.9 Bay Delta

Potential Changes in EC

Delta

Monthly average EC levels in the Sacramento River at Emmaton would often be substantially higher in September through December of wet and above normal water year types under Alternative 4, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 4-4, Figures 4-2, 4-3, 4-15 through 4-18). Monthly average EC levels in July through October of below normal, dry, and critical water year types also would be higher (Appendix F, Attachment 3-6, Table 4-4). Monthly average EC levels in February through June would be similar to or lower than the No Action Alternative EC levels (Appendix F, Attachment 3-6, Table 4-4, Figures 4-8 through 4-12).

Monthly average EC levels in the San Joaquin River at Vernalis under Alternative 4 would generally be like the levels occurring under the No Action Alternative (Appendix F, Attachment 3-6, Table 6-4, Figures 6-1 through 6-18). Somewhat higher monthly EC levels would occur in April through June of below normal water years, April through August of dry water years, and February through August of critical water years, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 6-4, and Figures 6-8 through 6-14).

Monthly average EC levels in the San Joaquin River at Jersey Point, like the Sacramento River at Emmaton, would often be substantially higher in September through December of wet and above normal water year types under Alternative 4, relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-4, Figures 7-2, 7-3, 7-15 through 7-18). January, February, March, April, and June would also see somewhat higher EC levels relative to the No Action Alternative (Appendix F, Attachment 3-6, Table 7-4, Figures 7-7 through 7-10, and Figure 7-12).

Monthly average EC levels at the Banks and Jones pumping plants under Alternative 4, relative to the No Action Alternative, would be higher in September through December, most notably in wet and above normal water year types (Appendix F, Attachment 3-6, Tables 15-4 and 16-4, Figures 15-2, 15-3, 16-2, and 16-3). Monthly average EC levels in March through May in all water year types also would be higher under Alternative 4 (Appendix F, Attachment 3-6, Tables 15-4 and 16-4). In February, June, July, and August, monthly average EC levels would be similar to or lower than No Action Alternative EC levels (Appendix F, Attachment 3-6, Tables 15-4 and 16-4, Figures 15-8, 15-12 through 15-14, 16-8, and 16-12 through 16-14).

While there would be higher monthly average EC levels under Alternative 4 relative to the No Action Alternative, in some months, the CVP/SWP would continue operation in real-time to meet the Bay-Delta WQCP EC objectives, which aim to protect agricultural and fish and wildlife beneficial uses. The western Delta EC objectives for the Sacramento River at Emmaton and San Joaquin River at Jersey Point for agricultural beneficial use protection apply from April through June, July, or August, depending on water year type (SWRCB 2006:13). The San Joaquin River at Jersey Point objective for fish and wildlife protection also applies during April and May (SWRCB 2006:14). During these months, the monthly average EC levels under Alternative 4 would be similar to the No Action Alternative (Appendix F, Attachment 3-6, Tables 4-4 and 7-4). The southern Delta EC objectives to protect agricultural uses for the San Joaquin River at Vernalis and the export area for the Banks and Jones pumping plants apply year-round. Banks and Jones pumping plants would have higher EC levels in the fall and spring, and generally lower monthly average EC in summer, relative to the No Action Alternative (Appendix F, Attachment 3-6, Tables 15-4 and 16-4), and monthly average EC levels at Vernalis would overall be similar to the No Action Alternative (Appendix F, Attachment 3-6, Table 6-4). Thus, the differences in EC in the Delta under Alternative 4, relative to the No Action Alternative, would not contribute to agricultural or fish and wildlife beneficial use impairments in the Delta.

Suisun Marsh

In the Sacramento River at Collinsville, a Bay-Delta WQCP compliance location for the eastern portion of Suisun Marsh, monthly average EC levels would be substantially higher under Alternative 4, relative to the No Action Alternative, in September through December of wet and above normal water year types (Appendix F, Attachment 3-6, Table 11-4, Figures 11-2 and 11-3). The EC differences would occur primarily at the low end of the modeled EC range; there is little difference between the upper monthly average EC levels at Collinsville relative to the No Action Alternative (Appendix F, Attachment 3-6, Figures 11-15 through 11-18). Monthly average EC levels in January through June would overall be similar to No Action Alternative EC levels (Appendix F, Attachment 3-6, Table 11-4, Figures 11-7 through 11-12).

Suisun Bay and San Francisco Bay

Based on the modeling results discussed above, the EC of Delta outflow under Alternative 4 may be different than what would occur under the No Action Alternative in certain months of certain water year types. Also, Alternative 4 would result in lower Delta outflow rates in June through November and higher outflow rates in December through May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-4). These differences in Delta EC and outflow could cause the freshwater-seawater salinity gradient within Suisun Bay and the northern portion of San Francisco Bay to differ between Alternative 4 and the No Action Alternative. These differences are not expected to result in substantial changes in overall salinity conditions within Suisun Bay and San Francisco Bay, because seawater is the bays' predominant salinity source.

Potential Changes in Chloride

The discussion below assesses the differences between chloride at the five assessment locations – Contra Costa Pumping Plant #1, San Joaquin River at Antioch, Banks and Jones pumping plants, and North Bay Aqueduct – under Alternative 4 as compared to the No Action Alternative. The assessment is based on modeling results presented in Appendix F, Attachment 3-10, *Salinity Results (DSM2)*.

Monthly average chloride concentrations at Contra Costa Pumping Plant #1 would often be substantially higher in October through December of wet and above normal water year types, and somewhat higher in March, April, and May of all water year types under Alternative 4, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 19-4, Figures 19-1 through 19-18). Monthly average chloride concentrations in February and June through August would be similar to or less than concentrations under the No Action Alternative (Appendix F, Attachment 3-10, Table 19-4, Figures 19-8, and 19-12 through 19-14).

Monthly average chloride concentrations in the San Joaquin River at Antioch would often be substantially higher in September through December of wet and above normal water year types under Alternative 4, (Appendix F, Attachment 3-10, Table 20-4, Figures 20-2 and 20-3). In January through August, monthly average chloride concentrations would be similar to or less than No Action Alternative concentrations (Appendix F, Attachment 3-10, Table 20-4, Figures 20-7 through 20-14).

Monthly average chloride concentrations at Banks and Jones pumping plants would be somewhat higher in October through December of wet and above normal water year types under Alternative 4, relative to the No Action Alternative (Appendix F, Attachment 3-10, Table 21-4 and Table 22-4, Figures 21-2, 21-3, 22-2, and 22-3). Monthly average chloride concentrations in March through May would be higher in all water year types (Appendix F, Attachment 3-10, Tables 21-4 and 22-4, Figures 21-1 through 21-6 and 22-1 through 22-6). In February and June through August, monthly average chloride concentrations would be similar to or lower than those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Tables 21-4 and 22-4, Figures 21-8, 21-12 through 21-14, 22-8, and 22-12 through 22-14).

Monthly average chloride concentrations in Barker Slough at the North Bay Aqueduct under Alternative 4 would be the same as those that would occur under the No Action Alternative (Appendix F, Attachment 3-10, Table 23-4, Figures 23-1 through 23-18).

Alternative 4 would generally result in higher monthly average chloride concentrations in October through December, particularly in wet and above normal water year types, and in March through May of all water year types, as compared to the No Action Alternative. In some months, the CVP/SWP would operate in real-time to meet the Bay-Delta WQCP chloride objectives, which aim to protect municipal and industrial beneficial uses. In October through December and March through May, when chloride would be higher compared to the No Action Alternative, the maximum mean daily chloride objectives of 250 mg/L would continue to apply at Contra Costa Pumping Plant #1, Banks and Jones pumping plants, and Barker Slough at North Bay Aqueduct (SWRCB 2006:12). Also, the maximum mean daily chloride objective of 150 mg/L would continue to apply at Contra Costa Pumping Plant #1 or San Joaquin River at Antioch for a certain number of days per year, depending on water year type (SWRCB 2006:12). Thus, Alternative 4 would not contribute to the impairment of using Delta waters for municipal and industrial beneficial uses.

Suisun Bay, Suisun Marsh, and San Francisco Bay waters are not designated for municipal and domestic supply uses, and other salinity-related effects in these waters are addressed above in the EC discussion.

Potential Changes in Bromide

As discussed for Alternative 1, based on the EC levels modeled for Alternative 4, monthly average bromide concentrations at Delta drinking water intakes could be higher than those that would occur under the No Action Alternative, particularly in the fall. However, for the reasons provided for Alternative 1, Alternative 4 would not be expected to contribute to drinking water impairments related to bromide, relative to those that would occur under the No Action Alternative.

Potential Changes in Methylmercury

Long-term average water column methylmercury concentrations in the Delta under Alternative 4 would be the nearly same (i.e., within 0.003 ng/L) as those that would occur under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Thus, Alternative 4 would not contribute to higher methylmercury concentrations in the Delta through changes in source water inflows.

All modeled fish tissue concentrations exceed the water quality objective of 0.24 mg/kg under the No Action Alternative and Alternative 4, as shown by fish tissue concentration results presented in Appendix G, Attachment 1, Table G1.5-5, *Methylmercury Concentrations in 350 millimeter Largemouth Bass Fillets for Alternative 4, and Comparison to No Action Alternative*, and the EQs plotted and provided in Appendix G, Attachment 1, Figures G1.5-1 and G1.5-2; all EQs are greater than 1.0. Compared to the No Action Alternative, Alternative 4, fish tissue methylmercury concentrations would be from 3.5% higher to 1.6% lower at all modeled locations for the entire period modeled (Appendix G, Attachment 1, Table G1.5-5). For the drought period modeled, fish tissue methylmercury concentrations would be from 1.4% higher to 0.9% lower than the No Action Alternative at all modeled locations (Appendix G, Attachment 1, Table G1.5-5).

The differences between the fish tissue methylmercury concentrations under Alternative 4, relative to the No Action Alternative, are expected to be within the uncertainty inherent in the modeling approach and would likely not be measurable in the environment. The bioaccumulation models contain multiple sources of uncertainty associated with their development related to analytical variability; temporal and/or seasonal variability in Delta source water concentrations of methylmercury; interconversion of mercury species (i.e., the non-conservative nature of methylmercury as a modeled constituent); and limited sample size (both in number of fish and time span over which the measurements were made). Although there is uncertainty in the models used, the results serve as reasonable approximations of a very complex process. Considering the uncertainty, the small (i.e., < 5%) differences in modeled fish tissue mercury concentrations should be interpreted to be within the uncertainty of the overall approach, and not predictive of actual adverse effects.

Based on the overall similar methylmercury concentrations at all modeled Delta locations, water operations under Alternative 4 would not contribute to additional water quality degradation with respect to methylmercury, or in increased health risks to wildlife or humans consuming wildlife, as compared to the No Action Alternative. Thus, the differences in methylmercury in the Delta between Alternative 4 and the No Action Alternative would not contribute to additional beneficial use impairments in the Delta.

Long-term average methylmercury concentrations in the western Delta under Alternative 4 would be similar to those under the No Action Alternative (Appendix G, Attachment 1, Table G1.1-2). Alternative 4 would result in lower Delta outflow rates in June through November and higher outflow rates in December through May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-4). The long-term average Delta outflow would be similar (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-4). Thus, water operations would not contribute to additional water quality degradation with respect to methylmercury or increased biota bioaccumulation in Suisun Bay and San Francisco Bay, compared to the No Action Alternative.

Potential Changes in Selenium

Based on modeled Delta water concentrations, selenium concentrations in the Delta under Alternative 4 would be nearly the same (i.e., within 0.01 µg/L) those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Long-term average selenium concentrations in the water column at the three western Delta locations under Alternative 4 would be the same as those that would occur under the No Action Alternative. Thus, Alternative 4 would not contribute to additional selenium-related water quality degradation, as compared to the No Action Alternative.

Modeled selenium concentrations in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 4 are similar to those modeled for the No Action Alternative, as shown in Appendix G, Attachment 2, Table G2.3-4, *Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative and Alternative 4*. Also, EQs computed for the applicable toxicity benchmarks show that selenium concentrations in biota under both the No Action Alternative and Alternative 4 would be below the thresholds identified for ecological risk (Appendix G, Attachment 2, Tables G2.3-5, *Summary Table for Selenium Concentrations in Biota, and Comparisons for No Action Alternative to Benchmarks* and G2.3-9, *Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 4 to No Action Alternative and Benchmarks*, Figures G2.3-1 through G2.3-4). Thus, Alternative 4 would not result in increased health risks to wildlife that consume other wildlife associated with whole-body fish, bird eggs (invertebrate diet), bird eggs (fish diet), and fish fillets, compared to the No Action Alternative.

Modeled selenium concentrations in whole-body Sturgeon in the western Delta under Alternative 4 also are similar to those modeled for the No Action Alternative (Appendix G, Attachment 2, Tables G2.3-10 and G2.3-12). Low Toxicity Threshold EQs are less than 1.0 for entire 82-year period modeled and slightly exceed 1.0 for drought period modeled (Appendix G, Attachment 2, Table G2.3-11, Figure G2.3-5), but are similar for Alternative 4 and the No Action Alternative. Modeled EQs for the High Toxicity Threshold at all locations are less than 1.0 for the entire period modeled and the drought period modeled, and are similar for Alternative 4 and the No Action Alternative. Thus, Alternative 4 would not result in increased health risks to wildlife or humans consuming wildlife associated with sturgeon.

Long-term average water column selenium concentrations in the western Delta under Alternative 4 would be similar to those that would occur under the No Action Alternative (Appendix G, Attachment 2, Table G2.2-1). Alternative 4 would result in lower Delta outflow rates in June through November and higher outflow rates in December through May (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-4). The long-term average Delta outflow would be similar (Appendix F, Attachment 3-2, *Flow Results (CalSim II)*, Table 41-4). Thus, Alternative 4 would not contribute to additional water quality degradation with respect to selenium or increased biota bioaccumulation in Suisun Bay and San Francisco Bay.

Potential Changes in Trace Metals

For the same reasons described for Alternative 1, Alternative 4 would not affect existing Delta impairments related to trace metals and would not result in additional trace metals-related impairments in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Nutrients

For the same reasons described for Alternative 1 (see Section G.2.3.1.9, *Bay-Delta*), Alternative 4 would not contribute to different Delta nutrient concentrations or nutrient distributions that would adversely affect beneficial uses or substantially degrade the water quality, relative to the conditions that would occur under the No Action Alternative. Further, any potential differences in total nitrogen and phosphorus loading that would occur in Delta outflow to Suisun Bay and Marsh, and San Francisco Bay, relative to the No Action Alternative, are not expected to degrade water quality with regard to nutrients that would create adverse effects to beneficial uses or further impair Suisun Bay and Marsh, or San Francisco Bay.

Potential Changes in Dissolved Oxygen

For the same reasons described for Alternative 1, Alternative 4 would not substantially affect dissolved oxygen concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay relative to the No Action Alternative. Alternative 4 would not make existing dissolved oxygen impairments in the Delta and Suisun Marsh worse.

Potential Changes in Pathogens

For the same reasons described for Alternative 1, Alternative 4 would not substantially affect pathogen levels in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Legacy Contaminants

For the same reasons described for Alternative 1, Alternative 4 would not substantially affect legacy contaminants levels (e.g., dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative.

Potential Changes in Pesticides

For the same reasons described for Alternative 1, Alternative 4 would not substantially affect pesticide concentrations in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative. Under Alternative 4, the Clifton Court Aquatic Weed program discussed in the Alternative 1 pesticides assessment would not be implemented.

Potential Changes in Organic Carbon

For the same reasons described for Alternative 1, Alternative 4 would not result in organic carbon concentration differences in the Delta, Suisun Bay and Marsh, or San Francisco Bay, relative to the No Action Alternative, that would adversely affect beneficial uses.

G.2.6.2 *Program-Level Effects*

Under Alternative 4, program level effects would include the construction actions related to the increased water use efficiency component. This action would have the potential to similarly affect water quality program-level construction actions as actions under Alternative 1 and Alternative 3. While these could have short-term effects on water quality, including increased sedimentation and turbidity, implementing Mitigation Measures WQ-1, WQ-2, WQ-3, and WQ-4, described below in Section G.2.7, would reduce or eliminate the effects on water quality. Adverse effects on water quality and violations to water quality standards are not expected from Alternative 4 program-level activity.

G.2.7 Mitigation Measures

Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan.

A Spill Prevention, Control, and Countermeasure Plan (SPCCP) shall be developed and implemented to minimize the potential for, and effects from, spills of hazardous, toxic, and petroleum substances during construction and maintenance. The SPCCP will be completed before construction activities begin. SPCCP implementation will comply with State and Federal water quality regulations. The SPCCP will describe spill sources and spill pathways, as well as the actions that would be taken in the event of a spill (e.g., an oil spill from engine refueling will be cleaned up immediately with oil absorbents) or the exposure of an undocumented hazard. The SPCCP will describe containment facilities and practices, such as double-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures, and spill response kits. It will also describe how and when employees will be trained in proper handling and spill prevention and response procedures.

The SPCCP will be reviewed and approved before the onset of construction activities and will routinely inspect the construction area to verify that the SPCCP measures are properly implemented and maintained. Contractors will be notified immediately if there is a noncompliance issue and will work to regain compliance.

If a spill is reportable, the construction contractor’s superintendent will notify the Lead Agency, and will contact the appropriate safety and cleanup crews to ensure the SPCCP is followed. A written description of reportable releases will be submitted to the RWQCB and the California Department of Toxic Substances Control. This submittal will describe the release, including the type of material and an estimate of the amount spilled, state the date of the release, explain why the spill occurred, and outline the steps taken to prevent and control future releases. The releases will be documented on a spill report form.

Mitigation Measure WQ-2: Implement a Stormwater Pollution and Prevention Plan.

Prior to initiating construction and maintenance activities, the construction contractor will prepare a Stormwater Pollution and Prevention Plan (SWPPP) describing best management practices (BMPs) that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. Specific BMPs in the SWPPP will be site-specific and prepared in accordance with the regional water board field manual. The SWPPP will include the following standard erosion- and sediment-control BMPs:

- **Construction timing.** All construction and ongoing operations and maintenance activities will occur from April 15 through November 1 to avoid ground disturbance in the rainy season.
- **Grading spoils stabilization.** Grading spoils generated during construction may be temporarily stockpiled in staging areas. Such staging areas will not contain native or sensitive vegetation communities and will not support sensitive plant or animal species. Silt fences, non-monofilament fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with a geotextile material to increase protection from wind and water erosion. Materials used for stabilizing spoils will be selected to be non-injurious to wildlife
- **Permanent site stabilization.** The construction contractor will install structural or vegetative methods to permanently stabilize all graded or disturbed areas once construction is complete. Structural methods could include installing biodegradable fiber rolls or erosion-control blankets. Vegetative methods could include applying organic mulch and tackifiers, and/or an erosion-control native seed mix.
- **Construction equipment and materials staging.** Equipment and materials will be staged in designated staging areas that meet the requirements identified above for stabilizing grading spoils.
- **Minimizing soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance and/or destruction of existing vegetation. This will be accomplished, in part, through establishing designated equipment staging areas, ingress and egress corridors, equipment exclusion zones, and protecting existing trees before beginning grading operations.
- **Installing sediment barriers.** The construction contractor will install silt fences, fiber rolls, or similar devices to prevent sediment-laden water from leaving the construction area to the extent feasible in areas where construction occurs in saturated soils.

Mitigation Measure WQ-3: Develop a turbidity monitoring program.

The Basin Plan for the Sacramento River and San Joaquin River basins (Fourth Edition) (Central Valley RWQCB 2016) contains turbidity objectives. The plan states that where natural turbidity is between five and 50 NTUs, turbidity levels may not be elevated by 20% above ambient conditions; where ambient conditions are between 50 and 100 NTUs, conditions may not be increased by more than 10 NTUs; and where natural turbidity is greater than 100 NTUs, increases will not exceed 10%. A sampling plan shall be developed and implemented based on specific site conditions and in consultation with the RWQCB. If turbidity limits exceed basin plan standards, construction-related earth-disturbing activities will slow to a point that would alleviate the problem.

Mitigation Measure WQ-4: Develop a water quality mitigation and monitoring program.

A program shall be developed and implemented to reduce, minimize, or eliminate increases in water quality constituents. The program will develop a monitoring plan, including frequent sampling and reporting, particularly for existing constituents of concern. Reclamation will coordinate with the implementation of current TMDLs to share monitoring information and contribute to the efforts to reduce constituents of concern. Efforts could include water quality (through the water column), soil, and fish and invertebrate tissue monitoring.

G.2.8 Summary of Impacts

Table G.2-1, *Impact Summary*, includes a summary of impacts, the magnitude and direction of those impacts, and potential mitigation measures to consider.

Table G.2-1. Impact Summary

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
Project-Level Impacts			
Potential changes in water quality	No Action	No Impact	-
	1	Flow reductions in study area rivers from CVP/SWP operation changes would not result in water quality degradation.	-
	2	Flow reductions in Clear Creek and the Stanislaus River could result in water quality degradation.	-
	3	Flow reductions in Clear Creek and the Stanislaus River could result in water quality degradation.	-
	4	Flow reductions in study area rivers from CVP/SWP operation changes would not result water quality degradation.	-
Bay-Delta Region: Potential Changes in EC	No Action	No Impact	-
	1	Higher monthly average EC at certain Delta locations in certain months, relative to No Action Alternative: ● Sacramento River at Emmaton: substantially higher in September through December of wet and above normal water years. ● San Joaquin River at Vernalis: somewhat higher in April and May. ● San Joaquin River at Jersey Point: substantially higher in September through December of wet and above normal water years; somewhat higher in other months. ● Banks and Jones pumping plants: higher in September through January, most notably in wet and above normal years. ● Sacramento River at Collinsville: substantially higher in September through December of wet and above normal water years; somewhat higher in December through May of all water years. No substantial differences in overall Suisun Marsh, Suisun Bay and San Francisco Bay EC conditions expected.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	2	Higher monthly average EC at certain Delta locations in certain months, relative to No Action Alternative: • Sacramento River at Emmaton: substantially higher in September through December of wet and above normal water years, and January of below normal, dry, and critical water years. • San Joaquin River at Vernalis: substantially higher in October, somewhat higher in March through June. • San Joaquin River at Jersey Point: substantially higher in September through December of wet and above normal water years; somewhat higher in February through June. • Banks and Jones pumping plants: higher in September through January, most notably in wet and above normal years. • Sacramento River at Collinsville: substantially higher in September through December of wet and above normal water years; somewhat higher in December through May of all water years. No substantial differences in overall Suisun Marsh, Suisun Bay and San Francisco Bay EC conditions expected.	-
	3	Higher monthly average EC at certain Delta locations in certain months, relative to No Action Alternative: • Sacramento River at Emmaton: substantially higher in September through December of wet and above normal water years, and January of below normal, dry, and critical water years. • San Joaquin River at Vernalis: substantially higher in October, somewhat higher in March through June. • San Joaquin River at Jersey Point: substantially higher in September through December of wet and above normal water years; somewhat higher in February through June. • Banks and Jones pumping plants: higher in September through January, most notably in wet and above normal years. • Sacramento River at Collinsville: substantially higher in September through December of wet and above normal water years; somewhat higher in December through May of all water years. No substantial differences in overall Suisun Marsh, Suisun Bay and San Francisco Bay EC conditions expected.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	4	Higher monthly average EC at certain Delta locations in certain months, relative to No Action Alternative: • Sacramento River at Emmaton: substantially higher in September through December of wet and above normal water years. • San Joaquin River at Vernalis: somewhat higher in February through August. • San Joaquin River at Jersey Point: substantially higher in September through December of wet and above normal water years; somewhat higher in February through June. • Banks and Jones pumping plants: higher in September through December, and March through May. • Sacramento River at Collinsville: substantially higher in September through December of wet and above normal water years. No substantial differences in overall Suisun Marsh, Suisun Bay and San Francisco Bay EC conditions expected.	-
Bay-Delta Region: Potential Changes in Chloride	No Action	No Impact	-
	1	Higher monthly average chloride at certain Delta locations in certain months, relative to No Action Alternative: • Contra Costa Pumping Plant #1: substantially higher in October through December of wet and above normal water years; somewhat higher in September and January of all water years. • San Joaquin River at Antioch: substantially higher in September through December of wet and above normal water years, somewhat higher in January through August of all water years. • Banks and Jones pumping plants: higher in September through January of all water years. • Barker Slough at North Bay Aqueduct: little to no difference. Salinity-related effects to Suisun Marsh, Suisun Bay, and San Francisco Bay addressed via evaluating effects to EC.	-
	2	Higher monthly average chloride at certain Delta locations in certain months, relative to No Action Alternative:	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		• Contra Costa Pumping Plant #1: substantially higher in October through December of wet and above normal water years; somewhat higher in September, January, and February of all water years. • San Joaquin River at Antioch: substantially higher in September through December of wet and above normal water years, somewhat higher in December through May and August of all water years. • Banks and Jones pumping plants: higher in September through January of all water years. • Barker Slough at North Bay Aqueduct: little to no difference. Salinity-related effects to Suisun Marsh, Suisun Bay, and San Francisco Bay addressed via evaluating effects to EC.	
	3	Higher monthly average chloride at certain Delta locations in certain months, relative to No Action Alternative: • Contra Costa Pumping Plant #1: substantially higher in October through December of wet and above normal water years; somewhat higher in September, January, and February of all water years. • San Joaquin River at Antioch: substantially higher in September through December of wet and above normal water years, somewhat higher in December through May of all water years. • Banks and Jones pumping plants: higher in September through January of all water years. • Barker Slough at North Bay Aqueduct: little to no difference. Salinity-related effects to Suisun Marsh, Suisun Bay, and San Francisco Bay addressed via evaluating effects to EC.	-
	4	Higher monthly average chloride at certain Delta locations in certain months, relative to No Action Alternative: • Contra Costa Pumping Plant #1: substantially higher in October through December of wet and above normal water years. • San Joaquin River at Antioch: substantially higher in September through December of wet and above normal water years. • Banks and Jones pumping plants: higher in October through December of wet and above normal water years, and March through May of all water years. • Barker Slough at North Bay Aqueduct: no difference.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		Salinity-related effects to Suisun Marsh, Suisun Bay, and San Francisco Bay addressed via evaluating effects to EC.	
Bay-Delta Region: Potential Changes in Bromide	No Action	No Impact	-
	1	Potentially higher bromide concentrations at Delta export locations, as related to higher EC, relative to the No Action Alternative.	-
	2	Potentially higher bromide concentrations at Delta export locations, as related to higher EC, relative to the No Action Alternative.	-
	3	Potentially higher bromide concentrations at Delta export locations, as related to higher EC, relative to the No Action Alternative.	-
	4	Potentially higher bromide concentrations at Delta export locations, as related to higher EC, relative to the No Action Alternative.	-
Bay-Delta Region: Potential Changes in Methylmercury	No Action	No Impact	-
	1	Long-term average methylmercury concentrations in Delta water and fish tissues would be similar to or slightly lower than No Action Alternative; no additional degradation or bioaccumulation of methylmercury in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
	2	Long-term average methylmercury concentrations in Delta water and fish tissues would be similar to or slightly lower than No Action Alternative; no additional degradation or bioaccumulation of methylmercury in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
	3	Long-term average methylmercury concentrations in Delta water and fish tissues would be similar to or slightly lower than No Action Alternative; no additional degradation or bioaccumulation of	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		methylmercury in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	
	4	Long-term average methylmercury concentrations in Delta water and fish tissues would be similar to the No Action Alternative; no additional degradation or bioaccumulation of methylmercury in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
Bay-Delta Region: Potential Changes in Selenium	No Action	No Impact	-
	1	Long-term average selenium concentrations in Delta water, and bird egg and fish tissues would be similar to No Action Alternative; no additional degradation or bioaccumulation of selenium in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
	2	Long-term average selenium concentrations in Delta water, and bird egg and fish tissues would be similar to No Action Alternative; no additional degradation or bioaccumulation of selenium in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
	3	Long-term average selenium concentrations in Delta water, and bird egg and fish tissues would be similar to No Action Alternative; no additional degradation or bioaccumulation of selenium in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
	4	Long-term average selenium concentrations in Delta water, and bird egg and fish tissues would be similar to No Action Alternative; no additional degradation or bioaccumulation of selenium in Suisun Bay or San Francisco Bay, relative to the No Action Alternative.	-
Bay-Delta Region: Potential Changes in Trace Metals	No Action	No Impact	-
	1	Existing trace metals impairments would not be affected and no contributions to additional impairments would occur, relative to the No Action Alternative.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	2	Existing trace metals impairments would not be affected and no contributions to additional impairments would occur, relative to the No Action Alternative.	-
	3	Existing trace metals impairments would not be affected and no contributions to additional impairments would occur, relative to the No Action Alternative.	-
	4	Existing trace metals impairments would not be affected and no contributions to additional impairments would occur, relative to the No Action Alternative.	-
Bay-Delta Region: Potential Changes in Nutrients	No Action	No Impact	-
	1	Nutrients levels and distributions would not be substantially different from No Action Alternative conditions in the Delta; potentially lower nutrient loading to Suisun Marsh, Suisun Bay, and San Francisco Bay.	-
	2	Nutrients levels and distributions would not be substantially different from No Action Alternative conditions in the Delta; potentially lower nutrient loading to Suisun Marsh, Suisun Bay, and San Francisco Bay.	-
	3	Nutrients levels and distributions would not be substantially different from No Action Alternative conditions in the Delta; potentially lower nutrient loading to Suisun Marsh, Suisun Bay, and San Francisco Bay.	-
	4	Nutrients levels and distributions would not be substantially different from No Action Alternative conditions in the Delta; potentially lower nutrient loading to Suisun Marsh, Suisun Bay, and San Francisco Bay.	-
Bay-Delta Region: Potential Changes in Dissolved Oxygen	No Action	No Impact	-
	1	Dissolved oxygen levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be affected and existing impairments would not be made worse, relative to No Action Alternative conditions.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	2	Dissolved oxygen levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be affected and existing impairments would not be made worse, relative to No Action Alternative conditions.	-
	3	Dissolved oxygen levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be affected and existing impairments would not be made worse, relative to No Action Alternative conditions.	-
	4	Dissolved oxygen levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be affected and existing impairments would not be made worse, relative to No Action Alternative conditions.	-
Bay-Delta Region: Potential Changes in Pathogens	No Action	No Impact	-
	1	Would not contribute to higher pathogens levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	2	Would not contribute to higher pathogens levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	3	Would not contribute to higher pathogens levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	4	Would not contribute to higher pathogens levels in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
Delta, Suisun Bay and Marsh, and San Francisco Bay: Potential Changes in Legacy Contaminants	No Action	No Impact	-
	1	Levels of legacy contaminants (dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Marsh, Suisun Bay, and San Francisco	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		Bay would not be substantially affected, relative to the No Action Alternative.	
	2	Levels of legacy contaminants (dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be substantially affected, relative to the No Action Alternative.	-
	3	Levels of legacy contaminants (dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be substantially affected, relative to the No Action Alternative.	-
	4	Levels of legacy contaminants (dioxin and furan compounds, PCBs, and PAHs) in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay would not be substantially affected, relative to the No Action Alternative.	-
Delta, Suisun Bay and Marsh, and San Francisco Bay: Potential Changes in Pesticides	No Action	No Impact	-
	1	No substantial increased risk of higher pesticide concentrations or pesticide-related toxicity in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	2	No substantial increased risk of higher pesticide concentrations or pesticide-related toxicity in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	3	No substantial increased risk of higher pesticide concentrations or pesticide-related toxicity in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-
	4	No substantial increased risk of higher pesticide concentrations or pesticide-related toxicity in the Delta, Suisun Marsh, Suisun Bay, and San Francisco Bay, relative to the No Action Alternative.	-

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
Delta, Suisun Bay and Marsh, and San Francisco Bay: Potential Changes in Organic Carbon	No Action	No Impact	-
	1	No substantial changes in total organic carbon concentrations in the Delta or Suisun Marsh; could result in lower organic carbon loading to Suisun Bay and San Francisco Bay.	-
	2	No substantial changes in total organic carbon concentrations in the Delta or Suisun Marsh; could result in lower organic carbon loading to Suisun Bay and San Francisco Bay.	-
	3	No substantial changes in total organic carbon concentrations in the Delta or Suisun Marsh; could result in lower organic carbon loading to Suisun Bay and San Francisco Bay.	-
	4	No substantial changes in total organic carbon concentrations in the Delta or Suisun Marsh; could result in lower organic carbon loading to Suisun Bay and San Francisco Bay.	-
Program-Level Impacts			
Potential changes in water quality	No Action	No Impact	
	1	Program-level actions and construction activities could affect water quality, including turbidity, mercury and selenium bioaccumulation, dissolved organic carbon, and increased sedimentation.	MM WQ-1; MM WQ-2; MM WQ-3; MM WQ-4.
	2	No program-level actions proposed.	-
	3	Program-level actions and construction activities could affect water quality, including turbidity, mercury and selenium bioaccumulation, dissolved organic carbon, and increased sedimentation.	MM WQ-1; MM WQ-2; MM WQ-3; MM WQ-4.

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	4	Program-level actions and construction activities could affect water quality, including turbidity and increased sedimentation.	MM WQ-1; MM WQ-2; MM WQ-3; MM WQ-4.

G.2.9 Cumulative Effects

Population growth, climate change, changes in water quality regulations, and past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Methodology,* may change water quality conditions in the study area. The cumulative projects include actions across California to reduce water quality issues, including Bay-Delta Water Quality Control Plan Update, FERC Relicensing Projects, agricultural drainage programs, and San Luis Reservoir Low Point Improvement Project. The cumulative projects also include numerous projects to reduce water quality issues related to nutrients, agricultural drainage, and other discharges of constituents of concern.

Collectively, these cumulative projects are anticipated to generate direct or indirect improvements in local or broader regional water quality conditions. Their construction could generate potential short-term impacts to water quality, but mitigation measures and best management practices will reduce the potential impacts. The combined water quality effects of past, present, and reasonably foreseeable future projects will vary. Some projects will potentially contribute to the degradation of various water quality parameters, whereas other projects will improve water quality in certain areas. Population growth is expected to produce increased constituent loadings to surface waters through increased urban stormwater runoff, increased municipal wastewater treatment plant discharges, and changes in land uses. Regulations, programs, and projects will aim to control pollutant discharges to surface waters and improve or maintain water quality conditions.

The No Action Alternative would generate no changes to water operations and there would be no improvement in the existing limits on water supply availability affecting CVP and SWP water users. There would also be no change to the water quality conditions that currently contribute to the limits on water supply deliveries. This includes water quality concerns within the study area that currently impact beneficial uses. Newly created tidal habitat under the No Action Alternative could potentially lead to new sources of localized organic carbon loading within the Delta. However, the degree to which new tidal habitat areas may be future sources of organic carbon for the Delta's aquatic environment is uncertain. In addition, adding tidal habitat under the No Action Alternative could result in increased mercury methylation within the Delta, increased biotic exposure to and uptake of methylmercury, ultimately resulting in increased mercury bioaccumulation in fish tissues. Tidal habitat design and location considerations would minimize any addition of dissolved organic carbon at drinking water supply intakes and biota methylmercury bioaccumulation. Thus, the No Action Alternative would have no contribution to the cumulative water quality condition.

Alternative 2 would negatively affect water quality in Clear Creek and the Stanislaus River by reducing flows in all water year types. This flow reduction could result in less dilution, causing increased constituents of concern concentrations within Clear Creek and the Stanislaus River compared to current conditions. Flow reductions could lead to an increase in the frequency of exceedances of water quality standards and negatively impact assigned beneficial uses. Alternative 2's contribution to water quality degradation would not be substantial. When considered in combination with the other projects in this assessment, the contribution made by Alternative 2 would not be substantial because these projects are intended to improve overall water quality conditions.

Alternatives 1, 3, and 4 would have similar or less impact compared to Alternative 2. They would not generate substantial contributions to cumulative water quality conditions in the Trinity River, Sacramento River, Clear Creek, Feather River, American River, Stanislaus River, and San Joaquin River areas. When considered in combination with the other projects in this assessment, the contribution made by Alternatives 1, 3, and 4 would not be substantial because these projects are intended to improve overall water quality conditions.

Specific to the CVP and SWP Service Area, all action alternatives would result in high chloride concentrations during some months. However, the CVP/SWP would continue operation, in real-time, to meet the Bay-Delta WQCP objectives for chloride, which aim to protect municipal and industrial beneficial uses. Thus, all action alternatives would not generate substantial contributions to cumulative water quality conditions in the CVP and SWP Service Area.

Specific to the Bay-Delta region, the project alternatives would have negligible, if any, effects on trace metals, dissolved oxygen, pathogens, pesticides, or legacy contaminants (i.e., dioxin and furan compounds, PCBs, and PAHs). Thus, the project alternatives would not have an effect on the future cumulative conditions of these constituents and constituent groups. However, the project alternatives could have some effect on EC, chloride, bromide, methylmercury, selenium, nutrients, and organic carbon, in the Delta, Suisun Marsh, Suisun Bay, and/or San Francisco Bay.

G.2.9.1 *Salinity-Related Parameters: EC, Chloride, and Bromide*

The western, northwestern, southern, and export area portions of the Delta are on the SWRCB's CWA section 303(d) list as impaired due to elevated EC/salinity. Suisun Marsh is listed as impaired due to salinity and chloride (SWRCB 2017a). Bromide is not specifically identified as a constituent contributing to impairment, but is also a salinity-related parameter, so is addressed with EC and chloride. Climate change is anticipated to cause an increase in EC/chloride/salinity in the western and southern due to sea level rise, which would contribute to continued adverse cumulative conditions for EC and chloride, and potentially bromide, in the western Delta.

Several regulatory programs aim to address salinity in the Central Valley and have the potential to reduce salt loads to the Bay-Delta region. The Central Valley RWQCB has adopted a Salt and Nitrate Control Program Basin Plan Amendment to manage salt and nitrate discharges within the Central Valley region (it is pending approval by the SWRCB and USEPA). Further, the Central Valley RWQCB includes requirements in municipal wastewater treatment plant NPDES permits to control salinity discharges to surface waters. While implementing additional controls should reduce salinity in discharges, the cumulative condition for EC and chloride will likely be adverse, primarily because of sea level rise and how that affects EC in the western and southern Delta, and Suisun Marsh. The cumulative condition for bromide also could be adverse, depending on the extent to which sea level rise results in higher bromide concentrations at drinking water treatment plant intakes in the Delta.

All action alternatives also would not contribute to additional adverse effects on Delta EC, chloride, and bromide, and Suisun Marsh salinity/chloride. The CVP and SWP would continue to be operated, in real-time, to meet the Bay-Delta WQCP objectives for EC, which aim to protect agricultural and fish and wildlife beneficial uses, and chloride for the protection of municipal and industrial supply uses. Although there could be some level of water quality degradation for EC and chloride under these alternatives, relative to the No Action Alternative, operations to meet the Bay-Delta WQCP objectives would ensure that beneficial uses would remain protected with regard to EC and chloride levels. While there are no objectives specifically for bromide, bromide concentrations are related to EC and chloride, and thus, all action alternatives would not be expected to contribute to additional adverse effects on beneficial uses because of the operations to meet Bay-Delta WQCP objectives.

G.2.9.2 *Methylmercury*

Numerous regulatory efforts are implemented or under development to control and reduce mercury loading to the Bay-Delta region, including TMDLs, increased restrictions on point-source discharges such as municipal wastewater treatment plants, greater restrictions on suction dredging in Delta tributary watersheds, and continued clean-up actions on mine drainage in the upper watersheds. A key challenge surrounds the pool of mercury deposited in Delta sediments, which cannot be readily or rapidly reduced, despite efforts to reduce future loads in Delta tributaries, and serves as a source for continued methylation and Delta biota methylmercury bioaccumulation. Consequently, methylmercury levels in Bay-Delta waters are considered to be an adverse cumulative condition.

All action alternatives would not contribute to additional adverse effects on Bay-Delta methylmercury. Based on the water and fish tissue modeling performed for the Project-Level analysis, methylmercury concentrations in water and fish tissue are not expected to be substantially affected by water operations under the project alternatives. Implementation of tidal habitat under Alternatives 1 and 3 could create conditions resulting in increased mercury methylation within the Delta and increased biotic exposure to and uptake of methylmercury, resulting in increased mercury bioaccumulation in fish tissues. Increased methylmercury bioaccumulation would contribute to the adverse cumulative condition for methylmercury in the Bay-Delta region. The degree to which newly created tidal habitat will become new sources of methylmercury to Bay-Delta biota will depend on tidal habitat siting and design. Ongoing studies in the Delta (e.g., DWR 2015) will further inform the siting and design of future tidal habitat restoration areas.

G.2.9.3 *Selenium*

Numerous regulatory efforts have been implemented to control and reduce selenium loading to the Bay-Delta region, primarily through TMDLs. Thus, future cumulative selenium conditions in the Bay-Delta region are expected to be no worse, and possibly better, than existing conditions. However, because Suisun Bay and San Francisco Bay are currently listed as impaired for elevated selenium (SWRCB 2017a), it is anticipated that the cumulative condition for selenium will remain adverse.

All action alternatives would not contribute to additional adverse effects on Bay-Delta selenium. Based on the water and fish tissue modeling performed for the Project-Level analysis, long-term average selenium concentrations in water and fish tissue are expected to be affected minimally, if at all, by water operations under the project alternatives.

G.2.9.4 *Nutrients*

Ammonia and nitrate levels in the Bay-Delta region are expected to be reduced in the future as municipal wastewater treatment plants discharging to Bay-Delta waters implement nitrification and de-nitrification processes. The Central Valley RWQCB is currently permitting such requirements with regularity, and thus notable reductions in wastewater treatment plant-related ammonia and nitrate discharges are expected in the future. Other new or greater sources that would offset such point-source reductions are not anticipated. Thus, ammonia and nitrate levels under the cumulative condition are not expected to be adverse.

Primary sources of phosphorus to Delta waters include agriculture, municipal wastewater treatment plants, individual septic treatment systems, urban runoff, stream bank erosion, and decaying plant material. Currently, there is no clear evidence that phosphorous levels adversely affect Bay-Delta beneficial uses. Due to increased regulations and anticipated regulatory monitoring - that may include additional water quality objectives for nutrients, including phosphorus - loading from agriculture, municipal wastewater treatment plants, individual septic treatment systems, and urban runoff are all expected to remain at similar levels to those under current conditions, or decline, under the future cumulative condition. Loadings from stream bank erosion and decaying plants are not expected to change notably in the future. Hence, phosphorus levels are not anticipated to be adverse under the cumulative condition.

G.2.9.5 *Organic Carbon*

Dissolved organic carbon concentrations in Delta waters are at levels of concern due to disinfection byproduct formation risk at drinking water treatment plants that use the Delta as a drinking water supply. However, total organic carbon is a critically important base of the food web in the Bay-Delta region. The loading of total organic carbon to the Bay-Delta waters may increase in the future cumulative condition due to ongoing and future habitat restoration activities. Loading from other sources, such as municipal wastewater treatment plants and storm water, may also be higher in the future cumulative condition. If future drinking water regulations require substantially lower concentrations of disinfection byproducts in drinking water, total and dissolved organic carbon concentrations in the Delta could be considered adverse, relative to drinking water uses, but not relative to aquatic life beneficial uses. Conversely, if in the future regulations for disinfection byproducts in drinking water supplies remain the same as present regulations, then even with some level of organic carbon increases in Delta waters, future cumulative total and dissolved organic carbon concentrations would not be considered adverse, relative to drinking water uses. Total and dissolved organic carbon concentrations in Suisun Bay, Suisun Marsh, and San Francisco Bay would not be adverse, because these water bodies are not drinking water supplies, but the presence of total organic carbon in these water bodies is important for the food web.

In cases where project alternatives are forecast to reduce flows and potentially affect water quality through impacts to beneficial uses and/or increasing concentrations of constituents of concern, the cumulative projects analyzed will cumulatively impact water quality; however, the action alternatives' contribution to cumulative impacts would not be substantial.

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Acronyms

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