Chapter 7
Aquatic Resources

7.1 Introduction

This chapter describes the environmental setting for aquatic resources and the regulatory setting associated with this resource area. It also evaluates environmental impacts on aquatic resources that could result from the Lower San Joaquin River (LSJR) and southern Delta water quality (SDWQ) alternatives, and, if applicable, the mitigation measures that would reduce significant impacts. The evaluation of impacts focuses on water resources within plan area that comprise the ecosystem for aquatic species. These water resources consists of: the LSJR (downstream of the Merced River confluence); the major San Joaquin River (SJR) tributaries (the Stanislaus, Tuolumne, and Merced Rivers) below the rim dams that regulate their flows (the New Melones, New Don Pedro, and New Exchequer Dams, respectively); the reservoirs created by these dams (New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure, respectively); and the southern Delta. To the extent that environmental impacts from the LSJR alternatives and SDWQ alternatives may affect aquatic resources in the Delta and other areas outside of the LSJR and its major tributaries, those areas are also evaluated.

The LSJR alternatives could affect flows in the LSJR and Delta, the reservoir operations on the major LSJR tributaries, and factors associated with such changes. Because fish species are the aquatic resource most sensitive to changes in flow, the impact analysis focuses on impacts on fish communities resulting from changes in flow conditions and reservoir operations associated with the LSJR alternatives. The analysis evaluates expected impacts by comparing the occurrence and potential occurrence of fish species populations and their critical life stages relative to changes in the magnitude, timing, frequency, and duration of flows and reservoir surface water elevations associated with the LSJR alternatives. The impact analysis evaluates the expected species responses to such changes in environmental conditions.

The impacts of LSJR alternatives on aquatic resources are summarized in Table 7-1. Impacts are evaluated based on predicted effects on key evaluation, or “indicator species.” These species include warmwater reservoir fish (e.g., largemouth bass), coldwater reservoir fish (e.g., rainbow trout), and anadromous fish (fall-run Chinook salmon and steelhead). Indicator species were selected based on their sensitivity to expected changes in environmental conditions in the plan area and their utility in evaluating broader ecosystem and community-level effects of these changes on aquatic resources. Central Valley fall-run Chinook salmon and Central Valley steelhead are among the most sensitive to changes in inflows from the SJR and have the greatest potential to be affected by the LSJR alternatives (see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*). Specific mechanisms used in this analysis to evaluate impacts of the LSJR alternatives are listed below.

- Changes in reservoir surface water elevations and storage such that reductions in warmwater and coldwater habitat could occur.

- Changes in flow in the major SJR tributaries and LSJR such that reductions in quantity and quality of spawning, rearing, and migration habitat could occur.
- Changes in flow such that fish could be exposed to increased temperatures; changes in flow such that fish could experience increased exposure to pollutants, suspended sediment and turbidity, or increased risk of disease.
- Changes in river surface water elevation such that redd dewatering could occur.
- Changes in peak flood flows such that spawning habitat quality could be reduced by mobilization or washing out.
- Modifications to the availability of food associated with changes in flows
- Changes in flow such that fish transport could be reduced.
- Reductions in flow such that predation risk could increase.
- Increases in exposure to entrainment risk and poor habitat conditions associated with the Central Valley Project (CVP) and State Water Project (SWP) exports.

The SDWQ alternatives would not result in any significant impacts on the environment. Regarding salinity (EC, or electrical conductivity, a measure of salinity) levels on the SJR at Vernalis, as described in Section 7.2.2, the SDWQ alternatives would not result in a change in salinity levels at Vernalis and, therefore, would not result in a change from baseline conditions. Regarding changes to salinity levels in the interior southern Delta under the SDWQ alternatives, as discussed in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality,* and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta,* it is not expected that salinity at these locations would exceed historical monthly salinity levels, which range between 0.2 deciSiemens per meter (dS/m) and 1.4 dS/m. Salinity levels would be within the historical range of salinity levels that the indicator fish species (described below) can tolerate. These salinity levels are not expected to result in reduced habitat conditions in the southern Delta and would not be expected to impact aquatic resources. Therefore, the SDWQ alternatives are not analyzed in detail in this chapter.

Impacts related to LSJR Alternative 1 and SDWQ Alternative 1 (No Project) are presented in Chapter 15, *LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, and the supporting technical analysis is presented in Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*. Impacts related to methods of compliance are discussed in Appendix H, *Evaluation of Methods of Compliance*.

Table 7-1. Summary of Aquatic Resources Impacts

Alternative	Summary of Impact (s)	Significance Determination
AQUA-1: Changes in availability of warmwater species reservoir habitat resulting from changes in reservoir water levels		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	Changes in the occurrence of 15 foot fluctuations in reservoir levels would be less than 10%; therefore, a reduction in spawning/rearing success of warmwater species is not expected.	Less than significant
AQUA-2: Changes in availability of coldwater species reservoir habitat resulting from changes in reservoir storage		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	Changes to reservoir storage levels in the end of September would be less than 10%; therefore, a reduction in the availability of coldwater habitat is not expected.	Less than significant
AQUA-3: Changes in quantity/quality of spawning, rearing, and migration habitat resulting from changes in flow		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	Flows would be reduced greater than 10% during rearing and outmigrating periods on the Stanislaus River; furthermore, insufficient water would be available in the spring period (February–June) when compared to baseline conditions for adaptive management. Therefore, substantial impacts to the quantity/quality of spawning, rearing, and migration habitat would occur. The monthly median flow or the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR during salmonid rearing and outmigrating periods; furthermore, the overall volume of water would be similar to baseline conditions on the Merced River during this time period, thus there would be sufficient water during the spring period to adaptively manage flows. Therefore, a reduction in the quantity/quality of spawning, rearing, and migration habitat on these rivers would not occur.	Significant and unavoidable
LSJR Alternative 3	The overall volume of water February–June would be similar to baseline conditions on the Stanislaus River; therefore, there would be sufficient water during the spring period to adaptively manage flows. Furthermore, flows would not be reduced greater than 10% during salmonid rearing and outmigrating periods on the Tuolumne, Merced, and LSJR. Therefore, a reduction in the quantity/quality of spawning, rearing, and migration would occur.	Less than significant

Alternative	Summary of Impact (s)	Significance Determination
LSJR Alternative 4	Flows would not be reduced greater than 10% on the major SJR tributaries or LSJR; therefore, a reduction in the quantity/quality of spawning, rearing, and migration habitat would occur.	Less than significant
AQUA-4: Changes in exposure of fish to stressful water temperatures resulting from changes in reservoir storage and releases		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	The frequency of temperatures exceeding U.S. Environmental Protection Agency recommended criteria are anticipated to increase by over 10% on the Stanislaus River, therefore, significant impacts would occur on. The monthly median flow or the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR; therefore, changes in the exposure of fish to stressful water temperatures would not occur.	Significant and unavoidable
LSJR Alternative 3	The overall volume of water February–June would be similar to baseline conditions on the Stanislaus River; therefore, there would be sufficient water during the spring period to adaptively manage flows and changes in exposure of fish to stressful water temperatures would not occur. Flows are expected to generally increase on the Tuolumne and Merced Rivers and not substantially change on the LSJR from baseline conditions; therefore, changes in the exposure of fish to stressful water temperatures would not occur.	Less than significant
LSJR Alternative 4	The frequency of water temperatures potentially causing thermal stress in juvenile salmon and steelhead during the spring rearing and outmigration period would decrease in each of the rivers; therefore, changes in the exposure of fish to stressful water temperatures would not occur.	Less than significant
AQUA-5 : Changes in exposure to pollutants resulting from changes in flow (dilution/mobilization effects)		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	Lower flows and increased thermal stress is anticipated on the Stanislaus River, therefore, substantially low dilution effects would be expected resulting in an increased vulnerability of fish to the effects of pollutants. The monthly median flow or the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR; therefore, substantially low dilution effects would not be expected and there would not be an increased vulnerability of fish to the effects of pollutants.	Significant and unavoidable

Alternative	Summary of Impact (s)	Significance Determination
LSJR Alternative 3	The overall volume of water February– June would be similar to baseline conditions on the Stanislaus River; therefore, substantially low dilution effects are not expected and there would not be an increased vulnerability of fish to the effects of pollutants because there would be sufficient water during the spring period to adaptively manage flows. Flows are expected to generally increase on the Tuolumne and Merced Rivers and not substantially change on the LSJR from baseline conditions; therefore, substantially low dilution effects are not expected and there would not be an increased vulnerability of fish to the effects of pollutants.	Less than significant
LSJR Alternative 4	Dilution would potentially increase as a result of the increase in flows, and temperatures would either be maintained or reduced; thus, an increase in exposure to pollutants would not occur.	Less than significant
AQUA-6: Changes in exposure to suspended sediment and turbidity resulting from changes in flow (mobilization)		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	Changes in the frequency, duration, and magnitude of increased suspended sediment and turbidity levels are expected to be minor and within the range of historical levels experienced by native fishes and other aquatic species on the major SJR tributaries and the LSJR.	Less than significant
AQUA-7: Changes in redd dewatering and fish stranding losses resulting from flow fluctuations		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2	Increases in the frequency of flow reductions of 1 foot or more by 14 percent in March could substantially increase the frequency of dewatering and stranding impacts on steelhead redds and Chinook salmon fry in the Stanislaus River. therefore, there would be substantial impacts on redd dewatering and fish stranding losses on the Stanislaus River. Redd dewatering would be similar to baseline conditions on the Tuolumne and Merced.	Significant and unavoidable
LSJR Alternatives 3–4	The potential for significant redd dewatering and fish stranding impacts would be similar to baseline conditions or would be reduced when compared to baseline conditions. Although the potential for significant impacts exist on the Stanislaus River in March (e.g., increases in the frequency of flow reductions of 1 foot or more by 15% under LSJR Alternative 3 and increases in the frequency of flow reductions of 1 foot or more by 11% under LSJR Alternative 4), the overall volume of water February—June would be similar or greater than baseline conditions such that there would be sufficient water to adaptively manage flows to minimize potential redd dewatering and stranding impacts. All other rivers	Less than significant

Alternative	Summary of Impact (s)	Significance Determination
	would either result in no change from the baseline with respect to redd dewatering or a reduction in the potential for redd dewatering.	
AQUA-8: Changes in spawning habitat quality (spawning gravel) resulting from changes in peak flows		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	Changes in the frequency of peak flows are not expected to be substantially modified from baseline conditions, therefore, there would be no substantial impact on spawning habitat quality resulting from changes in peak flow.	Less than significant
AQUA-9: Changes in food availability resulting from changes in flow, nutrient transport, and water quality (food web support)		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	Changes in the primary processes (i.e. bed mobilizing flows, and floodplain inundating flows) that alter food web support would not be substantial, therefore, there would be no substantial impact to food availability.	Less than significant
AQUA-10: Changes in predation risk resulting from changes in flow and water temperature		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	Lower flows and higher temperatures are expected on the Stanislaus River when compared to baseline conditions; therefore, it is expected that there would be an increase predation risk . Flows and temperatures would remain unchanged compared to baseline conditions on the Tuolumne River, and the overall volume of water available February–June would be similar to baseline conditions on the Merced River and the LSJR; therefore, it is expected that there would not be an increase in predation risk.	Significant and unavoidable
LSJR Alternative 3	The overall volume of water February– June would be similar to baseline conditions on the Stanislaus River; therefore, there would be sufficient water during the spring period to adaptively manage flows and as a result there would not be an increase in predation risk. Flows are expected to generally increase on the Tuolumne and Merced Rivers and not substantially change on the LSJR from baseline conditions; therefore, it is expected there would not be an increase in predation risk.	Less than significant
LSJR Alternative 4	Changes in flow and temperatures are not anticipated to result in stress to fish; therefore, it is expected that there would not be an increase in predation risk.	Less than significant

Alternative	Summary of Impact (s)	Significance Determination
AQUA-11: Changes in disease risk resulting from changes in flow, water temperature, and water quality		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	In April, water temperatures exceeding 59°F at the confluence of the Stanislaus River are predicted to occur 91% of the time; therefore, there is the potential for a substantial increase in disease risk exists in the Stanislaus River . Monthly median flows and the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR; therefore, an increase in occurrence of disease above 59°F is not expected to exceed 20%, and the risk of disease is not expected to increase.	Significant and unavoidable
LSJR Alternative 3	The overall volume of water February–June would be similar to baseline conditions on the Stanislaus River. Aan increase in occurrence of disease above 59°F is not expected to exceed 12%. Therefore, there would be sufficient water during the spring period to adaptively manage flows and a substantial increase in disease risk is not expected. Monthly median flows and the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR; therefore, an increase in occurrence of disease above 59°F is not expected to exceed 20%, and the risk of disease is not expected to increase.	Less than significant
LSJR Alternative 4	An increase in the occurrence of temperatures above 59°F would be less than 1%; therefore, there would be no substantial increase in the risk of disease.	Less than significant
AQUA-12: Changes in fish transport resulting from changes in flow		
LSJR Alternative 1	See note. [1]	
LSJR Alternative 2	Flows would be lower during the outmigrating period on the Stanislaus River; furthermore, insufficient water would be available in the spring period (February–June) when compared to baseline conditions for adaptive management. Therefore, there it is expected that travel times of juveniles to the Bay-Delta would be significantly impacted. The monthly median flow or the overall volume of water February–June would not substantially decrease on the Tuolumne, Merced, and LSJR during salmonid rearing and outmigrating periods; furthermore, the overall volume of water during this time period would be similar to baseline conditions on the Merced River and, therefore, there would be sufficient water during the spring period to adaptively manage flows. Thus, it is not expected fish transport would decrease relative to baseline conditions.	Significant and unavoidable

Alternative	Summary of Impact (s)	Significance Determination
LSJR Alternative 3	The overall volume of water February–June would be similar to baseline conditions on the Stanislaus River; therefore, there would be sufficient water during the spring period to adaptively manage flows. Thus, it is not expected fish transport flows would decrease relative to baseline conditions. Monthly median flows and the overall volume of water February–June would not substantially decrease on the Tuolumne and Merced Rivers and the LSJR; therefore, it is not expected fish transport flows would decrease relative to baseline conditions.	Less than significant
LSJR Alternative 4	Changes in flows are expected to decrease average travel times to the Bay-Delta and as a result, fish transport would increase.	Less than significant
AQUA-13: Changes in southern Delta and estuarine habitat resulting from changes in SJR inflows and export effects		
LSJR Alternative 1	See note. [1]	
LSJR Alternatives 2–4	No substantial change in export pumping or the direction or magnitude of flows in the southern Delta is expected. The combination of monthly increases and decreases in pumping rates would not have substantial long-term effects on export pumping or flow patterns in the southern Delta. Furthermore, there would be little effect on Delta outflows and the position of X2, Delta operations would continue to be governed by current restrictions on export pumping rates, inflow/export ratios, and Old Middle River (OMR) flows to protect listed fish species from direct and indirect impacts of southern Delta operations. Therefore, changes in southern Delta and estuarine habitat are expected to be less than significant.	Less than significant

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

7.2 Environmental Setting

This section describes the life history, habitat requirements, and factors that affect the abundance of aquatic biological resources, including special-status, recreational, and indicator species in the plan area, and reviews historical and current fish communities and environmental stressors in the LSJR, major SJR tributaries, and the southern Delta. Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives* contains additional information on the species targeted for protection and on the environmental stressors.

7.2.1 Fish Species

The LSJR, major SJR tributaries, and the southern Delta support a diverse assemblage of native and nonnative fishes. Historically, the SJR and its major tributaries in the plan area supported a distinctive native fish fauna adapted to widely fluctuating riverine conditions ranging from large winter and spring floods to low summer flows. Prior to large-scale hydrologic and physical alteration of the basin and species introductions, these environmental conditions resulted in a rich and diverse native fish fauna characterized by four major fish assemblages. The rainbow trout assemblage occurred in high gradient, upper elevation portions of the SJR basin, and commonly included riffle sculpin, Sacramento sucker, and speckled dace. The California roach assemblage occurred in small, warm tributaries at middle elevations, and may have seasonally included Sacramento sucker, Sacramento pikeminnow, Chinook salmon, and steelhead. The Pikeminnow-hardhead-sucker assemblage historically occurred in larger mainstem portions of the SJR and its tributaries and included speckled dace, California roach, riffle and prickly sculpin, threespine stickleback, and rainbow trout. Anadromous species, including Chinook salmon, steelhead, and Pacific lamprey, spawned and reared in this zone. The deep-bodied fish assemblage generally occurred in the low gradient, valley-bottom portions of the SJR, and included Sacramento perch(*Archoplites interruptus*), thicktail chub, tule perch, hitch, and blackfish. Chinook salmon, steelhead, and sturgeon occurred in this zone on their way upstream to spawn or on their way downstream toward the ocean (Moyle 2002).

The fish assemblages that currently occur in SJR and major tributaries are the result of substantial changes to the physical environment and a long history of species introductions. A number of the native species are now uncommon, rare, or extinct, and have been designated as special-status species (Table 7-2). Some of these special-status species are the indicator species mentioned in Section 7.1 (largemouth bass, rainbow trout, fall-run Chinook salmon, and steelhead). Other species, both native and nonnative, support important recreational fisheries in the plan area (Table 7-3).

Table 7-2. Special-Status Fish Species that Occur in the Plan Area

	Status[1]	Recreationally Important?			
Species Name	Fed/State	Yes/No	Location	Habitat	Critical Habitat Designated?
* Central Valley fall-/late fall–run Chinook salmon *Oncorhynchus tshawytscha*	SC/–	Yes	Pacific Ocean, Bay-Delta, SJR and major tributaries, Sacramento River and major tributaries.	Occurs in well-oxygenated, cool, riverine habitat with water temperatures 8.0–12.5°C (46.5–54.5°F). Habitat types are riffles, runs, and pools.	No
Central Valley spring-run Chinook salmon *Oncorhynchus tshawytscha*	T/CT	No	Pacific Ocean, Bay-Delta, Sacramento River and major tributaries.	Occurs in well-oxygenated, cool, riverine habitat with water temperatures 8.0–12.5°C (46.5–54.5°F). Coldwater pools are needed for holding adults.	Yes, but not in the plan area

Species Name	Status[1] Fed/State	Recreationally Important? Yes/No	Location	Habitat	Critical Habitat Designated?
*Central Valley steelhead *Oncorhynchus mykiss*	T/–	No	Pacific Ocean, Bay-Delta, SJR and major tributaries, Sacramento River and major tributaries.	Occurs in well-oxygenated, cool, riverine habitat with water temperatures 7.8°–18°C (46–64.4°F). (Moyle 2002). Habitat types are riffles, runs, and pools.	Yes, the LSJR from the Merced River confluence to Vernalis, including the major tributaries, and the southern Delta.
Green sturgeon (southern DPS) *Acipenser medirostris*	T/CSC	No	Pacific Ocean, Bay-Delta, Sacramento River.	Occurs in both freshwater and saltwater habitat. Spawn in deep pools or in turbulent areas in the mainstem of large rivers (Moyle 2002) with well-oxygenated water with temperatures 8°–14°C (46.5–57.2°F).	Yes, the Bay-Delta
Delta smelt *Hypomesus transpacificus*	T/CE	No	Primarily in the Bay-Delta, but has been found as far upstream as the mouth of the American River, on the Sacramento River, and at Mossdale on the SJR; range extends downstream to San Pablo Bay.	Endemic to the Bay-Delta and generally spend entire lifecycle in the open surface waters of the Bay-Delta and Suisun Bay. Prefer areas where fresh and brackish water mix in the salinity range of 2–7ppt.	Yes, the southern Delta
Longfin smelt *Spirinchus thaleichthys*	–/CT	No	Primarily in the Bay-Delta, but also in Humboldt Bay, Eel River estuary, and Klamath River estuary.	Primary habitat is the open water of estuaries; can be found in both the seawater and freshwater areas, typically in the middle or deeper parts of the water column. Spawning takes place in salt or brackish estuary waters with freshwater inputs.	No

Species Name	Status[1] Fed/State	Recreationally Important? Yes/No	Location	Habitat	Critical Habitat Designated?
Sacramento splittail *Pogonichthys macrolepidotus*	–/CSC	No	Throughout the year in low-salinity waters and freshwater areas of the Bay-Delta, Yolo Bypass, Suisun Marsh, Napa River, and Petaluma River (Moyle 2002).	Utilize floodplain habitat for feeding and spawning. Spawn among submerged and flooded vegetation in sloughs and the lower reaches of rivers.	No
River lamprey *Lampetra ayresi*	–/CSC	No	Bay-Delta and SJR from Friant Dam to Merced River and the LSJR.	Has not been thoroughly studied in California but appears to be more abundant in the lower Sacramento river and LSJR than in other streams in California.	No
San Joaquin roach *Lavinia symmetricus ssp.1*	–/CSC	No	Throughout the Sacramento–San Joaquin watersheds and mid-elevation streams in the Sierra foothills.	Subspecies of California Roach generally found in small, warm streams, and individuals frequent a wide variety of habitats often isolated by downstream barriers. Tolerant of relatively high water temperatures 30-35°C (86-95°F) with low oxygen levels.	No
Pacific lamprey *Entosphenus tridentatus*	SC/–	No	Pacific Ocean, Bay-Delta, SJR and major tributaries, Sacramento River.	Occurs in well-oxygenated, cool, riverine habitat with water temperatures 12-18°C (53.5–64.5°F). Spawning habitats are similar to that of salmonids.	No

Species Name	Status[1] Fed/State	Recreationally Important? Yes/No	Location	Habitat	Critical Habitat Designated?
Hardhead *Mylopharodon conocephalus*	–/CSC	No	SJR and major tributaries, Sacramento River and major tributaries.	Occurs in low to mid-elevation environments with clear, deep pools and runs with sand-gravel-boulder substrates. Optimal water temperatures ranging between 24 -28°C (75-82°F), however most streams where these fish occur have temperatures over 20°C (68°F) (Moyle 2002).	No

[1] Status:

Federal

E = Listed as endangered under the federal Endangered Species Act (ESA).

T = Listed as threatened under ESA.

SC = Listed as a species of concern.

– = No federal status.

State

CE = Listed as endangered under the California Endangered Species Act (CESA).

CT = Listed as threatened under CESA.

CSC = California species of special concern.

– = No state status.

* Central Valley fall-run Chinook salmon and Central Valley steelhead are considered indicator species of coldwater communities.

DPS = distinct population segment

°F = degrees Fahrenheit

°C = degrees Celsius

ppt = parts per thousand

Table 7-3. Recreationally Important Fish Species in the Plan Area

Species Name	Status Fed/State	Recreationally Important? Yes/No	Location	Habitat	Critical Habitat Designated?
*Rainbow trout *Oncorhynchus mykiss*	–/–	Yes	SJR and major tributaries, Sacramento River and major tributaries. Also stocked in reservoirs in the plan area.	Occurs in well-oxygenated, cool, riverine habitat with water temperatures 7.8°–18°C (46–64.4°F). Habitat types are riffles, runs, and pools.	No
*Largemouth bass[1] *Micropterus salmoides*	–/–	Yes	Bay-Delta, SJR, and tributary Central Valley rivers. Also stocked in reservoirs in the plan area.	Found in warm, quiet water with low turbidity and aquatic plants, such as lakes, reservoirs, sloughs, and river backwaters. Constructs its nests for eggs in shallow water. Optimal temperatures range from 25–30°C (77-86°F) but can persist in temperatures that approach 36–37°C (97-99°F) (Moyle 2002).	No
Striped bass *Monrone saxatilis*	–/–	Yes	Bay-Delta, SJR and major tributaries, Sacramento River and major tributaries.	Found in lakes, ponds, streams, and wetlands. Spawn in fresh water in the spring (April–May) when water temperatures are about 15.5°C (60°F).	No
White sturgeon *Acipenser transmontanus*	–/–	Yes	Pacific Ocean, Bay-Delta.	Inhabits riverine, estuarine, and marine habitats at various life stages during their long lives (BDCP 2010). Greatest portion of the population occurs in the brackish portion of the estuary, moving in response to	No

Species Name	Status Fed/State	Recreationally Important? Yes/No	Location	Habitat	Critical Habitat Designated?
				salinity changes.	
American shad *Alosa sapidissima*	–/–	Yes	Bay-Delta, Sacramento River, and SJR. Also stocked in reservoirs in the plan area.	Occurs in well-oxygenated, cool, riverine habitat. Peak spawning occurs in mid-May to mid-June with water temperatures of 11-17°C (51.8–62.6°F).	No
Kokanee *Oncorhynchus nerka*	–/–	Yes	Reservoirs in the plan area.	Landlocked populations occur in well-oxygenated reservoirs on major SJR tributaries. Preferred water temperatures are 10-15°C (50–59°F).	No

[1] Largemouth bass are considered an indicator species of warmwater reservoir fish communities that include fishes such as sunfish and catfish. Rainbow trout are considered an indicator species of coldwater reservoir fish communities.

°F = degrees Fahrenheit

°C = degrees Celsius

Chinook Salmon

Central Valley Fall-Run

The Central Valley fall-run Chinook salmon evolutionarily significant unit (ESU) is listed as federal species of concern.

Central Valley fall-run Chinook salmon historically spawned in all major Central Valley tributaries, as well as the mainstem of the Sacramento River and SJR (Moyle 2002). Because much of fall-run Chinook salmon historical spawning and rearing habitat included the reaches downstream of major dams, the fall runs in the Central Valley were not as severely affected by early water projects as spring-run Chinook salmon and steelhead, which ascended to higher elevations to spawn (Reynolds et al. 1993, Yoshiyama et al. 1996, McEwan 2001). Changes in seasonal hydrologic patterns resulting from operation of upstream reservoirs for water supplies, flood control, and hydroelectric power generation have altered instream flows and habitat conditions for fall-run Chinook salmon and other species downstream of the dams (Williams 2006).

Trends in adult fall-run Chinook salmon escapement on the SJR and major tributaries has been relatively low since the 1950s, ranging from several hundred adults to approximately 100,000 adults. Results of escapement estimates have shown a relationship between adult escapement in one year and spring flows on the SJR 2.5 years earlier when the juveniles in the cohort were rearing and migrating downstream through the Delta. Adult escapement appears to be cyclical and may be related to hydrology during juvenile rearing and migration periods, among other factors (DFG 2005; SJRTC 2008). Population trends for fall-run Chinook salmon are discussed in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*.

SJR fall-run Chinook salmon migrate into natal streams from late October to early December, with peak migration typically occurring in November (Table 3.13 of Appendix C). SJR fall-run Chinook salmon typically begin spawning between November and January when temperatures in the rivers are less than 55°F. The majority of redds (a gravel depression in the riverbed the adults make with their tails for spawning) are observed in the month of November (McBain and Trush 2002). Egg incubation typically occurs between November and March, lasting 40–60 days, but can vary depending on water temperatures and timing of spawning. Optimal water temperatures for egg incubation range from 41 degrees Fahrenheit (°F) to 55°F (Moyle 2002; USEPA 2003). Eggs that incubate at temperatures higher than 60°F and lower than 38°F have suffered high mortality rates (Boles et al. 1988).

Newly hatched salmon (alevins) remain in the gravel for about 4–6 weeks, depending on surrounding water temperatures, until the yolk sac has been absorbed (Moyle 2002; NMFS 2009a). Generally, alevins suffer low mortality when consistently incubated at water temperatures between 50°F and 55°F. However, if incubated at constant temperatures between 55°F and 57.5°F, mortality has been shown to increase in excess of 50 percent (Boles et al. 1988).

Most fall-run Chinook salmon fry (the life stage after alevins) emerge from the gravel between February and March (McBain and Trush 2002; Table 3.13 of Appendix C) and are immediately dispersed into downstream feeding areas. However, many juveniles may rear in river for some length of time before migrating downstream (Moyle 2002). Rearing and outmigration of fall-run Chinook salmon typically occurs between February and June; however, peaks in fry outmigration occur in February and March and smolt (>75 mm) outmigration occurs in April and May (Rotary Screw Trap data, DFG Mossdale Trawl, Figure 3.3 of Appendix C). Preferred water temperature of rearing and outmigrating fall-run Chinook salmon have been reported to be above 57°F; however, maximum growth generally occurs at 55°F or below (Boles et al. 1988; USEPA 2003).

Juvenile Central Valley fall-run Chinook salmon undergo a change known as “smoltification” when they reach 3–4 inches (75–100 millimeters [mm]) during outmigration. Smoltification involves physiological and morphological changes that prepare juveniles for ocean entry (DFG 2010a).

Central Valley Spring-Run

The Central Valley spring-run ESU is a special-status species currently listed as threatened under ESA and CESA.

Spring-run Chinook salmon once occupied all major river systems in California and was widely distributed in Central Valley rivers (Myers et al. 1998). Spring-run Chinook salmon were widely distributed in streams of the Sacramento River and SJR Basins, spawning and rearing over extensive areas in the upper and middle reaches (elevations ranging from 1,400 to 5,200 feet (ft) [450 to 1,600 meters (m)]) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers (Myers et al. 1998). The Central Valley as a whole was estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s. From 1900 to 1948, hydroelectric development and irrigation projects truncated large portions of the headwaters of most Central Valley Rivers by dam construction and greatly reduced access of spring-run Chinook salmon to spawning habitat (Yoshiyama et al. 1996). As mentioned above, the SJR population was essentially extirpated by the late 1940s. Populations in the upper Sacramento, Feather, and Yuba Rivers were eliminated with the construction of major dams during the 1950s and 1960s.

Currently, no spring-run Chinook salmon are found in the SJR Basin due to the extirpation of the run after the completion of construction of Friant Dam in 1948 and subsequent drying of the Upper SJR (Moyle 2002). However, a recent court decision has mandated the reintroduction of the spring-run Chinook salmon to this section of the SJR and flows to sustain the reintroduced population. In 2009, the first restoration flows were released from Friant Dam, and in 2010 the SJR reconnected to the LSJR at the Merced River confluence. Spring-run are planned for introduction into the river by 2013, however, the major goal of the San Joaquin River Restoration Program is to establish a naturally self-sustaining population (see Chapter 16, *Cumulative Impact Summary, Growth-Inducting Effects, and Irreversible Commitment of Resources*, for a discussion of the program) (USBR 2011).

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance between 1960 and 2009. Although recent Central Valley spring-run Chinook salmon population trends are negative, annual abundance estimates display a high level of variation. The overall number of Central Valley spring-run Chinook salmon remains well below estimates of historical abundance. Central Valley spring-run Chinook salmon have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are very small relative to fall-run Chinook salmon populations (Good et al. 2005).

Naturally-spawning populations of Central Valley spring-run Chinook salmon with consistent spawning returns use the Bay-Delta as a migration corridor and are currently restricted to Butte Creek, Deer Creek, and Mill Creek (Moyle 2002, Good et al. 2005).

Spring-run Chinook salmon enter freshwater in the winter and spring and spawn in the late summer. This life history requires that they migrate far enough upstream to find habitat that remains cool enough (less than 70°F) for the adults to survive (Williams 2006). Embryos are less tolerant of warm water than adults, and as with fall-run Chinook salmon, spawning begins when water cools to around 57°F or 59°F, usually by September. The spring-run Chinook salmon life cycle is well adapted to streams with snowmelt runoff (Williams 2006).

In general, physical parameters (e.g., temperature and salinity thresholds) for spring-run Chinook salmon are similar to that of fall-run Chinook salmon.

Central Valley Steelhead

The Central Valley steelhead distinct population segment (DPS) is a special-status species that is listed as threatened under ESA but not under CESA.

Central Valley steelhead were widely distributed historically throughout the Sacramento River and SJR. Historical Central Valley steelhead run sizes are difficult to estimate given the paucity of data but may have approached one to two million adults annually (McEwan 2001). Adult steelhead typically migrate upstream and spawn during the winter months when river flows are high and water clarity is low. Unlike Chinook salmon, adult steelhead maynot die after spawning and can return to coastal waters. Juvenile steelhead cannot be differentiated from resident rainbow trout based on visual characteristics. In addition, steelhead frequently inhabit streams and rivers that are difficult to access and survey. Thus, information on the trends in steelhead abundance in the Central Valley has primarily been limited to observations at fish ladders and weirs (McEwan 2001).

Until recently, Central Valley steelhead were thought to be extirpated from the SJR Basin. However, recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras Rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001, Zimmerman et al. 2008). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread throughout accessible streams and rivers in the Central Valley (Good et al. 2005). Some of these fish, however, may have been resident rainbow trout, which are the same species but are not anadromous. Nonhatchery stocks of rainbow trout that have anadromous components within them are found in the upper Sacramento River and its tributaries, Mill, Deer, and Butte Creeks, and the Feather, Yuba, American, Mokelumne, and Calaveras Rivers (McEwan 2001).

The most recent status review of the California Central Valley steelhead DPS (NMFS 2009a) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction. Analysis of data from the Chipps Island monitoring program indicates that natural steelhead production has continued to decline, and hatchery-origin fish represent an increasing fraction of the juvenile production in the Central Valley. In recent years, the proportion of hatchery-produced juvenile steelhead in the catch has exceeded 90 percent, and in 2010 it was 95 percent of the catch. This recent trend appears to be related to poor ocean conditions and dry hydrology in the Central Valley (NMFS 2009b). Population trends for Central Valley steelhead are discussed in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*.

Central Valley steelhead in the plan area can begin upstream migration as early as July and continue through April, with upstream migration peaking between October and February. Central Valley steelhead spawn downstream of impassable dams on the major SJR tributaries and the LSJR, similar to SJR Basin fall-run Chinook salmon (NMFS 2009c). Spawning typically occurs from December through June and peaks between January and March (NMFS 2009a; Table 3.14 of Appendix C) where cool (30–52°F), well-oxygenated water is available year-round (McEwan and Jackson 1996). Once spawning is complete, adult Central Valley steelhead may return to the ocean in preparation for a subsequent year and others die after spawning.

Depending on water temperature, Central Valley steelhead eggs may incubate in redds from 4 weeks to 4 months before hatching as alevins (McEwan 2001; NMFS 2009c). When water temperatures are warmer, less incubation time is needed and, conversely, when water temperatures are cooler, more incubation time is needed. Central Valley steelhead eggs that typically incubate at 50–59°F hatch in about 4 weeks, and alevins emerge from the gravel 4–8 weeks after hatching (Shapovalov and Taft 1954; Reynolds et al. 1993). Juvenile Central Valley steelhead rear for 1–3 years (1 percent spend 3 years) in cool, clear, fast flowing, permanent freshwater streams and rivers where riffles predominate over pools (DFG 2010a). Some juveniles may utilize tidal marsh areas, nontidal freshwater marshes, and other shallow water areas in the Bay-Delta as rearing areas for short periods prior to their final emigration to sea (NMFS 2009a).

Juveniles are dependent on suitable rearing habitat for an extended amount of time prior to outmigration, especially during the summer when suitable conditions are most restricted due to a host of stressors such as temperature, water quality and quantity, and ability to access floodplain.

Diversity and richness of habitat and food sources, particularly in shallow water habitats, allows juveniles to grow larger before ocean entry, thereby increasing their chances of survival in the marine environment. A longer rearing period for juvenile Central Valley steelhead allows for them to be considerably larger and have a greater swimming ability than Chinook salmon juveniles during outmigration (ICF International 2012).

Central Valley steelhead juveniles generally begin outmigration anywhere between late December through July, with peaks occurring between March and April (McBain and Trush 2002; Table 3.14 of Appendix C; USDOI 2008,). As with Chinook salmon, juveniles undergo smoltification during outmigration. Central Valley steelhead smoltification has been reported to occur successfully at 44–52°F (Myrick and Cech 2001; USDOI 2008).

Green Sturgeon

The North American green sturgeon (southern DPS) is a special-status species listed under ESA as threatened and is identified as a California species of special concern (Table 7-2).

Musick et al. (2000) suggest that the abundance of North American green sturgeon populations has declined as much as 88 percent. Salvage data from the export facilities in the southern Delta (1968–2006) supports this conclusion. Before 1986, the average number of southern DPS green sturgeon individuals salvaged per year at the two export facilities combined was 1,621; from 1986 on, the average per year was fewer than 100 (ICF International 2012).

Green sturgeon pass through the San Francisco Bay to the ocean where they primarily move northward, spending much of their lives in the ocean or in Oregon and Washington estuaries (Kelley et al. 2007). Adult green sturgeon are marine dependent and spend less time in estuarine and freshwater environments. Typically, these fish spend 3–13 years in the ocean before returning to freshwater to spawn (Moyle 2002). The LSJR and Bay-Delta serve as a migratory corridor, feeding area, and juvenile rearing habitat (ICF International 2012).

Preferred spawning habitats for green sturgeon are thought to contain large cobble in deep and cool pools with turbulent water (Adams et al. 2002; Moyle 2002). Currently, spawning populations of green sturgeon are found in only three river systems: the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. The preferred water temperature for spawning ranges between 46.5°F and 57°F. Eggs hatch roughly 8 days after spawning, and larvae are 8–19 mm TL (Moyle 2002).

Juveniles appear to spend 1–4 years in freshwater and estuarine habitats, primarily in summer and fall, before they enter the ocean. Juvenile green sturgeon have not been detected in the SJR; however, Moyle (2002) suggests that reproduction may have taken place in the SJR because adults have been captured at Santa Clara Shoal and Brannan Island.

Juvenile and adults are benthic (bottom) feeders, but mysid shrimp and amphipods comprise the majority of their diet (Moyle 2002).

Delta Smelt

Delta smelt is listed as threatened under ESA and endangered under CESA, and the U.S. Fish and Wildlife Service (USFWS) has designated critical habitat for delta smelt that incorporates the legal Delta.

Delta smelt are small fish (55–70 mm), rarely live more than 1 year, have low fecundity, and are not recreationally or commercially fished. Delta smelt is endemic to the Bay-Delta, and individuals generally spend their entire lifecycles in the open surface waters of the Bay-Delta and Suisun Bay. Delta smelt is a euryhaline fish (can adapt to a wide range of salinities) that rarely occurs in water of more than 10–12 parts per thousand (ppt) salinity; therefore, its distribution is controlled largely by freshwater flows into the Bay-Delta (Moyle 2002).

Delta smelt begin upstream migration into fresh water to spawn in September and October. Spawning can occur from late February to July, although most reproduction appears to take place between April and mid-May. Embryonic development is reported to last 11–13 days at 57–61°F (Moyle 2002). Baskerville-Bridges et al. (2004) reported hatching of delta smelt eggs after 8–10 days at 59–62.5°F. Although spawning may occur at up to 71.5°F, hatching success of the larvae is very low at that high of temperatures (Bennett 2005). Spawning occurs primarily in sloughs and shallow edge areas in the Sacramento and Mokelumne Rivers and the SJR, the western and southern Delta, Suisun Bay, Suisun Marsh, and occasionally, in wet years, the Napa River (Wang 2007). Delta smelt have been found on the Sacramento River as far upstream as the confluence with American River and as far downstream as Mossdale on the SJR (Moyle 2002).

Upon hatching, larvae are semi buoyant, staying near the bottom, and are transported downstream to the low salinity habitat. Within a few weeks, larvae develop an air bladder and become pelagic (Moyle 2002). Young-of-the-year delta smelt (i.e., production from spawning in the current year) rear from late spring through fall and early winter. Once in the rearing stage, growth is rapid, and juvenile fish are commonly 40–50 mm total length (TL) by early August (Radtke 1966). They reach adult size by early fall. Delta smelt growth during the fall months slows considerably (only 3–9 mm total), presumably because most of the energy ingested is being directed towards gonadal development (Radtke 1966).

The food available to all life stages is constrained by mouth gape and status of fin development; for example, larger mouths can ingest larger prey items, and fully developed fins allow for increased directional mobility. Delta smelt are visual feeders, swimming actively near the water surface, feeding on zooplankton (USFWS 2008).

Delta smelt seem to prefer water with high turbidity, based on a negative correlation between water quality and the frequencies of delta smelt occurrence in survey trawls during summer, fall, and early winter. For example, the likelihood of delta smelt occurrence in trawls at a given sampling station decreases with increasing Secchi depth[1] (Feyrer et al. 2007; Nobriga et al. 2008). This is consistent with behavioral observations of captive delta smelt. Few daylight trawls catch delta smelt at Secchi depths over 0.5 m and capture probabilities are highest at 0.40 m depth or less. Delta smelt's preference for turbid water may be related to increased foraging efficiency and reduced risk of predation (NMFS 2009a).

Temperature also affects delta smelt distribution. Swanson et al. (2000) indicate delta smelt tolerate temperatures between 46.5°F and 77°F; however, warmer water temperatures of more than 77°F restrict their distribution more than colder water temperatures. Delta smelt of all sizes are found in the main channels of the Delta and Suisun Marsh and the open waters of Suisun Bay where the

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[1] Secchi Depth is a measurement of water clarity. A small white Secchi disk is lowered into the water column until it is no longer visible. Increased Secchi Depth is an indicator of clear or less turbid water.

waters are well oxygenated and temperatures are usually less than 77°F in summer (Nobriga et al. 2008).

Longfin Smelt

Longfin smelt is a special-status species that is not listed under ESA but is listed as threatened under CESA.

Populations of longfin smelt in California historically have been known to occur from the Bay-Delta, Humboldt Bay, the Eel River estuary, and the Klamath River estuary (Emmett et al. 1991). In the Bay-Delta, longfin smelt are rarely found upstream of Rio Vista or Medford Island. Adults occur seasonally as far downstream as South Bay, but they are concentrated in Suisun, San Pablo, and North San Francisco Bays (Baxter 1999). Longfin smelt generally have a 2-year lifecycle. During this second year, they primarily inhabit the San Francisco Bay.

Spawning typically takes place as early as November and may extend into June, peaking between February and April. Spawning occurs in fresh or slightly brackish water over aquatic vegetation or sandy-gravel substrates when temperatures drop roughly below 64.5°F (Baxter et al. 2008). Based on their distribution patterns during the spawning season, the main spawning area appears to be downstream of Rio Vista on the Sacramento River (ICF International 2012). Spawning probably also occurs in the eastern portion of Suisun Bay and, in some years, the larger sloughs of Suisun Marsh. Historically, spawning probably also occurred in the SJR. Recent catches of longfin smelt in the SJR have been extremely low, potentially as a result of low flows in the river, which contribute to habitat degradation, unsuitable water temperature, and poor water quality (Moyle 2002).

Longfin smelt eggs typically hatch in February and disperse downstream. The principal nursery habitat for larvae is the Suisun and San Pablo Bays. However, the distribution of eggs may be shifted upstream in years of low outflow (Moyle 2002). Mortality for longfin smelt is highest February–May when larvae complete fin development, begin feeding, and are more exposed to predators. A positive relationship is observed between longfin smelt abundance and Delta outflow during the designated critical outflow period for longfin smelt between December and May (Stevens and Miller 1983, Kimmerer 2002).

Sacramento Splittail

Sacramento splittail is a special-status species that is not listed as threatened or endangered under ESA or CESA but is a California species of special concern.

Sacramento splittail was listed as a federally threatened species but was delisted September 22, 2003. It is a large minnow endemic to the Bay-Delta and is confined to the lower reaches of the Sacramento River and SJR, the Delta, Suisun and Napa Marshes, and tributaries of northern San Pablo Bay (Wang 1986; Moyle et al. 1995). Although the Sacramento splittail is generally considered a freshwater species, the adults and subadults have a moderate to high tolerance for saline waters (up to 10–18 ppt). The salt tolerance of Sacramento splittail larvae is unknown; however, because adults tolerate water with salinities of 10–18 ppt, Sacramento splittail is considered an estuarine species (Meng and Moyle 1995; Moyle et al. 2004).

The decline in abundance of Sacramento splittail is attributable to the loss or alteration of lowland habitats (Young and Cech Jr. 1996). Specifically, the decline in abundance has been attributed to the reduction of the Delta outflow as a result of dam construction and upstream diversions and the changes in hydrodynamics in the Delta as a result of Delta exports (DFG 1992a; Moyle 2002). It is likely high salinities restrict the downstream range of Sacramento splittail and that without adequate Delta outflow, juveniles are not able to rear in appropriate nursery areas (Young and Cech Jr. 1996).

Sacramento splittail have a high reproductive capacity. Individuals live 5–7 years and generally begin spawning at 1–2 years. Spawning, which seems to be triggered by increasing water temperatures and hours of sunlight, occurs over beds of submerged vegetation in slow-moving stretches of water, such as flooded terrestrial areas and dead-end sloughs (Sommer et al. 1997). Large-scale spawning and juvenile recruitment occurs only in years with significant protracted (greater than or equal to 30 days) floodplain inundation (McBain and Trush 2002), particularly in the Sutter and Yolo Bypasses (Meng and Moyle 1995; Sommer et al. 1997). Spawning also occurs in perennial marshes and along vegetated edges of the Sacramento River and SJR (Moyle et al. 2004). Adults spawn from late February through early July, most frequently during March and April (Wang 1986), and occasionally as early as January (Feyrer 2004).

Hatched larvae remain in shallow, weedy areas until they move to deeper offshore habitat later in the summer (Wang 1986). Young Sacramento splittail may occur in shallow and open waters of the Bay-Delta and San Pablo Bay, but they are particularly abundant in the northern and western Delta.

Sacramento splittail are benthic foragers that feed extensively on mysid shrimp and opportunistically on earthworms, clams, insect larvae, and other invertebrates (Moyle et al. 1995).

River Lamprey

River lamprey is a special-status species that is not listed as threatened or endangered under ESA or CESA but is a species of special concern in California.

The biology of the river lamprey has not been well studied in California. As a result, much of this discussion is derived from information known for river lamprey from British Columbia. Thus, timing and life history events may be dissimilar due to differences in abiotic factors that are unique to California river systems (e.g., temperature, hydrology). River lamprey appear to be more abundant in the lower Sacramento River, LSJR, and Stanislaus and Tuolumne Rivers than in other streams in California (Moyle 2002).

River lamprey begin their migration into freshwater in the fall towards suitable spawning areas upstream. However, river lamprey can spend their entire life in freshwater as adults (such as the land-locked population of Sonoma Creek). Spawning occurs February–May in gravelly riffles. The eggs hatch into ammocoetes that remain in fresh water for approximately 3–5 years in silty or sandy low-velocity backwaters or stream edges where they bury into the substrate and filter-feed on algae, detritus, and microorganisms (Moyle et al. 1995; USBR 2011).

During summer, ammocoetes change into juveniles and then adults at approximately 12 centimeter (cm) TL. This process takes 9–10 months, during which individuals may shrink in length by up to 20 percent. Adults spend approximately 3–4 months in the ocean where they grow rapidly to 25–31 cm TL. If the ammocoete stage is 3–5 years, the total life span of river lamprey is estimated to be 6–7 years (Moyle et al. 1995; Moyle 2002).

River lamprey adults are parasitic during both freshwater and saltwater phases. Adults feed on a variety of host fish species that are small to intermediate size (4–12 inches TL) (Moyle et al. 1995).

San Joaquin Roach

The San Joaquin roach is a subspecies of the California roach. The San Joaquin roach is not a special-status species and is found throughout the Sacramento River and SJR Basins (Moyle 2002).

Roach frequent a variety of habitats, are generally found in small, warm streams, and are most abundant in mid-elevation streams in the Sierra foothills. Roach are tolerant of relatively high temperatures (86–95°F) and low oxygen levels (1-2 parts per million [ppm]). They also thrive in cold, clear, well-aerated streams, in heavily modified habitats, and in the main channels of rivers, such as the Tuolumne River. (Moyle 2002.)

Roach are omnivorous and feed largely by browsing on the river bottom. However, in the Tuolumne River (below Preston Falls), they feed in fairly fast current on drift organisms, such as terrestrial insects. In larger streams, such as the North Fork Stanislaus River, aquatic insects may dominate their diets year-round. (Moyle 2002.)

Roach usually mature after reaching 45–60 mm TL at 2 or 3 years of age. Spawning is from March through early July, depending on water temperature, usually occurring when temperatures exceed 60.8°F. (Moyle 2002.)

Pacific Lamprey

Pacific lamprey is not listed as threated or endangered under ESA or CESA but is a federal species of concern.

In the Central Valley, Pacific lamprey occur in the lower Sacramento River and SJR and many of their tributaries, including the major SJR tributaries (Brown and Moyle 1993). Similar to the river lamprey, the majority of Pacific lamprey spend the predatory phase of their life in the ocean (USBR 2011). Pacific lamprey begin their migration into freshwater towards upstream spawning areas primarily between early March and late June. Spawning habitat requirements are thought to be similar to those of salmonids (Moyle 2002).

Pacific lamprey construct nests in gravelly substrates at a depth of 30–150 cm with moderately swift currents and water temperatures of typically 53.5–64.5°F. The eggs hatch into ammocoetes (larvae) after 19 days at 59°F and then drift downstream to suitable areas in sand or mud. Ammocoetes remain in fresh water for approximately 5–7 years where they bury into silt and mud and feed on algae, organic material, and microorganisms in various locations. Ammocoetes change into juveniles when they reach 14–16 cm total length (TL). Downstream migration begins when the change is complete and generally coincides with high flow events in winter and spring (Moyle 2002; USBR 2011).

Hardhead

Hardhead is a special-status species that is not listed as threated or endangered under ESA or CESA but is a California species of special concern.

Hardhead is widely distributed in low- to mid-elevation streams in the Sacramento River and SJR Basins, scattered in tributary streams and absent from valley reaches of the LSJR (Brown and Moyle 1993). Hardhead is also abundant in a few mid-elevation reservoirs used largely for hydroelectric power generation, such as Redinger and Kerkhoff Reservoirs (Moyle 2002).

Optimal temperatures for hardhead are determined to be 75–83°F, and most streams where hardhead are present have summer temperatures in excess of 68°F. At higher temperatures, hardhead is relatively intolerant of low oxygen levels, a factor that may limit its distribution to well-oxygenated streams and reservoir surface waters (Moyle 2002). Hardhead prefers clear, deep (more than 80 cm) pools and runs with sand-gravel-boulder substrates and slow velocities (20–40 centimeters per second). Hardhead are always found in association with Sacramento pikeminnow (*Ptychocheilus grandis*) and usually with Sacramento sucker (*Catostomus occidentalis*). Hardhead tend to be absent from streams where introduced species, especially centrarchids, predominate (Brown and Moyle 1993).

Hardhead mature in their third year and spawn mainly in April and May (Grant and Maslin 1999). Juvenile recruitment patterns suggest that spawning may extend into August in some foothill streams. Hardhead from larger rivers or reservoirs may migrate 30–75 kilometers (km) or more upstream in April and May, usually into tributary streams (Moyle et al. 1995). In small streams, hardhead may move only a short distance from their home pools for spawning, either upstream or downstream (Grant and Maslin 1999).

Hardhead are omnivores that consume drifting insects and algae in the water column and forage for benthic invertebrates and aquatic plant material on the bottom of the river floor (Alley and Li 1977).

Rainbow Trout

Rainbow trout is not a special-status species. Rainbow trout are the same species as steelhead, but they are landlocked and do not go out to the ocean.

Rainbow trout are introduced into reservoirs and lakes by the California Department of Fish and Game as sport fish. They are also found in rivers and streams throughout California. In lakes and reservoirs, rainbow trout will seek out the coldest temperatures and highest oxygen levels in the hypoliminion. Rainbow trout spawn in the same habitat as steelhead and if in reservoirs, will migrate up into streams to spawn. Juvenile trout inhabit rivers the first year or two of their life, and are found in cool, fast-flowing water. Water temperatures range from 0-23^{0}C (32-73^{0}F). They use a variety of habitats depending on size. Fry (<50 mm) use shallow edge water habitat with slower velocities. Juveniles (>50 mm)occur in deeper and faster water away from channel edges among cover and rocks. Adult fish use pools and faster, deeper water for foraging. (Moyle 2002).

Largemouth Bass

Largemouth bass is not a special-status species. First introduced into California in 1874, it spread to suitable habitat throughout the state and has become an important warmwater game fish in the state (Dill and Cordone 1997; Moyle 2002).

Largemouth bass are found in warm, quiet water with low turbidity and aquatic plants, such as farm ponds, lakes, reservoirs, sloughs, and river backwaters. Adult bass remain close to shore and usually are abundant in water 1–3 m deep near submerged rocks or branches. Young-of-the-year largemouth bass also stay close to shore in schools but swim about in the open (Moyle 2002).

Many California reservoirs and farm ponds provide excellent largemouth bass fishing with sizable populations of large, fast-growing fish. In reservoirs, the manipulation of water levels for water supply or hydropower production influences bass populations by affecting food availability and spawning success (Moyle 2002). However, largemouth bass are largely more tolerant to environmental stressors, such as the change in water levels in reservoirs, than native special-status fishes (Schindler et al. 1997; Moyle 2002).

Largemouth bass tolerate extreme water quality conditions, such as temperatures of 96.8–98.6°F with dissolved oxygen (DO) concentrations as low as 1 mg/l. Water temperatures optimum for growth range from 77°F to 86°F (Moyle 2002). Very little growth occurs at temperatures below 59°F or above 96.8°F (Stuber et al. 1982).

Optimal riverine habitat for largemouth bass consists of large, slow-moving rivers or pools with fine-grained (sand or mud) substrates, some aquatic vegetation, and relatively clear water. Optimal velocities are generally less than 0.2 feet/second (ft/s), and velocities more than 0.34 ft/s are avoided. Velocities of over 0.66 ft/s are believed to be unsuitable (Stuber et al. 1982).

Largemouth bass spawn for the first time during their second or third spring, when they are approximately 180–210 mm. Spawning begins in March or April when water temperatures reach 59–60.8°F and may continue through June when water temperatures up to 75.2°F (Moyle 2002; ICF International 2012). Males build nests in a wide variety of substrates, including sand, mud, cobble, and vegetation, and gravel. Gravel seems to be preferred, while silty substrates are unsuitable (Stuber et al. 1982). Rising waters in reservoirs may cause active nests to be located as deep as 4–5m. The eggs adhere to the nest substrate and hatch in 2–5 days (Moyle 2002).

For the first month or two after hatching, the fry feed mainly on rotifers and small crustaceans, but by the time they are 50 to 60 mm, they feed largely on aquatic insects and fish fry, including those of their own species. Once largemouth bass exceed 100–125 mm, they feed principally on fish; however, prey preferences can vary from year to year (Moyle 2002).

Striped Bass

Striped bass, an introduced species, is not a special-status species but supports a popular and economically important recreational fishery.

Striped bass is a POD[2] species (Baxter et al. 2008) that is native to the Atlantic Coast of North America and was introduced to California in 1879 (Dill and Cordone 1997; Moyle 2002). Since being introduced, striped bass have become widespread in the Bay-Delta as both juveniles and adults. The species can also be found in the larger river systems downstream of impassible dams and the LSJR (Baxter et al. 2008).

Approximately one half to two thirds of the striped bass population spawns in the Sacramento River Basin, while the remaining population spawns in the SJR Basin and Bay-Delta. Striped bass move regularly between salt and fresh water. Adults and juveniles can survive temperatures as high as 93°F for short periods of time. Adults are capable of withstanding abrupt temperature changes during shifts from seawater to fresh water. They can also withstand low oxygen levels (3–5 milligrams per liter [mg/l]) for short periods and high turbidity, although extreme conditions inhibit reproduction (Moyle 2002).

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[2] Since late 2004, scientific and public attention has focused on the unexpected decline of several pelagic (open-water) fishes (delta smelt, longfin smelt, juvenile striped bass, and threadfin shad) in the freshwater portion of the Delta. This decline has collectively become known as the Pelagic Organism Decline (POD).

Striped bass spawn in the Bay-Delta and lower reaches of the Sacramento River and SJR, including their tributaries. Spawning usually begins in April or May when water temperatures reach 60°F and continues sporadically over 3–5 weeks. It peaks in May and June, depending on the interaction of three factors: temperature, flow, and salinity (Farley 1966). Optimum temperatures appear to be roughly between 59°F and 68°F. Successful spawning in the LSJR above Vernalis occurs mainly during years of high flow when the large volume of runoff dilutes salty irrigation wastewater that normally comprises much of the river flow. In years of lower flow, spawning occurs in the Bay-Delta itself. The interaction of these factors produces spawning habitat in the LSJR and the southern Delta from sloughs near Venice Island down to Antioch (Farley 1966; Moyle 2002).

Eggs hatch in approximately 2 days at 64.5–66°F, and the larvae stage lasts an additional 4–5 weeks. Embryos and larvae drift into the Bay-Delta[3] and disperse as they grow. Larvae and juveniles feed primarily on invertebrates but switch their diet mainly to piscivory when transitioning to sub-adulthood. In the Delta, adults feed mostly on threadfin shad and smaller striped bass, whereas in San Pablo Bay and the Pacific Ocean they take a wide variety of pelagic fishes (fishes that live near the water's surface (Moyle 2002).

Striped bass are a major source of mortality of juvenile salmon and other fishes entrained by the SWP pumps of the southern Delta. Striped bass prey on both fish entering the fish rescue facility and on fish that are trucked back to the Bay-Delta after being salvaged (Moyle 2002).

White Sturgeon

While not a special-status species, white sturgeon is a recreationally important species in the Bay-Delta that inhabits riverine, estuarine, and marine habitats.

The white sturgeon population, as with that of green sturgeon, has significantly declined in recent years in the Bay-Delta and riverine systems. This decline appears to be the result of juveniles' high vulnerability to the entrainment effects of the major pumps in the southern Delta during years when spring flows are low (USFWS 1996; ICF International 2012).

White sturgeon is the most abundant type of sturgeon in the Bay-Delta, with the greatest portion of the population occurring in the brackish portion of the estuary (USBR 2011; ICF International 2012). Habitats for migration of white sturgeon are downstream of spawning areas and include the mainstem Sacramento River and Bay-Delta. These corridors allow the upstream passage of adults and the downstream emigration of juveniles (ICF International 2012).

White sturgeon spawn between mid-February and early June when water temperatures range from 46.5°F to 66°F (USBR 2011), generally peaking around 57°F. Only a small fraction of the adult population spawns each year, with some fish potentially spawning in the LSJR. Spawning success varies from year to year, so the population in the Bay-Delta tends to be dominated by a few large year classes. Large year classes are associated with high outflows through the estuary in spring. This relationship may result from larval sturgeon being moved quickly downstream to suitable rearing areas where food is abundant and the probability of being sucked into diversions is low (Moyle

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[3] Larval striped bass are associated with X2. X2 is the location of the 2 parts per thousand salinity contour (isohaline), one meter off the bottom of the estuary measured in kilometers upstream from the Golden Gate Bridge. The abundance of several estuarine species has been correlated with X2. In the 1995 Water Quality Control Plan, an electrical conductivity value of 2.64 mmhos/cm is used to represent the X2 location.

2002). Temperatures suitable for incubation and hatching range from 46°F to 68°F; higher temperatures result in greater mortality and premature hatching (ICF International 2012).

American Shad

American shad is not a special-status species. American shad was introduced into the Sacramento River in the late 1800s and supported a commercial fishery by 1879 (Reynolds et al. 1993). Once established, American shad quickly spread into other rivers along the West Coast, including the LSJR (Dill and Cordone 1997). American shad population abundance in the Central Valley has declined from historical levels. The decline is attributed to increased water diversions and changing ocean conditions. The limited population data available also appears to indicate that American shad recruitment is lower during drier years (when Delta outflow is low) (Moyle 2002). Drought conditions are often accompanied by increases of temperature, causing juveniles rearing in the Bay-Delta and LSJR to become stressed.

Mature American shad start appearing in the LSJR in late April, with increased recruitment occurring in wetter years. Peak spawning occurs from mid-May to mid-June at water temperatures of 51.8–62.6°F; however, some spawning can occur as late as early September. American shad spawn mostly in main channels of rivers over a wide variety of substrates, although sand and gravel are most commonly used. Depth of the water is usually less than 3 m but can range from 1 to 10 m. Following their first spawning event, American shad will return annually to spawn until they are up to 7 years of age (Moyle 2002).

Depending on water temperatures, larvae hatch from eggs in 3–12 days. Larval American shad are planktonic for about 4 weeks and cannot survive in saltwater (Zydlewski and McCormick 1997). The first several months are usually spent in fresh water, but small shad can live in salinities of up to 20 ppt. American shad seem to prefer temperatures of 62.6°F–77°F during the rearing stage (Stier and Crance 1985; Moyle 2002).

While in the Bay-Delta, young American shad feed on zooplankton, especially mysid shrimp, copepods, and amphipods. Although they feed primarily in the water column, they are opportunistic and will also take abundant bottom organisms and surface insects. Entry into saltwater takes place in September, October, and November, but may start as early as June, especially in wet years when outflows are high. Peak salvage of juvenile shad at the southern Delta pumping plants generally occurs during this time (Moyle 2002).

Kokanee

Kokanee is not a special-status species. It was brought from Idaho to California in 1941 (Moyle 2002). Kokanee is the nonanadromous form of sockeye salmon; individuals mature in lakes and reservoirs rather than in the ocean. Kokanee prefer well-oxygenated, open waters of lakes and reservoirs, roughly 1–3 m from the water's surface where temperatures range between 50 and 59°F. Most kokanee populations mature in 4 years; however, populations can mature in as little as 2 years to as many as 7 years. (Moyle 2002.) Like other salmonid species, once kokanee mature, they typically return to the stream in which they were hatched as fry (Moyle 2002).

Spawning behavior of kokanee is similar to that of other salmonids (e.g., mate selection, redd construction, death after spawning). Typically, kokanee spawn between August and February; however, they have been observed to spawn as late as April in California. Most spawning takes place in the gravel riffles of small streams a short distance from a lake or reservoir where temperatures are roughly 43–55.5°F. Fry typically emerge from the redds in April and June and immediately move to downstream rearing habitat. (Moyle 2002.)

7.2.2 Reservoirs, Tributaries, and LSJR

This section describes the environmental setting for aquatic resources that may be affected by the LSJR alternatives, including: the major storage reservoirs on the Merced, Tuolumne, and Stanislaus Rivers, the downstream reaches of the Stanislaus, Tuolumne, and Merced Rivers below the rim dams, and the LSJR and southern Delta. Table 7-4 summarizes the indicator species found in these geographic locations and their life stage.

Stanislaus River

This section describes the environmental setting for aquatic resources in the Stanislaus River that may be affected by the LSJR alternatives, including New Melones Reservoir and the Stanislaus River below New Melones Dam. The status of fall-run Chinook salmon and Central Valley steelhead in the Stanislaus River is discussed, in addition to the baseline environmental stressors affecting aquatic resources in the Stanislaus River.

New Melones Reservoir

New Melones Reservoir supports sport fisheries for coldwater and warmwater species, including rainbow trout, brown trout, kokanee, largemouth bass, smallmouth bass, crappie, bluegill, catfish, minnows, suckers, and carp. Rainbow and brown trout are generally restricted to colder, deeper water during summer while most of the other species inhabit warmer surface and shallow inshore waters (USBR 2009).

Stanislaus River Below New Melones

Historically, spring-run Chinook salmon, fall-run Chinook salmon, Central Valley steelhead, and possibly late fall-run Chinook salmon occurred in the Stanislaus River (Yoshiyama et al. 1996, 1998). Salmon and steelhead were abundant in the Merced and Tuolumne Rivers and presumably the Stanislaus River before the Gold Rush began in 1849 and declined thereafter in response to dam construction, expansion of commercial fishing, and habitat degradation associated with early hydraulic mining, dredging, and water diversions. Spring-run Chinook salmon are thought to have been extirpated from the Stanislaus River after the construction of Melones Dam in 1926, which blocked access to their historical spawning habitat in the upper watershed (Yoshiyama et al. 1996, 1998). Goodwin Dam, completed in 1913, was passable but became a complete barrier to migration by 1940 and is now the upstream limit of migration for anadromous fish (Stanislaus River Fish Group 2003). These barriers likely had a similar effect on steelhead because of their dependence on higher elevation streams for holding, spawning, and early rearing.

Table 7-4. Geographic and Seasonal Occurrence of Indicator Fish Species and Life Stages

Life Stage	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Central Valley Fall-Run Chinook Salmon													
Adult migration	Bay-Delta, SJR and major tributaries							░	░	░	▓	▓	░
Spawning/incubation	Major SJR tributaries	░								░	▓	▓	▓
Juvenile rearing/emigration	Bay-Delta, SJR and major tributaries	░	▓	▓	▓	▓	░						
Central Valley steelhead													
Adult migration	Bay-Delta, SJR and major tributaries	▓	▓	░				░	░	░	▓	▓	▓
Spawning/incubation	Major SJR tributaries	▓	▓	▓	░								░
Juvenile rearing	Major SJR tributaries	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Juvenile emigration (age 1+)	Bay-Delta, SJR and major tributaries	░	▓	▓	▓	▓	░						
Rainbow Trout													
Adult migration (lake to stream)	New Melones, New Don Pedro, Lake McClure and Lake McSwain	░											░
Spawning/incubation	Major SJR tributaries		▓	▓	▓	░	░						
Juvenile rearing	Major SJR tributaries	░	░	░	░	░	░	░	░	░	░	░	░
Largemouth Bass													
Spawning/incubation	Bay-Delta, SJR and major tributaries, reservoirs				▓	▓	▓						
Juvenile rearing to adult	Bay-Delta, SJR and major tributaries, reservoirs	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓

▓ Primary occurrence periods considered in impact assessment.

░ Non-primary occurrence period.

Sources: Adapted from Rosenfield and Baxter 2007; Wang and Brown 1993; USFWS 1996; McEwan 2001; Moyle 2002; Hallock 1989.

Note: Federal ESA list Accessed January 12, 2012; DFG Special Status List Accessed January 12, 2012; and USBR 2011.

Today, the lower Stanislaus River supports only fall-run Chinook salmon and steelhead. All anadromous salmonids are currently restricted to the lowermost 58 river miles (RMs) of the river below Goodwin Dam. Small numbers of adult salmon are observed in the summer but these may be spring-run strays from the Sacramento River Basin based on the recovery of tagged adults originating from the Feather River Hatchery (Stanislaus River Fish Group 2003). Other anadromous fish species that occur in the lower Stanislaus River include striped bass, American shad, Pacific lamprey, and river lamprey (Stanislaus River Fish Group et al. 2003). Striped bass and American shad were introduced into the Sacramento and SJR Basin in the late 1880s (Stanislaus River Fish Group et al. 2003).

Indicator Species

Fall-Run Chinook Salmon

The fall-run Chinook salmon population of the Stanislaus River is maintained by natural production and hatchery strays originating from the Merced River, Mokelumne River, and Sacramento River basin hatcheries. The Department of Fish and Game (DFG) began estimating the number of fall-run Chinook salmon that returned to spawn each year (i.e., spawning escapement) in the Stanislaus River in 1947 (Stanislaus River Fish Group 2003). Since 1947, annual escapement to the Stanislaus River has fluctuated substantially with the highest returns generally occurring during wet periods or after years of relatively high spring flows and the lowest returns generally occurring during dry periods or after years of relatively low flows (Figure 7-1).

Annual escapement of fall run was minimally estimated at 4,000–35,000 spawners (average about 11,100) during 1946–1959 before the construction of Tulloch Dam in 1959. In the following 12-year period (1960–1971), the average run size was about 6,000 fish. Fall-run abundances during the 1970s and 1980s ranged up to 13,600 (average about 4,300) spawners annually (DFG unpublished data). The numbers of spawners returning to the Stanislaus River have been especially low during most of the 1990s—<500 fish annually in 1990–1993, 600–800 fish in 1994–1995, and <200 fish in 1996—but there was a modest increase to 1,500 spawners in 1997 and 2,200 spawners in 1998 (DFG unpublished data) (Figure 7-1).

Juvenile salmon may occur throughout the Stanislaus River below Goodwin Dam during the primary rearing and emigration period (February–May). Monitoring of downstream movements of juvenile Chinook salmon at Oakdale and Caswell from 1996–2005 revealed a consistent migration pattern characterized by downstream dispersal of newly emerged fry from late January through early March followed by the emigration of smaller numbers of parr and smolts through mid-June. Peak movements of juveniles generally coincided with rapid increases or peaks in flow (i.e., flow pulses), especially during the fry emigration period (Pyper and Justice 2006).

Steelhead

Steelhead were thought to have been extirpated from their entire historical range in the San Joaquin Valley, but current populations consisting of anadromous and resident forms survive in the Stanislaus, Tuolumne, and Merced Rivers (NMFS 2009a). None of these populations are considered to be viable at this time (Lindley et al. 2007). Information regarding steelhead numbers on the Stanislaus River is scarce and has typically been gathered incidental to existing monitoring activities for fall-run Chinook salmon. For example, in 2006–2007, 12 steelhead were observed passing through the counting weir (NMFS 2009c). Steelhead smolts have been captured in rotary screw traps at Oakdale and Caswell State Park since 1995 (S.P. Cramer and Associates Inc. 2000, 2001), but the numbers are very low, ranging from 10 to 30 annually. Most of the steelhead smolts are captured from January to mid-April at a size of 175–300 mm fork length. The distribution and habitat preferences of spawning adults in the Stanislaus River is unknown but it is presumed that the majority of spawning occurs between Goodwin Dam and Orange Blossom Bridge.

Most of the environmental factors that potentially limit survival and production of fall-run Chinook salmon in the Stanislaus River likely apply to steelhead to some degree. However, because juveniles rear in the river for 1 or more years before migrating to the ocean, steelhead also require suitable flows and temperatures during the critical summer months.

Environmental Stressors

Baseline stressors that affect aquatic resources in the Stanislaus River include impassable dams and alteration of the natural flow regime, loss of natural riverine function and morphology, agricultural and urban land uses, gravel mining, predation, and water quality (e.g., contaminants and suspended sediment) (NMFS 2009c).

Flow Regulation

Flow releases for fishery purposes in the lower Stanislaus River are designated in a 1987 agreement, the New Melones Interim Plan of Operations (IPO) between the Bureau of Reclamation (USBR) and DFG. The IPO specifies interim annual flow allocations for fisheries 98,300 acre-feet (AF) to 302,100 AF, depending on carryover storage at New Melones Reservoir and inflow. In addition to fish flow releases, D-1422[4] imposes flow requirements to provide water quality control and maintain monthly total dissolved solids (TDS) concentration; the Anadromous Fish Restoration Program (AFRP) recommended a instream flow schedule that increased flows during the spring outmigration period (February–May) and was expected to double salmon production for the SJR Basin; the National Marine Fisheries Service (NMFS) biological opinion (BO) Stanislaus River reasonable and prudent alternative, including Action 3.1.3 (NMFS BO) provides a minimum flow schedule measured at Goodwin Dam; and the U.S. Army Corps of Engineers (USACE) provides flood-control release limits. (For a discussion of the flows, see Chapter 2, Water Resources; Chapter 5, Water Supply, Surface Hydrology, and Water Quality; and, Appendix C, Chapter 3, Scientific Basis for Developing Alternative San Joaquin River Flow Objectives).

The historical relationship between spring flows during the Chinook salmon rearing and emigration period and subsequent adult abundance has been the basis for a number of analyses and experimental investigations aimed at understanding the factors influencing the population dynamics of Chinook salmon populations in the Stanislaus, Tuolumne, and Merced Rivers (see Appendix C, Chapter 3, *Scientific Basis for Developing Alternate San Joaquin River Flow Objectives*). These investigations suggest that flow in the SJR and major tributaries has a major influence on juvenile salmon survival between March and June as individuals complete the freshwater rearing, smoltification, and migration stages of their lifecycles.

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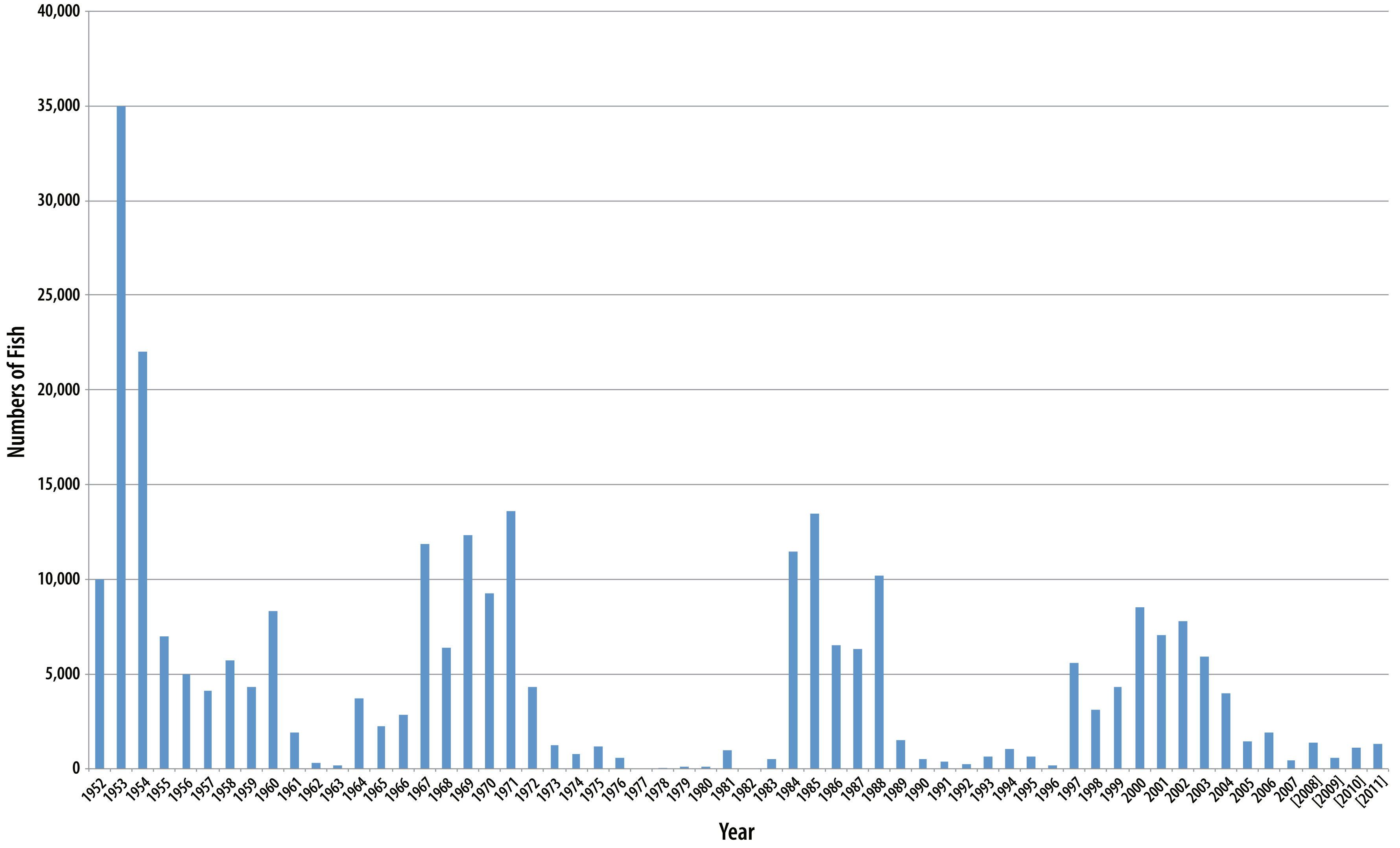
[4] State Water Board Decision 1422 approved the permits for USBR's New Melones Reservoir on the Stanislaus River and conditioned the permits on meeting total dissolved solids of 500 parts per million (833 mmhos/cm electrical conductivity [EC]) on the SJR at Vernalis.



Source: CDFG, GrandTab

Note: 2008-2011 data are preliminary

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Figure 7-1
Estimates of annual escapement of fall-run Chinook salmon in the Stanislaus River from 1952 to 2011

Habitat Alteration

Impaired geomorphic processes associated with gravel mining, upstream dams, and controlled flow releases are considered a major stressor on aquatic resources in the Stanislaus River. Historical gravel mining (dredged river channels and mine pits) and the cessation of gravel recruitment from upstream sources have reduced the availability of spawning gravel in the Stanislaus River below Goodwin Dam. Currently in the Stanislaus River, fall-run Chinook salmon are known to spawn in a 23-mile stretch downstream of Goodwin Dam, but most spawning occurs in the first 10 miles below New Melones Dam (USBR 2011). Since 1997, gravel replenishment projects have increased the amount of spawning habitat, but redd superimposition continues to be a problem and may limit the number of adult salmon that can successfully spawn in the Stanislaus River (Stanislaus River Fish Group 2003). Gravel replenishment projects have offset some habitat loss, but the rate of replenishment is neither sufficient to offset ongoing loss rates nor to offset losses from past years of operations (NMFS 2009c).

Since New Melones was constructed in 1979, the quantity and quality of spawning and rearing habitat has also been adversely affected by reductions in the frequency of bed-mobilizing and channel forming flows. The effects include encroachment of riparian vegetation, increased channel incision and bed armoring, and reductions in recruitment of spawning gravel to the active channel (Kondolf et al. 2001). Channel incision and flood attenuation have also reduced the frequency of overbank flows and the availability of floodplain habitat for salmon rearing and other ecosystem functions.

Water Quality

Land uses adjacent to the Stanislaus River and within its watershed influence the water quality of the river and the types and quantities of pollutants found in the water. Poor water quality associated with agricultural runoff (i.e., pesticides) and increasing urbanization has been identified as a potential stressor on steelhead and other aquatic resources in the lower Stanislaus River. Common pollutants include nutrients from agricultural and livestock operations; pesticides, herbicides, and fungicides applied to crops and orchards; sediment and soil from runoff of agricultural operations; oil or grease from junkyards along the river; and trace metals, heavy metals, and sediment from historical and current mining or gravel extraction operations(NMFS 2009a). Water quality impairments for the Stanislaus River below New Melones Reservoir include diazinon, group A pesticides,[5] and mercury. Additionally, chlorpyrifos and water temperature may also be added to the impaired water bodies 303(d) list[6] (see Section 7.3.1) as water quality impairments in the future.

Introduced Species and Predation

Striped bass, smallmouth bass, and largemouth bass are only a few of the introduced species that prey on salmonids, but they may be responsible for much of the increased predation pressure on special-status fish species compared to historical conditions (USDOI 2008). These introduced species have modified the fish assemblages on the Stanislaus River by increasing the number of nonnative species. For example, in the winter and spring of 2001 Mesick found large schools of

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[5] Group A pesticides include one or more of the following compounds: Aldrin, Dieldrin, Dndrin, Chlordane, LIndane, Heptachlor, Heptachlorepoxide, and Endosulfan and Toxaphene.

[6] 303(d) is a section under the Clean Water Act in which states, territories, and authorized tribes are required to develop a ranked list of water quality limited segments of rivers that do not meet water quality standards.

nonnative species (Sacramento pikeminnow) in the Stanislaus River that had consumed juvenile fall-run Chinook salmon and Central Valley steelhead. PFMC (1999) reported that the presence of striped bass in a river system near California's San Francisco Bay region resulted in estimated losses of 11–28 percent of native fall-run Chinook salmon. Historical gravel mining further contributed to habitat degradation through the creation of ditch-like channels and pits that provide habitat for predatory fishes (e.g., Sacramento pikeminnow) that prey on salmon and steelhead.

Disease

Diseased fish are present and have been caught in the Stanislaus River. Naturally produced Chinook salmon juveniles caught in rotary screw traps were diagnosed with the causative agent of bacterial kidney disease (BKD), *Renibacterium salmoninarum.* Additionally, columnaris disease, caused by the bacterium *Flexibacter columnaris*, was observed in juvenile Chinook salmon in 2007. This disease can rapidly increase in the population as water temperatures reach a mean daily temperature of 68–69.8°F (Nichols and Foott 2002).

Tuolumne River

This section describes the environmental setting for aquatic biological resources in the Tuolumne River that may be affected by the LSJR alternatives, including New Don Pedro Reservoir and the Tuolumne River below New Don Pedro Dam. The status of fall-run Chinook salmon and Central Valley steelhead in the Tuolumne River is discussed, in addition to the baseline environmental stressors affecting aquatic resources in the Tuolumne River.

New Don Pedro Reservoir

New Don Pedro Reservoir provides a warm and coldwater sport fishery. A variety of game fish are stocked in the reservoir. Warmwater game fish include: a Florida strain of largemouth bass, smallmouth and spotted bass, channel catfish, crappie, sunfish, blue gill, and carp. Coldwater game fish in the reservoir are kokanee, Chinook salmon, and brown, brook, and rainbow trout (Don Pedro Lake 2012).

Tuolumne River below New Don Pedro Reservoir

Historically, the Tuolumne River had 99 miles of anadromous fish habitat and there is approximately 47 miles of accessible habitat currently (USFWS 2008). La Grange Dam is the upstream extent of accessible anadromous fish habitat. Historically, the Tuolumne River supported abundant populations of Central Valley steelhead and fall-run and spring- run Chinook salmon (Yoshiyama et al. 1996) and now supports smaller populations of steelhead and fall-run Chinook salmon (NMFS 2009c). Spring-run Chinook salmon were extirpated from the Tuolumne River watershed when dam construction eliminated access to upstream habitats (Stillwater Sciences no date). Central Valley steelhead were thought to have been extirpated from the Tuolumne River, but fisheries monitoring for the Don Pedro FERC relicensing project have documented the presence of *Oncorhynchus mykiss (O. mykiss)* in the lower Tuolumne River (TID/MID 2012).

The mainstem Tuolumne supports both nonnative and native fish species. Nonnative fish species important for sport fisheries include American shad, catfish species, largemouth, smallmouth and striped bass, and sunfish species. Native fish species include Pacific and river lamprey, hardhead, Sacramento pikeminnow, Sacramento blackfish, and Sacramento sucker (TID/MID 2012).

Indicator Species

Fall-Run Chinook Salmon

The fall-run Chinook salmon population is maintained by natural production and hatchery strays from the Merced River and other basin hatcheries. Large numbers of unmarked hatchery salmon are released into the Merced River each year and may stray into the Tuolumne River. In recent years, up to 200,000 hatchery-origin salmon from the Merced River Hatchery have been released annually in the Tuolumne River. As a result, a significant number of hatchery-origin Merced River salmon return to the Tuolumne River each year. Since 1987, returning hatchery fish have comprised an average of 20 percent of the fall-run escapement. In addition, water diverted from the Tuolumne River is released into the lower Merced River during the irrigation season (spring, summer, and fall). This interbasin transfer may affect imprinting of Merced River salmon and may increase the likelihood of straying into the Tuolumne River. The rate of straying of wild and unmarked hatchery salmon into the Tuolumne River is not known but could be substantial. (Stillwater Sciences no date). Since 1960, annual escapement to the Tuolumne River has fluctuated substantially with the highest returns generally occurring during wet periods or after years of relatively high spring flows and the lowest returns generally occurring during dry periods or after years of relatively low flows (Figure 7-2).

Tuolumne River Chinook salmon estimates have varied over the year. A high of 45,900 fish occurred in 1959, and a low of 77 occurred in 1991. The population estimate for 2011 was 893 fish (DFG unpublished data). Survival and recruitment on the Tuolumne River, as in the Stanislaus and Merced Rivers, is higher when increased winter and spring flows are present. Figure 7-2 shows the annual escapement of fall-run Chinook salmon from 1952 to 2011 (DFG unpublished data).

Spawning in the Tuolumne River has been observed mainly upstream of Hickman Bridge. Spawning is most heavily concentrated in the reach between RM 51.5 (upstream of Old La Grange Bridge) and Basso Bridge. Adult Chinook salmon in the Tuolumne River generally spawn September–December, but some later arriving fish have been observed. Recent observations of fry emergence in late May suggest that adults spawn as late as February. Also, in 2000, adults were observed in the river during summer (Stillwater Sciences no date). Fry emergence extends primarily December–March (Stillwater Sciences 1999, 2000 as cited in Stillwater Sciences no date, 2001a).

Juvenile Chinook salmon leave the river as fry, juveniles, subyearlings (smolts), or yearlings. Large numbers of fry leave the river particularly during wet years (Stillwater Sciences 1999, 2000, 2001a). Smolts emigrate February–June. A few salmon oversummer in the river and emigrate during the fall and early winter as yearlings (Stillwater Sciences no date).

Steelhead

The historical distribution of steelhead in the San Joaquin Basin, including the Tuolumne River, is poorly known, but steelhead were recorded by DFG in counts conducted at Dennett Dam (RM 16.2) in 1940 and 1942 (DFG, unpublished data). *O. mykiss* population estimate snorkeling surveys started in July 2008, pursuant to the April 2008 FERC order. The snorkeling study ended September 2011 to satisfy FERC requirements. The estimated population results are shown in Table 7-5 (TID/MID 2012).

Table 7-5. Estimated Population of *O. Mykiss* from TID/MID (2012) Snorkel Surveys

Date	Number of Juveniles	Number of Adults
July 2008	2,472	643
March 2009	63	170
July 2009	3,475	963
March 2010	0	109
August 2010	2,405	2,139
September 2011	47,432	9,541

An acoustic tag and tracking survey was done pursuant to the May 2010 FERC Order. *O. mykiss* were tagged with acoustic tags and tracked to determine spawning locations, migration patterns and potential habitat use of restored river reaches. Tracking began in 2010 and continued into 2011. No other fish were tagged in 2011. All tagged fish remained in the river. Two tagged fish moved up and down stream of up to 6.8 miles and all other fish remained near their release locations (TID/MID 2012).

Environmental Stressors

Anthropogenic factors have affected salmonid habitat on the Tuolumne River. Water supply development, flood control, gold dredging, aggregate mining, and hatchery operations have all affected salmonid populations on the Tuolumne River (Stillwater 2002).

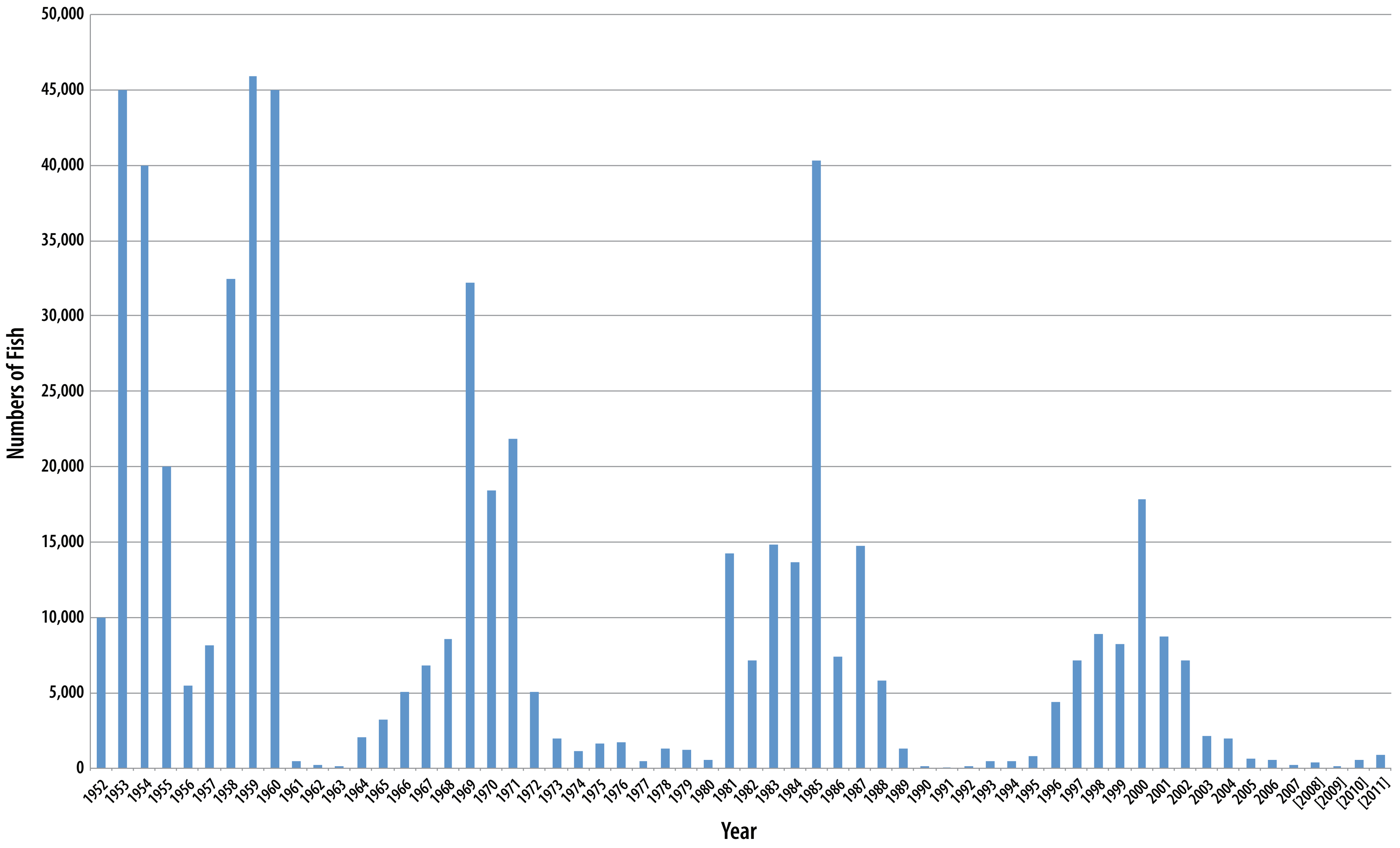
Flow Regulation

Available fish habitat on the Tuolumne River is primarily controlled by established flows. Flow requirements for the lower Tuolumne River are specified in the *New Don Pedro Proceeding Settlement Agreement* and the *FERC License Amendment for the New Don Pedro Project*. These flows are provided to protect fall-run Chinook salmon spawning below La Grange Dam. (For a discussion of the flows, see Chapter 2, *Water Resources*; Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*; and Appendix C, Chapter 3, *Scientific Basis for Developing Alternative San Joaquin River Flow Objectives*).

The historical relationship between spring flows during the juvenile emigration period and subsequent adult abundance has been the basis for a number of analyses and experimental investigations aimed at understanding the factors influencing salmon survival and population dynamics under historical and recent water management operations in the SJR and Delta (see Appendix C, Chapter 3, *Scientific Basis for Developing Alternate San Joaquin River Flow Objectives*). These investigations suggest that flow in the SJR and the major tributaries has a major influence on juvenile salmon survival between March and June as individuals complete the freshwater rearing, smoltification, and migration stage of their lifecycles.

Habitat Alteration

Habitats in the Tuolumne River downstream from LaGrange Dam have been influenced and altered by former gold mining activities and gravel mining (USBR 2011). As a result, there is limited spawning habitat in upstream areas, and this results in redd superimposition and egg mortality (Stillwater Sciences no date). During the early twentieth century, the Tuolumne River channel and floodplain were dredged for gold. The gold dredges excavated channel and floodplain deposits to the



Source: CDFG, GrandTab

Note: 2008-2011 data are preliminary

Graphics ... 00427.11 (11/12) AB

Figure 7-2

Estimates of annual escapement of fall-run Chinook salmon in the Tuolumne River from 1952 to 2011

depth of bedrock (approximately 25 feet [7.6 m]) and often realigned the river channel. Due to gravel mining activities, the channel has become constrained by dredge tailings, which restricts channel meander and reduces delivery of gravel to the river. Riparian vegetation is also scarce due to dredge tailings. By the end of the gold mining era, the floodplain adjacent to 12.5 miles (20 km) of the river (RM 50.5–38) had been converted to tailings deposits. Tailings remain in the reach from RM 45.4 to RM 40.3. (Stillwater Sciences no date.) Additionally, pits were made in the channel that provide habitat for largemouth bass and other predatory fish species.

Land clearing for gold dredging, aggregate mining, and agricultural and urban development has resulted in the loss of 85 percent of the Tuolumne River's historical riparian forest. Vegetation that once extended from bluff to bluff prior to the Gold rush era is now confined to a narrow band along the active channel margins in many areas, or is nonexistent. Nearly all of the areas in the gravel-bedded zone that historically supported riparian forests have been mined, grazed, or farmed (Stillwater Sciences, no date).

Under the FERC settlement agreement, habitat restoration has begun on the lower Tuolumne River. A total of 14 channel restoration projects have been identified in the *Habitat Restoration Plan for the Lower Tuolumne River Corridor* (McBain and Trush 1999). From reaches RM 0 to 52, which is below La Grange Dam, general restoration components include restoring floodplain habitat, planting riparian vegetation along the banks, and adding spawning gravel to reaches of the river that are conducive to spawning (USFWS 1999). Between 1994 and 2003, 19,250 cubic yards of gravel have been added to enhance spawning and rearing habitats in the Tuolumne River (Table 7-6).

Table 7-6. Tuolumne River Gravel Augmentation Projects

Tuolumne River Projects	Gravel Volume Added ($yard^3$)	Year Construction Completed
La Grange Gravel Addition Project, early	6,750	1994
La Grange Gravel Addition Project, Phases I and II	12,500	1999–2003

Source: (Mesick and Marston 2007)

Water Quality

As discussed for the Stanislaus River , land uses adjacent to and within the watershed influence the water quality of the river and the types and quantities of pollutants found in the water. Poor water quality associated with agricultural runoff (i.e., pesticides) and increasing urbanization has been identified as a potential stressor on steelhead and other aquatic resources in the lower Tuolumne River. Common pollutants include nutrients from agricultural and livestock operations; pesticides, herbicides, and fungicides applied to crops and orchards; sediment and soil from runoff of agricultural operations; oil or grease from junkyards along the river; and trace metals, heavy metals, and sediment from historical and current mining or gravel extraction operations(NMFS 2009a).

Introduced Species and Predation

Predation by introduced bass is considered a primary factor limiting survival of juvenile Chinook salmon in the lower Tuolumne River. In 1989 and 1990, predation studies were conducted by Turlock Irrigation District (TID) and Modesto Irrigation District (MID). The studies found largemouth and smallmouth bass to be the primary predators but also identified 12 additional fish species that could potentially prey on fry and juvenile Chinook salmon (TID/MID 1992). In-river mining pits provide habitat for largemouth bass and other nonnative predatory fish species (Stillwater Sciences no date).

Hatchery Operations

As discussed above, large numbers of unmarked hatchery salmon are released into the Merced River each year and may stray into the Tuolumne River. In recent years, up to 200,000 hatchery-origin salmon from the Merced River Hatchery have been released annually in the Tuolumne River. As a result, a significant number of hatchery-origin Merced River salmon return to the Tuolumne River each year. Fish produced by the hatcheries[7] have the potential to negatively affect natural[8] fall-run Chinook salmon by displacing wild[9] salmonid juveniles through competition and predation, competing with natural adults for limited resources, and hybridizing Central Valley Chinook salmon with fish from outside the SJR Basin. (DFG 2011a).

Disease

Fish species on the Tuolumne River are susceptible to similar diseases as those discussed earlier for fish in the Stanislaus River. The causative agent of BKD was detected in naturally produced juveniles caught in rotary screw traps from Tuolumne River.

Merced River

This section describes the environmental setting for aquatic biological resources in the Merced River that may be affected by the LSJR alternatives, including Lake McClure, Lake McSwain and the Merced River below Crocker-Huffman Dam. The status of fall-run Chinook salmon and steelhead in the Merced River is discussed, in addition to the baseline environmental stressors affecting aquatic resources in the Merced River.

Lake McClure and Lake McSwain

Lake McClure is impounded by New Exchequer Dam and Lake McSwain is impounded by McSwain Dam. Lake McClure and Lake McSwain support both warmwater and coldwater sport fish species. Lake McClure, contains a variety of sport fish species, such as largemouth bass, spotted bass, bluegill, green sunfish, kokanee, rainbow trout, and Chinook salmon. Common carp and catfish are also in the reservoir. Rainbow trout, kokanee, and Chinook salmon are stocked annually DFG. Spawning habitat for warmwater fish species is available in low gradient areas in Lake McClure. Spawning gravels in six tributaries surrounding the reservoir could provide spawning habitat for both warm- and coldwater species. Lake McSwain has the same fish species, but includes brook and brown trout (Merced ID 2011).

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[7] Hatchery fish are fish spawned in a hatchery.

[8] Natural fish are fish spawned in a river but can be first or second generation hatchery and, thus, have some hatchery ancestors.

[9] Wild fish are fish with no association to a hatchery.

Merced River Below Crocker-Huffman Dam

As with the Stanislaus and the Tuolumne Rivers, the Merced River historically supported abundant populations of coldwater fish species, such as Central Valley steelhead and spring- and fall-run Chinook salmon. Chinook salmon may have occurred up to an elevation of 2,000 feet near El Portal. By 1925, Crocker-Huffman, Merced Falls, and New Exchequer Dams had blocked anadromous fish passage. Crocker-Huffman and Merced Falls dams have fish ladders, but they were shut down when the Merced River Hatchery was constructed at the base of Crocker-Huffman Dam. These barriers likely had a similar effect on steelhead because of their dependence on higher elevation streams for holding, spawning, and early rearing (Stillwater Sciences 2002).

Today, the river only supports fall-run Chinook salmon and a small population of wild and hatchery steelhead. Currently, the Merced River is accessible to anadromous fishes for the first 51 RMs with access terminating at Crocker-Huffman Dam (USBR 2011). There are also limited numbers of hatchery-reared late-fall run Chinook that have strayed from their natal stream. The Merced River Hatchery, which has been operated by DFG since 1971, produces fall-run Chinook salmon that are released into the Merced River and used for studies throughout the SJR Basin (Stillwater Sciences 2002).

There is a variety of introduced fish species in the mainstem Merced River, including catfish, several species of bass, sunfish, American shad, threadfin shad, and carp. Native fish species include Sacramento sucker, prickly sculpin, Sacramento blackfish, Sacramento pikeminnow, Pacific and Kern Brook lamprey, hardhead, and Sacramento splittail (Stillwater Sciences 2002).

Indicator Species

Fall-Run Chinook Salmon

The fall-run Chinook salmon population of the Merced River is mainly comprised of hatchery fish and some naturally produced fish. Out-of-basin adult hatchery salmon stray into the Merced annually, and the Merced River Hatchery supplements the river with Chinook salmon every year.

Since the 1940s DFG has conducted escapement surveys to document the number and timing of adult Chinook salmon returning to the Merced River to spawn. Since 1998, DFG, with funding from the Central Valley Project Improvement Act-Comprehensive Monitoring and Assessment Program, also operated a rotary screw trap near the mouth of the river to document juvenile salmon outmigration and abundance (Stillwater 2002). The Merced's Chinook salmon recruitment and escapement are highly correlated with flows and water temperatures (Mesick 2010a).

Annual escapement for fall-run fish has fluctuated from a high of 29,749 in 1984 to 82 adults in 1990. Before 1966, the population was less than 500 fish until minimum instream flows were established under the Davis-Grunsky Act in October of 1966 and the Merced River Hatchery opened in 1970 (Mesick 2010a). Escapement from 2007 to 2009 declined to an average of about 500 fish, presumably because of poor ocean conditions (Lindley et al. 2009). The population estimate in 2011 is 1,942 fish. Figure 7-3 shows the annual escapement of fall-run Chinook salmon from 1952 to 2011 (DFG unpublished data).

Merced River Chinook salmon migrate upstream October–December and spawn through January (Stillwater Sciences 2002). Most spawning habitat is within the 24-mile reach of the Merced River between the Crocker-Huffman Dam and the town of Cressy, with rearing habitat extending downstream to the SJR confluence (USBR 2011). The majority of spawning occurs upstream of State Route 59 bridge (RM 42) (Yoshiyama et al 2000).

Juvenile Chinook salmon rear in the river mainly between February and May, but some fish stay year-round. Outmigration of juveniles 0+ age (fry) occurs from January through the beginning of June. Outmigration of 1+ age fish (smolts) occurs November–February.

Steelhead

Steelhead have been captured in the rotary screwtraps (Stillwater Sciences 2002), but no population estimates have been done on the Merced River. The distribution and habitat preferences of spawning adults in the Merced River is unknown, but it is presumed that the majority of spawning occurs between Crocker-Huffman Dam and the town of Cressy. Timing of adult and juvenile migration is unknown.

Most of the environmental factors that potentially limit survival and production of fall-run Chinook salmon in the Merced River likely apply to steelhead to some degree. However, because juveniles rear in the river for one or more years before migrating to the ocean, steelhead also require suitable flows and temperatures during the critical summer months.

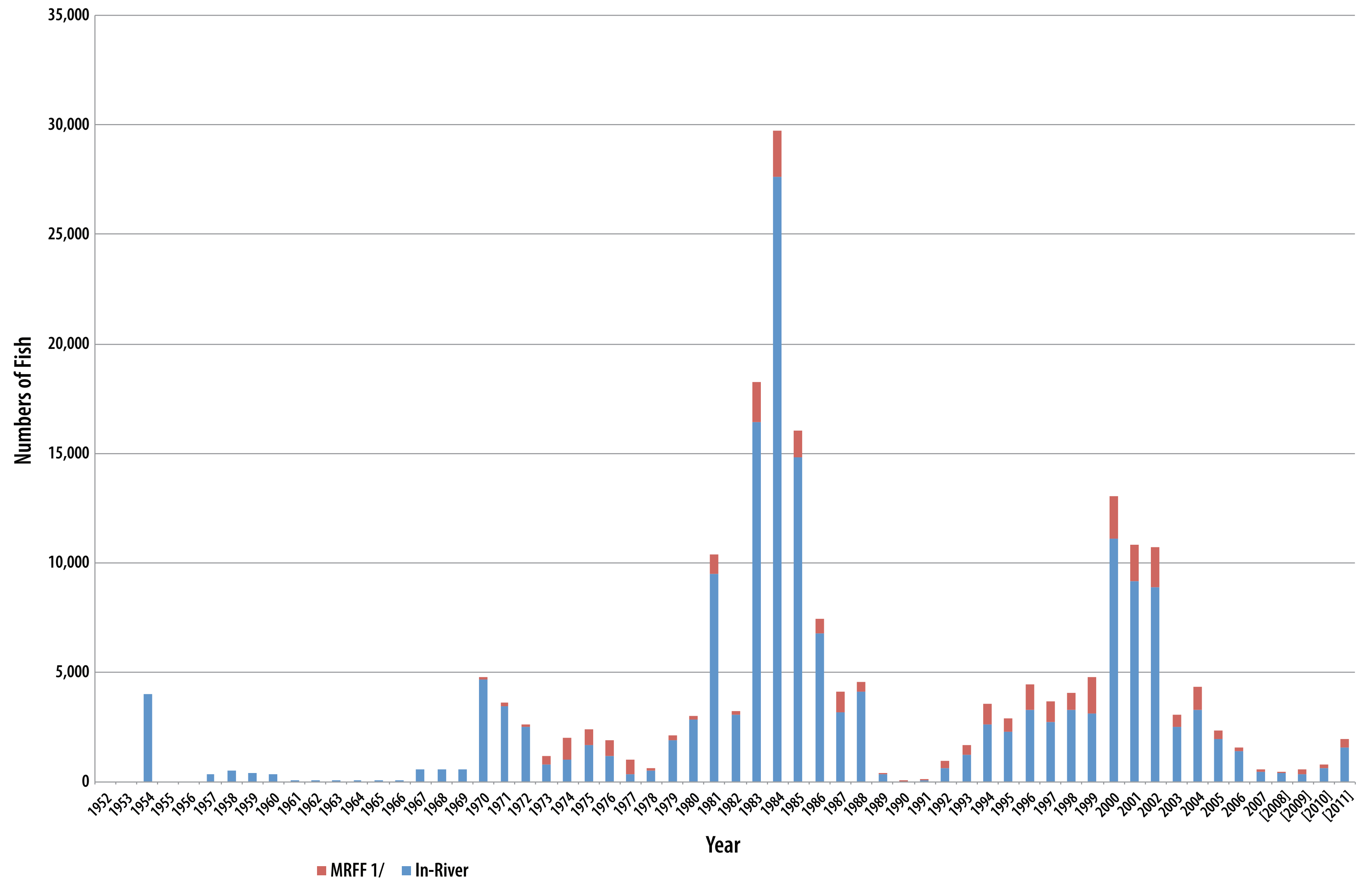
Environmental Stressors

Anthropogenic factors have affected salmonid habitat on the Merced River. Water supply development, flood control, gold dredging, aggregate mining, bank stabilization, and hatchery operations have all affected salmonid populations on the Merced River (Stillwater 2002).

Flow Regulation

Available fish habitat on the Merced River is primarily controlled by established flows. FERC License No. 2179 for the New Exchequer project and the Davis-Grunsky Contract No. D-GG417 mandates streamflows for fishery purposes in the lower Merced River. (For a discussion of the flows, see Chapter 2, Water Resources; Chapter 5, Water Supply, Surface Hydrology, and Water Quality; and Appendix C, Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives). Several dams and reservoirs control flows on the mainstem Merced River, two of which are Lake McClure (impounded by New Exchequer Dam) and Lake McSwain (impounded by McSwain Dam). Lake McClure is regulated by U.S. Army Corps of Engineers to maintain space in Lake McClure for incoming flood flows and limit the amount of water that can be released to the lower river. (Stillwater 2002). Also, USACE influences flows by establishing flood-control release limits for the Merced River not to exceed 6,000 cubic feet per second (cfs) downstream of Dry Creek.

The historical relationship between spring flows during the juvenile emigration period and subsequent adult abundance has been the basis for a number of analyses and experimental investigations aimed at understanding the factors influencing salmon survival and population dynamics under historical and recent water management operations in the SJR and Delta (see Appendix C, Chapter 3, Scientific Basis for Developing Alternate San Joaquin River Flow Objectives). These investigations suggest that flow in the SJR and major tributaries has a major influence on juvenile salmon survival between March and June as individuals complete the freshwater rearing, smoltification, and migration stages of their lifecycles.



Source: CDFG, GrandTab

Note: 2008-2011 data are preliminary

Graphics ... 00427.11 (11/12) AB

Figure 7-3
Estimates of annual escapement of fall-run Chinook salmon in the Merced River from 1952 to 2011

Habitat Alteration

Gold and aggregate mining have reduced spawning and rearing habitat for Chinook salmon and steelhead. Both gold and aggregate mining have removed gravel from the river, which is used as spawning substrate for adults (Stillwater Sciences 2002). From 1907 through 1952, the lower Merced river channel and floodplain were dredged for gold. After extracting the gold, the tailings were placed in rows on the floodplain. The tailings prevent riparian vegetation from establishing and confine the river channel to a narrow corridor. Because of the dredging and the lack of sediment supply from upstream, the dredged reach is characterized by long, deep pools Both Chinook salmon and steelhead need shallow, riffle habitat with gravel for successful spawning. (Stillwater 2002). Aggregate mining, which began in the 1940s and continues today, excavates floodplain habitat important for rearing Chinook salmon and spawning Sacramento splittail. Inundation of floodplains is also important for establishing and maintaining a healthy riparian vegetation community (Stillwater Sciences 2002). Aggregate mining also creates pits that provide habitat for largemouth bass, which prey on native fish, including outmigrating juvenile Chinook salmon. In-channel mining has been discontinued, but floodplain and terrace mining continues today (Stillwater 2002).Bank stabilization has been used throughout the Merced River to prevent bank erosion. The riprap, concrete rubble, and gabions that have been used limit channel migration and native riparian vegetation establishment (Stillwater Sciences 2002). Channel migration is important to allow different instream habitat types to form (pools, riffles, runs), which support different life stages of salmon and other fish species. Riparian vegetation along the river banks provides food and cover and controls water temperatures for juvenile salmonids. Rock stabilization along the banks prevents riparian vegetation from establishing and is typically associated with nonnative , invasive plant species such as giant reed (*Arundo donax*) (Stillwater Sciences 2002).

Water Quality

As discussed above for the Stanislaus and Tuolumne, pollutants from agriculture and increasing urbanization has been identified as a potential stressor on steelhead and other aquatic resources in the Merced River. Unsuitable water temperatures for Chinook salmon and Central Valley steelhead have been identified in the Merced River. Elevated water temperatures have been recorded in the lower reach, some portions of the spawning reach, and at the Merced River Hatchery in October and November. In late April and May, water temperatures exceed limits for emigrating smolts. Elevated spring water temperatures are more prevalent on the Merced River than in the Stanislaus or Tuolumne Rivers due to the Merced River's southerly location and higher air temperatures (Stillwater Sciences 2002).

Introduced Species and Predation

Predation by introduced bass species is considered a primary factor limiting survival of juvenile Chinook salmon in the Merced River. As discussed above, in-river mining pits provide habitat for largemouth bass and other nonnative predatory fish species. (Stillwater Sciences no date).

Hatchery Operations

The Merced River has one hatchery, the Merced River Hatchery, located below the Crocker-Huffman Dam. It is the only hatchery in the SJR Basin. In recent years, the percentage of hatchery-reared fall-run Chinook salmon returning to the LSJR and major SJR tributaries has been high (Greene 2009) even though hatchery fish are typically less productive and have higher straying rates than wild fish. A study by Mesick (2009) found that up to 58 percent of Merced River Hatchery fall-run Chinook salmon strayed to the Sacramento River Basin when flows in the SJR were less than 3,500 cfs for 10 days in late October, but stray rates were less than 6 percent when flows were at least 3,500 cfs (CSPA and CWIN 2010; Mesick 2010b). This report indicated that providing 1,200 cfs flows from the major SJR tributaries to the LSJR for 10 days in late October increases escapement by an average of 10 percent (CSPA and CWIN 2010).

The average estimated returns of hatchery Chinook salmon to the Merced River from 1998 to 2007 was 72.8 percent. Because of the high numbers of hatchery fish returning to the Merced and the low numbers of salmon returning every year, this creates a high risk of extinction for the Merced River fall-run population (Mesick 2010a). Hatchery production has been shown to negatively affect the genetic diversity and fitness of wild salmonid populations. Impacts can be genetic, ecological, or behavioral. Fish produced in the Merced River Hatchery can displace wild salmonid juveniles through competition and predation, competition with wild adults for limited resources, and introgression with other runs of Chinook salmon outside of the SJR Basin. However, a large portion of the existing genetic diversity for Central Valley Chinook salmon are contained in hatchery origin stocks, so hatchery stocks may be important contributors to overall stock recovery, including natural, wild, and hatchery origin fish.

Disease

Between 2000 and 2002, BKD was been detected in both natural and hatchery fall-run Chinook salmon juveniles in the Merced River (Nichols and Foott 2002). Occurrence of the parasite that causes BKD in samples of fish kidneys generally increased from 2 percent of the juvenile samples in 2000 to 90–100 percent of the 2001 samples. It then decreased to only 51 percent of the 2002 samples. Heavy infections were observed in 22 percent of the samples in 2002 (Nichols and Foott 2002).

Lower San Joaquin River

The LSJR between the Merced River and the Delta historically supported a distinctive native fish fauna adapted to widely fluctuating riverine conditions ranging from large winter and spring floods to low summer flows. Prior to large-scale hydrologic and physical alteration of the SJR, the fish community in this reach was dominated by fishes adapted to warmwater habitats of the valley floor, including deep, slow river channels, oxbow and floodplain lakes, swamps, and sloughs. These fishes included Sacramento perch, thicktail chub, tule perch (*Hysterocarpus traskii*), hitch, Sacramento blackfish (*Orthodon microlepidotus*), Sacramento splittail, Sacramento pikeminnow, and suckers. Anadromous species, including spring-run Chinook salmon, fall-run Chinook salmon, and sturgeon occurred seasonally in these reaches during their upstream and downstream migrations. Key habitats that contributed substantially to the productivity of native fishes on the valley floor were the floodplains, riparian forests, and wetlands that were inundated by winter and spring floods (Moyle 2002.).

Currently, the SJR from the Merced River to the Delta provides migration habitat for fall-run Chinook salmon and steelhead as they migrate upstream to spawning tributaries and downstream toward the Delta. The seasonal timing of adults and juveniles in this reach generally corresponds to that described for each of the tributaries. Other native species that occur in this reach include Sacramento sucker, Sacramento pikeminnow, Sacramento splittail, tule perch, prickly sculpin (*Cottus asper*), Sacramento blackfish, and hardhead (Brown and May 2006).

Many of the species that were present historically in the LSJR have been replaced by nonnative fish species that are better adapted to the disturbed habitat conditions (Moyle 2002). Most notably, the deep-bodied fish assemblage of the valley floor and lower portions of the major tributaries has been largely replaced by nonnative species , such as largemouth bass, sunfish species, and other warmwater species, that likely prey or compete with the native species (Moyle 2002). Nonnative fishes reported to occur in the LSJR include red shiner (*Cyprinella lutrensis*), inland silverside (*Menidia beryllina*), threadfin shad, western mosquito fish (*Gambusia affinis*), fathead minnow (*Pimephales promelas*), largemouth bass, bigscale logperch (*Percina macrolepida*), bluegill, white crappie (*Promoxis annularis*), striped bass, redear sunfish (*Lepomis microlophus*), common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), black bullhead (*Ameiurus melas*), channel catfish, and green sunfish (Brown and May 2006).

Environmental Stressors

Baseline stressors that affect aquatic resources in the LSJR include alteration of the natural flow regime, loss of natural riverine function and morphology due to habitat modification and flood control activities, predation, water quality (e.g., temperature and pollutants) and disease. These stressors are discussed below.

Flow Regulation

The natural hydrologic regime and geomorphic processes of the LSJR have been substantially altered by upstream dams, diversions, and agricultural drainage. Analyses of the historical relationship between spring flows during the juvenile Chinook salmon emigration period and subsequent adult abundance indicate that flow in the SJR major tributaries and LSJR has a major influence on juvenile salmon survival between March and June as they complete their freshwater rearing, smoltification, and migration stages . Flow in the SJR major tributaries and LSJR may affect survival through a number of mechanisms, including effects on water temperature, predation, habitat availability (e.g., access to floodplain habitat), water quality (e.g., contaminants), and entrainment in diversions (see Appendix C, Chapter 3, *Scientific Basis for Developing Alternate San Joaquin River Flow Objectives*).

Habitat Alteration

Clearing of land for agriculture and flood control activities have resulted in loss or disconnection of the river from historical wetland, riparian, and floodplain areas (Brown 2000). The loss of habitat connectivity between the river and riparian areas in the LSJR has greatly affected salmonids (McBain and Trush 2002). Riparian forests that historically surrounded river and estuarine channels had an important role in minimizing stressors related to habitat availability, water temperature, and water quality. However, riparian forests have generally been converted to agricultural uses, reducing the amount of floodplains and other habitat and increasing surface water temperatures.

Flood-control levees closely border much of the river but are set back in places, creating some off-channel aquatic habitat areas when inundated. However, the levees and dikes have acted to isolate historical riparian land and floodplains from the channel. The bank protection along channel margins, coupled with a reduced flow regime, has stabilized the channel, reducing bank erosion, lateral migration, and greatly reducing the processes that create complex side channels and high flow scour channels (McBain and Trush 2002). This has led to a reduction of various types of habitat (e.g., refuge, rearing, and spawning) for steelhead, Chinook salmon, and other native fish species.

Water Quality

Water temperatures in the LSJR reflect those of the other tributaries and are generally within a range considered to be suitable (<68°F) for rearing and outmigrating Chinook salmon smolts during April and May (SJRGA 2011). However, in certain water year types, elevated water temperatures and other environmental stressors are stressful to fish, especially salmonids, during months when juveniles are rearing and outmigrating. As discussed earlier, cool water temperatures are vital for all life stages of Chinook salmon, Central Valley steelhead, and rainbow trout. All of the tributaries generally experience an increase in water temperatures in the late spring and summer, which then contributes to increases in water temperature in the LSJR. Summer water temperatures in many Central Valley streams regularly exceed 77°F (Moyle 2002). These sustained periods of increased water temperature are known to affect behavioral and biological functions of all fishes in the LSJR, notably salmonids and Central Valley steelhead.

The LSJR is generally considered to have poor water quality in part due to agricultural drainage, which is a major source of salts and pollutants (e.g., boron, selenium, pesticides). Discharges from the existing wastewater treatment plants (WWTP) also reduce water quality in the LSJR. However, water quality is known to improve during periods of high flow due to dilution effects.

Introduced Species and Predation

Many nonnative fish species prey on Central Valley steelhead and fall-run Chinook salmon in the LSJR. The most prevalent nonnative predators in the LSJR are typically striped bass, smallmouth bass, and largemouth bass. Although bass are only a few of the introduced species that prey on salmonids, they probably represent the greatest change (increase) in predation experienced in the critical habitat compared to historical conditions (USDOI 2008).

Disease

Diseases have been identified in LSJR fish populations. Samples from Chinook salmon juveniles caught with a Kodiak trawl at Mossdale in the LSJR were positive for the causative agent of BKD (Nichols and Foott 2002). Additionally, BKD was detected in both natural and hatchery juveniles from the LSJR in both 2000 and 2001 (Nichols and Foott 2002). Tubifix worms, *Ceratomyxa shasta,* are also a pathogen present in the Central Valley, and they are of particular concern on the LSJR.

Southern Delta

The southern Delta is part of the larger Bay-Delta system and provides habitat for resident and migratory fish species. Essential habitats for salmonids and other fish species consist of suitable water quality and water quantity conditions. For salmonids, these conditions must support juvenile and adult physiological transitions between fresh water and saltwater (NMFS 2009b). Changes to estuarine habitat that degrade any of these conditions can have a negative effect on aquatic resources. Therefore, similar stressors influence the abundance and presence of fish in the southern Delta and Bay-Delta as described above for the major SJR tributaries and LSJR. However, conditions in the southern Delta are also influenced by river inflow, tidal action, water export facilities and local pump diversions, and agricultural and municipal return flows.

Environmental Stressors

Baseline stressors that affect aquatic resources in the southern Delta include alteration of the natural Delta inflows and hydrodynamics, habitat alteration due to channelization, diversions and entrainment, water quality (e.g., temperature and pollutants) and predation. These stressors are discussed below.

Delta Inflows and Hydrodynamics

Recent fisheries investigations in the southern Delta have focused on the survival of Chinook salmon smolts in relation to SJR inflows, Delta exports, and barrier installation at the head of Old River(HORB). A review of these investigations and their findings is presented in Appendix C, Chapter 3, *Scientific Basis for Developing Alternate San Joaquin River Flow Objectives.*

Changes in delta smelt habitat quality in the San Francisco estuary can be indexed by changes in X2. The abundance of many local species has tended to increase in years when flows into the estuary are high and the 2 practical saline unit (psu) isohaline is pushed seaward (Jassby et al. 1995), implying that over the range of historical experience, the quantity or suitability of estuarine habitat increases when outflows are high (USBR 2008). Because large volumes of water are drawn from the estuary, water exports and inadvertent fish entrainment at the CVP and SWP export facilities are among the best studied top-down effects in the San Francisco estuary (Sommer et al. 2007). The export facilities are known to entrain most species of fish inhabiting the Delta (Brown et al. 1996) and are of particular concern in dry years, when the distributions of delta smelt and longfin smelt shift upstream, closer to the diversions (Stevens et al. 1985; Sommer et al. 1997).

Habitat Alteration

Prior to development and channelization, the Bay-Delta provided hospitable habitat for rearing and migrating salmonids. Historical floodplain areas were dynamic areas that generally contained complex, heterogeneous habitat types (e.g., grassland, riparian, tidal and nontidal marsh, and agriculture). Inundation of surrounding floodplains provided refuge, warmer temperatures, and abundant food supplies for rearing juvenile Chinook salmon, enabling them to grow faster than by solely migrating through riverine and southern Delta corridors. These smolts grew quickly and migrated out to the ocean sooner, ultimately resulting in higher survival rates in the ocean (Stillwater Sciences 2003).

Currently, the LSJR flow into the southern Delta is influenced by existing channels. From Vernalis, the Old River channel diverges from the LSJR downstream of Mossdale and connects with Middle River and Grant Line Canal. About 50 percent of the LSJR flow splits into the Old River channel, and the other 50 percent continues down the LSJR channel toward Stockton. Channel pathways affect migration of juvenile Chinook salmon. Temporary barriers or agricultural barriers in the Middle River, Grant Line Canal, and Old River can block access, restrict passage to rearing habitat, or redirect migration for adult and juvenile fall-run Chinook salmon. Specifically, the HORB has been installed in April and May of many years (not in years with flows above 7,000 cfs) to improve juvenile Chinook fish migration from the SJR Basin.

The current channelization and other southern Delta developments make the Bay-Delta less hospitable for Chinook salmon as compared to the historical Bay-Delta conditions. Central Valley salmonids and other native fishes use tidal marsh directly or indirectly for at least one if not several of their life stages. Tidal marsh provides spawning and rearing areas for Sacramento splittail and rearing habitat for salmonids. However, much of the historical riparian forests that support suitable habitat for these species has been converted for agricultural uses. This conversion has reduced the amount of floodplains and habitat and increased surface water temperatures.

Diversions and Entrainment

The two major water diversions in the southern Delta are the SWP (Banks Pumping Plant) and the CVP (Jones Pumping Plant). The Contra Costa Water District also diverts water from the southern Delta. Many small agricultural diversions (siphons and pumps) divert water from throughout the Delta during the spring and summer irrigation season. These diversions affect fish species by physically entraining them and altering flow such that migration cues are modified.

CVP and SWP export pumping is controlled under the 2006 Bay-Delta Plan objectives (Water Right Decision 1641). Both the CVP and the SWP have maximum permitted pumping (or diversion) rates. Delta outflow requirements may limit pumping if the combined Delta inflow is not enough to satisfy the in-Delta agricultural diversions and the full capacity CVP and SWP pumping. When pumping is limited, the cooperative operating agreement (COA) governs the CVP and SWP share in reservoir releases and Delta pumping. The CVP and SWP typically increase their rate of pumping approximately 10–40 percent during April and May.

The CVP and SWP pumping facilities are known to entrain various fish species in the southern Delta nearly year-round. The CVP and SWP fish facilities report entrainment of adult delta smelt during spawning migration December–April (USFWS 2008) while juveniles are entrained primarily April–June. Longfin smelt are primarily observed in the salvage operations during the spring (March–May) as juveniles, although larger subadult longfin smelt are also observed in the salvage operations during early winter. Young-of-the-year splittail are entrained April–August when fish are moving downstream into the Bay-Delta (Meng and Moyle 1995). Juvenile Chinook salmon are entrained in all months but primarily November–June when juveniles are migrating downstream. Green sturgeon are rarely entrained at the CVP and SWP fish facilities (probably due to low abundance in the southern Delta); however, entrainment has occurred in every month, indicating the presence of green sturgeon year-round (USBR 2009). Juvenile Central Valley steelhead from the SJR Basin are vulnerable to entrainment and salvage operations at the CVP and SWP export facilities, primarily March–May.

Pumping in the southern Delta can confuse salmonids and cause delayed outmigration of salmonids. While recent studies (Newman and Brandes 2010) indicate that spring water exports are not significantly impacting SJR outmigrating smolts under certain export conditions, there could be significant impacts on salmonids if exports are outside of the range tested. For example, increased pumping can create strong negative flows in Old and Middle River (OMR), which also create false migration pathways, confusing out-migrating and rearing salmonids. These impacts could affect salmonids between March and June but could vary with water year type. When exports are high relative to SJR flows, it is likely that little if any SJR Basin water reaches the San Francisco Bay. It is necessary for the scent of the SJR Basin to enter the bay in order for adult salmonids to find their way back to their natal streams. Specifically, Mesick (2001) observed that reduction, or even the elimination, of this scent trail is likely to increase fall-run Chinook salmon to stray from the SJR Basin and into the adjacent Mokelumne River or Sacramento River Basins.

There are over 2,200 small water diversions within the Delta, the majority of which are unscreened (Herren and Kawasaki 2001). These unscreened diversions have the potential to directly remove fish from the channels and alter local movement patterns (Kimmerer and Nobriga 2008; DFG 2011a). Removal of fish and alteration of movement patterns take place throughout the year and are highest during fall, winter, and spring (DFG 2011a). April–September is the high irrigation season and diversion period. Agricultural diversions have the limited potential to remove spring-run and winter-run Chinook salmon adults, juveniles, or fry, or any life stage of Central Valley steelhead from the Bay-Delta. It is undocumented how many juvenile Central Valley steelhead are entrained at the unscreened small water diversions in the Bay-Delta. However, because Central Valley steelhead are moderately large (more than 200 mm fork length), typically older, and relatively strong swimmers when outmigrating, the effects of small in-Delta agricultural water diversions are thought to be lower than those of Central Valley Chinook salmon. Longfin smelt and delta smelt are typically present in the Bay-Delta primarily November–June and not July–October. Since exports are typically greater when inflows from the Sacramento River and LSJR are greater in spring and summer, longfin smelt and delta smelt are expected to be affected by diversions.

Other smaller diversions, such as drawing cooling water for power generation plants and small agricultural diversions, also affect migrating Chinook salmon, but not to the extent of the CVP and SWP pumping facilities. Drawing cooling water from the Bay-Delta through power generation plants can remove fish and kill them due to mechanical and thermal trauma. These effects are potentially greatest on pelagic larvae of longfin smelt and delta smelt, one or both of which could be adjacent to the power plants in the western Delta during late December through July. Fall-run Chinook salmon fry may also be present and somewhat vulnerable late December through February during high-outflow years. Juvenile and adult smelt are present also during all other times of year but are less vulnerable because of greater mobility. The western Delta power plants are called to operate during times of high power demand, which are most apt to occur during peak summer temperatures July–September.

Water Quality

Because the southern Delta receives a substantial portion of its water from the LSJR, the influence of the relatively poor LSJR water quality is greatest in the southern Delta channels. Currently, the LSJR, Delta, and San Francisco Bay are listed under Section 303(d) of the federal Clean Water Act (CWA) as impaired for a variety of toxic contaminants that may contribute to reduced population abundance of important fishes and invertebrates.

Agricultural and urban runoff and domestic WWTP discharges in the southern Delta can cause direct and chronic toxicity to eggs, larvae, and adults of pelagic fish species. Some other contaminants that can affect pelagic fishes (delta smelt and longfin smelt) in the southern Delta are mercury, copper, oil and grease, selenium, pesticides, herbicides, and ammonia. These contaminants have the potential to affect fish or the food webs that support them and typically result from in-river activities (mining and dredging), urban runoff, urban sewage, municipal and industrial discharges, and agricultural drain water.

In addition, turbidity in the southern Delta is low, which may reduce habitat for delta smelt and other species (Feyrer 2004; Feyrer and Healey 2003; Feyrer et al. 2007; Monsen et al. 2007; Nobriga et al. 2008). Therefore, flow patterns that cause delta smelt to move into the southern Delta are likely to negatively affect the population. During the fall adult salmon migration season, when LSJR inflows to the Bay-Delta are less than 1,500 cfs, low DO levels in the SJR at the Stockton Deep Water Ship Channel (e.g., less than 6 parts per million) create a chemical migration barrier to upstream migrating adult salmon. Failure of SJR Basin salmon to reach the spawning grounds results in negative spawning impacts on the SJR fall-run Chinook salmon population (DFG 2011a).

Unsuitable salinity gradients can cause physiological stress for many aquatic species in the Bay-Delta. Inflow from the LSJR to the Bay-Delta helps to establish the location in the Bay-Delta of the low salinity zone (LSZ), an area often referenced by X2 that historically has had high prey densities and other favorable habitat conditions for rearing juvenile delta smelt, striped bass, and other fish species (USBR 2008). However, changes in Delta inflows from the LSJR have the potential to alter LSZ salinity gradients and the location of X2, which can influence temperature, turbidity, and other habitat characteristics (Moyle et al. 2010). These alterations can potentially create an environment that is physiologically stressful to most organisms that utilize the Bay-Delta and X2, including Chinook salmon and Central Valley steelhead.

Agricultural diversions also influence the typical salinity gradients that migrating smolts encounter. Typically, outmigrating smolts would perceive a steadily increasing salinity gradient as the ocean grew closer. However, today, outmigrating fall-run Chinook salmon smolts encounter agricultural return flows that are of elevated temperature, nutrient and pesticide load, and salinity concentration (State Water Board 1999) in the Bay-Delta. As juveniles enter the southern Delta, the EC at the three southern Delta compliance stations downstream of Vernalis (SJR at Brandt Bridge [P-12], Old River at Middle River [C-8], and Old River at Tracy Boulevard [C-6]) is generally slightly higher than the Vernalis EC. This is largely due to agricultural drainage and municipal discharges. As juveniles orient themselves and begin the last leg of their outmigration, they encounter a plume of low salinity Sacramento River water from the Delta Cross Channel, which is shuttled across the interior Bay-Delta. This unnatural variability in salinity gradient can disorient and stress outmigrating fish.

Water temperature is determined by a number of factors, such as quantity and quality of water, channel geometry, and ambient air temperatures (TBI 2010). In general, the special-status fish species listed in Table 7-2 require lower water temperatures than the recreationally important fish species listed in Table 7-3. Water temperatures in the southern Delta show temperatures generally increase as a function of distance downstream within the mainstem of the LSJR (SJRGA 2010). Sites sampled on the mainstem of the LSJR as it enters the southern Delta (e.g., Durham Ferry, Mossdale, and Old River at HORB) were within a range considered to be suitable during April and May (typically < 68°F) for emigrating juvenile Chinook salmon (SJRGA 2010). Temperatures are slightly higher, but generally under 68°F further downstream within the southern Delta (e.g., Old River-Indian Slough Confluence) during this time (SJRGA 2010). However, water temperatures during early June were within the range (>68°F)considered to be stressful for juvenile Chinook salmon (SJRGA 2010). Lethal temperatures for Chinook salmon and Central Valley steelhead juveniles are not reached under baseline conditions at Vernalis until August, and at that time these fishes typically are not present in the Bay-Delta.

Introduced Species and Predation

Predation rates in the southern Delta are believed to be higher than in other parts of the Bay-Delta. This is due to a variety of reasons, including: (1) turbidity is generally lower in the southern Delta, which increases visibility for predators (Nobriga et al. 2008; Feyrer et al. 2007); (2) many of the structures and facilities in the southern Delta support excellent conditions for predators by providing suitable habitat and flows, especially the Clifton Court Forebay and fish louver screens at the CVP and SWP facilities; and (3) recent invasions by the submerged plant, Brazilian water weed, *Egeria densa* (Nobriga et al. 2008; Feyrer et al. 2007). The Brazilian water weed is an invasive, nonnative freshwater species that grows in denser stands than native submerged aquatic vegetation, providing rearing habitat to nonnative fish species, including bass. Brazillian water weed filters sediment and nutrients from the water column resulting in decreased turbidity in the southern Delta, which historically provided cover and habitat for outmigrating smolts but now provides cover for larger predatory fishes.

7.3 Regulatory Setting

For a broad summary of relevant statutory and regulatory provisions and how the plan amendments comply with applicable regulatory requirements, see Chapter 1, *Introduction*. For a more specific description of regulatory requirements set as existing and historical instream flow prescriptions on the LSJR and major SJR tributaries, see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. Only those regulations relevant to nonconstruction activities and that pertain to aquatic resources are described in this chapter.

7.3.1 Federal

Relevant federal programs, policies, plans, or regulations related to aquatic resources are described below.

Clean Water Act

The CWA generally applies to all navigable waters of the United States and is discussed in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*.

Endangered Species Act

The ESA is administered by USFWS and NMFS. In general, NMFS is responsible for protecting ESA-listed threatened or endangered marine species and anadromous, commercially valuable fishes, whereas other listed species are under USFWS jurisdiction. An *endangered species* is defined as ". . . any species which is in danger of extinction throughout all or a significant portion of its range." A *threatened species* is defined as " . . . any species that is likely to become an Endangered Species within the foreseeable future throughout all or a significant portion of its range" (Title 16 U.S.C. § 1532). Section 9 of ESA makes it illegal to "take" (i.e., harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in such conduct) any endangered fish or wildlife species, and regulations contain similar provisions for most threatened fish and wildlife species (Title 16 U.S.C. § 1538).

ESA also requires the designation of critical habitat for listed species. *Critical habitat* is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to a species' conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation (NMFS 2011; NMFS 2009a; ICF International 2012).

Long-Term Central Valley Project Operations Criteria and Plan and Biological Opinions

The long-term SWP and CVP operations criteria and plan (OCAP) serves as the operational standard by which the U.S. Bureau of Reclamation (USBR) and the Department of Water Resources (DWR) operate the integrated SWP and CVP system. The OCAP describes how USBR and DWR operate the CVP and the SWP to divert, store, and convey water consistent with applicable law (USBR 2008).

U.S. Fish and Wildlife Service Biological Opinion

The 2008 USFWS BO concurred with USBR's determination that the coordinated operations of the SWP and CVP are not likely to adversely affect listed species, with the exception of delta smelt (USFWS 2008). The USFWS concluded that the coordinated operations of the SWP and CVP, as proposed, were likely to jeopardize the continued existence of delta smelt and adversely modify delta smelt critical habitat. Consequently, USFWS developed a reasonable and prudent alternative (RPA), consisting of a number of components and actions to avoid the likelihood of jeopardizing the continued existence or the destruction or adverse modification of critical habitat for delta smelt. These actions include: (1) preventing/reducing entrainment of delta smelt at the Jones and Banks pumping plants; (2) providing adequate habitat conditions that will allow adult delta smelt to successfully migrate and spawn in the Bay-Delta; (3) providing adequate habitat conditions that will allow larvae and juvenile delta smelt to rear; and (4) providing suitable habitat conditions that will allow successful recruitment of juvenile delta smelt to adulthood. In addition, USFWS specified that it is essential to monitor delta smelt abundance and distribution through continued sampling programs through the Interagency Ecological Program (IEP). The RPA restricted pump operations and limited deliveries of water to SWP and CVP contractors south of the Delta. In March of 2009, SWP and CVP contractors filed three separate lawsuits in federal court challenging the USFWS 2008 BO. On December 14, 2010, Judge Wanger issued a memorandum decision on cross motions for summary judgment in litigation concerning the USFWS 2008 BO which found several aspects of the RPA flawed and directed that they be addressed on remand. A final judgement issued March 28, 2011 remanded the BO to USFWS for further consideration and directed USFWS to issue a revised BO in accordance with the memorandum decision.

The operations of the SWP and CVP are currently subject to the terms and conditions of this BO until the new water conveyance infrastructure identified in the Plan becomes operational. At that time, an integrated BO on coordinated long-term operation of the CVP and SWP will be completed by USFWS and NMFS.

National Marine Fisheries Service Biological Opinion

The NMFS BO (NMFS 2009a) concluded that the SWP and CVP operations are likely to jeopardize the continued existence of the species listed below.

- Sacramento River winter-run Chinook salmon.
- Central Valley spring-run Chinook salmon.
- Central Valley steelhead.
- Southern DPS of North American green sturgeon.
- Southern resident killer whale.

NMFS (2009a) also concluded that USBR's proposed action is likely to destroy or adversely modify the designated critical habitats of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and green sturgeon. The operations of the SWP and CVP are currently subject to the terms and conditions of this BO, as modified under recent court order, are expected to be in effect until the new water conveyance infrastructure identified in the 2006 Bay-Delta Plan becomes operational. At that time, an integrated BO on coordinated long-term operation of the CVP and SWP will be completed by USFWS and NMFS that incorporates the Bay Delta Conservation Plan conservation strategy as part of USBR's proposed action.

The actions included in the RPA to USBR's proposed action are summarized below relevant to the plan area (NMFS 2009a).

- New OMR reverse flow levels to limit the strength of reverse flows and reducing entrainment at the SWP and CVP facilities.
- Use of additional technological measures at the SWP and CVP facilities to enhance screening and increase survival of fish.
- Additional measures to improve survival of San Joaquin steelhead smolts, including increased SJR flows and export curtailments, and a new study of acoustic tagged fish in the SJR Basin to evaluate and refine these measures.
- A year-round minimum flow regime on the Stanislaus River necessary to minimize project effects on each life stage of steelhead, including new springtime flows that will support rearing habitat formation and inundation, and create pulses that allow salmon to migrate out successfully.

Essential Fish Habitat

National Marine Fisheries Service (NMFS), regional fishery management councils, and federal and state agencies work together to address threats to fish by identifying Essential Fish Habitat (EFH) for each federally managed fish species and developing conservation measures to protect and enhance these habitats. Fish require healthy surroundings to survive and reproduce. Essential fish habitat includes all types of aquatic habitat (e.g., wetlands, coral reefs, seagrasses, rivers) where fish spawn, breed, forage, or grow to maturity. Following is the recognized EFH definition for Chinook salmon.

> Essential fish habitat for Chinook salmon has been identified as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. "Waters" is defined to include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities. "Necessary" means habitat required to support a sustainable fishery and a healthy ecosystem. "Spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life history (NMFS 2009b).

Recovery Plan for Sacramento–San Joaquin Delta Native Fish Species

The Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes was released in 1996 by USFWS with the basic goal of establishing self-sustaining populations of species of concern. The plan specifically focused on delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch.

National Wildlife Refuge System Improvement Act of 1997

Comprehensive conservation plans (CCPs) are prepared by USFWS and are required under the National Wildlife Refuge System Improvement Act of 1997. The San Joaquin River National Wildlife Refuge has prepared a final CCP. The primary goals of the refuge are to accomplish the following: conserve and protect the natural diversity of migratory birds, resident wildlife, fish, and plants through restoration and management of riparian, upland, and wetland habitats on refuge lands; contribute to the recovery of threatened and endangered species, as well as the protection of populations of special-status wildlife and plant species and their habitats; provide optimum wintering habitat for Aleutian Canada geese to ensure the continued recovery from threatened and endangered species status; coordinate the natural resource management of the San Joaquin River National Wildlife Refuge in the context of the larger Central Valley-San Francisco ecoregion; provide the public with opportunities for compatible, wildlife-dependent visitor services to enhance understanding, appreciation, and enjoyment of natural resources at the San Joaquin River National Wildlife Refuge (USBR 2011).

7.3.2 State

Relevant state programs, policies, plans, or regulations related to aquatic resources are described below.

California Water Code

The California Water Code authorizes the State Water Board to allocate surface water rights and permit diversion and use of water throughout the State of California. The State Water Board also considers the effects of water use and diversion on fisheries as a part of the permitting process. Division 7 of the California Water Code, known as the Porter-Cologne Water Quality Control Act, regulates activities that have the potential to effect water quality.

California Endangered Species Act of 1970

CESA (Fish & G. Code § 2050 et seq., and Cal. Code Regs., tit. 14, §§ 670.2, 670.51) prohibits “take” (defined as hunt, pursue, catch, capture, or kill) of species listed under CESA. A CESA permit must be obtained if a project will result in take of listed species, either during construction or over the life of the project. Section 2081 establishes an incidental take permit program for state-listed species. Under CESA, DFG has the responsibility for maintaining a list of threatened and endangered species designated under state law (Fish & G. Code § 2070). DFG also maintains lists of species of special concern, which serve as “watch lists” (see below, *California Department of Fish and Game Species Designations*). Pursuant to requirements of CESA, an agency reviewing proposed projects within its jurisdiction must determine whether any state-listed species may be present in the plan area and determine whether the proposed project will have a potentially significant impact upon such species. Project-related impacts on species on the CESA list would be considered significant and would require mitigation.

California Department of Fish and Game Species Designations

DFG maintains an informal list of species called “species of special concern.” These species are defined as plant and wildlife species that are of concern to the DFG because of population declines and restricted distributions and/or because they are associated with habitats that are declining in California. These species are inventoried in the California Natural Diversity Database (CNDDB) regardless of their legal status.

California Fish and Game Code

California Fish and Game Code (§§ 1601–1607) protects fishery resources by regulating “any activity that may substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake.” DFG requires notification prior to commencement and issuance of a lake or streambed alteration agreement if a proposed project will result in the alteration or degradation of ''waters of the State." The limit of DFGs jurisdiction is subject to the judgment of DFG itself; currently, this jurisdiction is interpreted to be the "stream zone," defined as "that portion of the stream channel that restricts lateral movement of water" and delineated at "the top of the bank or the outer edge of any riparian vegetation, whichever is more landward". DFG reviews the proposed actions and, if necessary, submits to the applicant a proposal for measures to protect affected fish and wildlife resources. The final proposal that is mutually agreed upon by the DFG and the applicant is the streambed alteration agreement.

Projects that require a streambed alteration agreement may also require a CWA 404 Section permit and/or CWA Section 401 water quality certification. State jurisdiction generally includes drainages, including artificial channels, up to the limits of riparian vegetation, and isolated wetlands.

Salmon, Central Valley Steelhead Trout, and Anadromous Fisheries Program Act

The 1988 Salmon, Central Valley Steelhead Trout, and Anadromous Fisheries Program Act was implemented in response to reports that the natural production of salmon and Central Valley steelhead in California had declined dramatically since the 1940s. DFG was charged with developing a plan or program with the goal of increasing salmon and Central Valley steelhead resources. In addition, it is also state policy that existing natural salmon and Central Valley steelhead habitat shall not be diminished further without adequate mitigation to offset the impacts of lost habitat (Fish & G. Code § 6902[c]).

7.3.3 Regional or Local

Relevant regional or local programs, policies, plans, or regulations related to aquatic resources are described below. Although local policies, plans, and regulations are not binding on the State of California, below is a description of relevant ones.

County General Plans

As required by state law, counties must develop their own general plans. Within the plan area, applicable general plans include the *Calaveras County General Plan* (1996), the *Tuolumne County General Plan* (1996), the *Mariposa County Wide General Plan* (2010), and the *San Joaquin County Wide General Plan* (2005). These plans have policies which can preserve and protect open space and natural resources such as rivers and reservoirs and the lands adjacent to them.

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan, approved and adopted in November 2000, includes compensation measures to offset the effects of development on special-status plant, fish, and wildlife species throughout San Joaquin County, including the LSJR. The plan's purpose is to provide a strategy for balancing the need to conserve open space and the need to convert open space to non-open space uses while protecting the region's agricultural economy and preserving landowner property rights. The plan also is to provide for the long-term management of plant, fish, and wildlife species, especially those that are currently listed or may be listed in the future under ESA or CESA (County of San Joaquin 2012).

7.4 Impact Analysis

This section lists the thresholds used to define impacts on aquatic resources. It describes the methods of analysis and the approach to determine the significance of impacts on aquatic resources. The impact discussion describes the changes to baseline resulting from the alternatives and incorporates the thresholds for determining whether those changes are significant. Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant impacts accompany the impact discussion, where appropriate.

7.4.1 Thresholds of Significance

The thresholds for determining the significance of impacts for this analysis are based on the State Water Board's Environmental Checklist in Appendix A of the Board's CEQA regulations (Cal. Code Regs., tit. 23, §§ 3720–3781) and the Environmental Checklist in Appendix G of the State CEQA Guidelines. The thresholds derived from the checklist(s) have been modified, as appropriate, to meet the circumstances of the alternatives. (Cal. Code Regs., tit. 23, § 3777, subd. (a)(2).) Biological resources, which were determined to include aquatic resources for the purposes of this SED, were identified as potentially significant (see Appendix B, *State Water Board's Environmental Checklist*) and therefore are discussed in the analysis. Impacts would be significant if the LSJR alternatives result in the following conditions.

- Cause significant adverse changes in availability of warmwater species reservoir habitat resulting from changes in reservoir water levels.
- Cause significant adverse changes in availability of coldwater species reservoir habitat resulting from changes in reservoir storage.
- Cause significant changes in quantity/quality of spawning, rearing, and migration habitat resulting from changes in flow.
- Cause significant changes in exposure of fish to stressful water temperatures resulting from changes in reservoir storage and releases.
- Cause significant changes in exposure to pollutants resulting from changes in flow (dilution/mobilization effects).
- Cause significant changes in exposure to suspended sediment and turbidity resulting from changes in flow (mobilization).
- Cause significant changes in redd dewatering and fish stranding losses resulting from flow fluctuations.
- Cause significant changes in spawning habitat quality (spawning gravel) resulting from changes in peak flows.
- Cause significant changes in food availability resulting from changes in flow, nutrient transport, and water quality (food web support).
- Cause significant changes in predation risk resulting from changes in flow and water temperature.
- Cause significant changes in disease risk resulting from changes in flow, water temperature, and water quality.

- Cause significant changes in fish transport resulting from changes in flow.
- Cause significant changes in southern Delta and estuarine habitat resulting in changes in SJR inflows and export effects.

The first two thresholds apply to recreationally and commercially important reservoir species. A significant impact under these thresholds would result in a significant impact under one or more of the Environmental Checklist thresholds identified in Appendix B.

7.4.2 Methods and Approach

LSJR Alternatives

The impact analysis for aquatic resources evaluates expected aquatic species responses to changes in environmental conditions under the alternatives. Impacts were evaluated based on expected changes in the environment relative to the temporal and spatial occurrence of aquatic species, such as Chinook salmon, and applicable life stages for which impact mechanisms and environmental requirements, or tolerances, are sufficiently understood to support an analysis. The methods used in the analysis varied by geographic area, species life stages, and environmental conditions, and depended largely on the available scientific information.

For the purposes of impact assessment, the plan area is divided into the following geographic areas.

- The major reservoirs: New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure.
- The major SJR tributaries: Stanislaus, Tuolumne, and Merced Rivers.
- LSJR (Merced River confluence with the SJR downstream to Vernalis).
- The southern Delta.

In order to analyze the potential impacts from the LSJR alternatives on aquatic resources relative to the thresholds discussed above, the impacts analysis focuses on the effects of changes in flows and reservoir levels and subsequent environmental conditions on aquatic resources. Changes in flow or reservoir levels directly relate to the quantity and quality of available habitat for various life stages of aquatic species and, therefore, also to population distribution, numbers, and dynamics (see Appendix C, *Technical Analysis on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*).

Impacts are evaluated based on predicted effects on indicator species. These species include warmwater reservoir fish (e.g., largemouth bass), coldwater reservoir fish (e.g., rainbow trout), and anadromous fish (fall-run Chinook salmon and steelhead). Indicator species were selected based on their sensitivity to expected changes under the LSJR alternatives in environmental conditions in each of the geographic areas in the plan area. The species were also selected based on their utility in evaluating broader ecosystem and community-level effects of these changes on aquatic resources. Specific indicator species were selected for the analysis because they meet one of the following criteria: (1) they are native species whose populations in California are declining and/or have received a special-status designation by federal or state resource agencies, or (2) they are recreationally important game fish species.

Quantitative evaluations were performed, if appropriate, using data sources, such as modeled diversions, reservoir operations, streamflow, and water temperature. Details of the models and results are presented in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*; Appendix C; Appendix F.1, *Hydrologic and Water Quality Modeling*; and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*. Identified impacts on aquatic resources were evaluated by applying one or more of the following methods.

- **Comparison of quantitative simulations:** Quantitative output from modeling tools was used for direct comparisons between baseline conditions and the LSJR alternatives to identify effects on aquatic resources.
- **Interpretation/extrapolation from quantitative simulations:** Output of quantitative models was interpreted/extrapolated to describe effects on aquatic resources.
- **Interpretation/extrapolation and qualitative assessment:** Existing data and information from previous studies were used to interpret/extrapolate the effects on aquatic resources and to provide a qualitative assessment.

Table 7-7 summarizes the criteria that were evaluated, the habitat variables, biological criteria, and the modeling tools or data used.

Table 7-7. A Summary of the Impact Thresholds, Variables, Criteria, and Data or Methods Used

Impact Thresholds	Environmental or Habitat Variable	Biological Criteria	Data and Method Used
AQUA-1: Changes in availability of warmwater species reservoir habitat resulting from changes in reservoir water levels	• Frequency/magnitude of reservoir drawdowns during primary spawning and rearing periods • Reservoir water surface elevation and area • Area of shallow, vegetated shorelines as a function of reservoir water surface elevation	• Habitat suitability criteria for indicator species (water level fluctuations)	• Hydrologic/reservoir operations model (Water Supply Effects Model [WSE]) • Relationships between reservoir storage and water surface elevation
AQUA-2: Changes in availability of coldwater species reservoir habitat resulting from changes in reservoir storage	• Reservoir storage (end of September)	• Habitat availability for indicator species	• Hydrologic/reservoir operations model (WSE model)
AQUA-3 : Changes in quantity/quality of spawning, rearing, and migration habitat resulting from changes in flow	• Frequency of flows exceeding flow thresholds during primary spawning, rearing, and migration periods • Spawning/rearing habitat availability • Floodplain/riparian habitat availability	• Minimum instream flow thresholds • Habitat quantity/quality (e.g., flow to wetted surface area relationships) • Frequency and extent of floodplain/riparian habitat inundation	• Hydrologic/reservoir operations model (WSE model) • Flow thresholds for floodplain/ riparian inundation
AQUA-4: Changes in exposure of fish to stressful water temperatures resulting from changes in reservoir storage and releases	• Frequency of temperatures exceeding criteria	• Water temperature criteria (e.g., USEPA criteria and LSJR water temperature modeling and analysis reports)	• Hydrologic/reservoir operation model (WSE model) • River temperature model • Temperature exceedances
AQUA-5: Changes in exposure to pollutants resulting from changes in flow (dilution/mobilization effects)	• Pollutant concentrations	• Acute and chronic toxicity levels for indicator species	• Published literature • Qualitative evaluation

Impact Thresholds	Environmental or Habitat Variable	Biological Criteria	Data and Method Used
AQUA-6: Changes in exposure to suspended sediment and turbidity resulting from changes in flow (mobilization)	• Suspended sediment and turbidity levels	• Species tolerance/avoidance thresholds	• Published literature • Qualitative evaluation
AQUA-7: Changes in redd dewatering and fish stranding losses resulting from flow fluctuations	• Magnitude and rate of flow reductions during primary spawning and fry rearing periods	• Habitat suitability criteria (e.g., spawning depth preferences and egg pocket depths)	• Hydrologic/reservoir operations model (WSE model) • Flow rating curves and relationship between river stage and flow
AQUA-8: Changes in spawning habitat quality (spawning gravel) resulting from changes in peak flows	• Frequency and magnitude of spawning habitat maintenance flows	• Flow thresholds for bed mobilization	• Hydrologic/reservoir operations model (WSE model)
AQUA-9: Changes in food availability resulting from changes in flow, nutrient transport, and water quality (food web support)	• Frequency and magnitude of winter-spring flows • Floodplain/riparian habitat inundation • Nutrient mobilization	• Ecosystem functional relationships	• Published literature • Qualitative evaluation
AQUA-10: Changes in predation risk resulting from changes in flow and water temperature	• Flows and water temperatures associated with increased predation	• Habitat suitability criteria for representative predator species	• Published literature • Qualitative evaluation
AQUA-11: Changes in disease risk resulting from changes in flow, water temperature, and water quality	• Water temperatures and pollutants associated with increased incidence of disease	• Temperature thresholds for disease incidence in indicator species	• Published literature • Qualitative evaluation • River temperature model • Temperature exceedances
AQUA-12: Changes in fish transport resulting from changes in flow	• Flows associated with the duration of outmigration •	• Residence time	• Published literature • Qualitative evaluation

Impact Thresholds	Environmental or Habitat Variable	Biological Criteria	Data and Method Used
AQUA-13: Changes in southern Delta and estuarine habitat resulting in changes in SJR inflows and export effects	• Delta inflow • Delta inflow to export ratios	• Frequency and magnitude of changes in inflow and inflow to export ratio • Change in abundance or survival indices for indicator species	• Hydrologic/reservoir operations model (WSE model) • Rules and objectives governing Delta operations • Qualitative evaluation

Additional information regarding specific methodologies used for AQUA-3 (changes in quantity/quality of spawning, rearing, and migration habitat resulting from changes in flow and wetted surface area) and AQUA-4 and AQUA-11 (changes in exposure of fish to stressful water temperatures resulting from changes in reservoir storage and release temperature), as well as for AQUA-6 and 8 (changes in peak flows) is provided below.

Habitat and Wetted Surface Area

Impacts of changes in the quality and quantity of spawning, rearing, and outmigrating habitat on salmonids as a result of changes in flows are determined through applying the State Water Board's Water Supply Effects (WSE) model to LSJR Alternatives 2, 3, and 4 and quantitatively assessing changes to instream flow relative to baseline conditions. Baseline median monthly flows for certain life stages are compared to expected median monthly flows under the LSJR alternatives. Median monthly flows are used because the median flow (i.e., the flow that would be available half of the time over a number of years) is considered a useful benchmark for detecting significant changes in flows that could have long-term effects on habitat availability. Also used to evaluate habitat is the overall cumulative distribution of flows February–June. As described in Appendix F.1, *Hydrologic and Water Quality Modeling*, Section F.1.3, the monthly cumulative distributions of flows provide a good summary of the range of flows that would be observed over a number of years. These distributions summarize the probability of future monthly flow conditions under baseline conditions and LSJR Alternatives 2, 3, and 4. Although the WSE model simulates some relatively large increases or decreases in the monthly river flows, these individual monthly changes would generally balance one another over the 82-year sequence, resulting in much smaller shifts in the cumulative distribution of flows for each month or for the seasonal flow volume distribution (February–June). The comparison of cumulative distributions of flows, in conjunction with the individual monthly changes in flow, provides an appropriate measure of hydrologic changes resulting from the LSJR alternatives and a useful measure of both the monthly and broader seasonal differences in flow that could affect habitat availability for specific life stages.

Changes in habitat availability were also evaluated on the basis of changes in wetted surface area (i.e., surface area adjacent or within a river channel that is inundated by water) of the river at different flows. Wetted surface area serves as a general indicator of habitat availability and is especially useful for evaluating potential changes in the availability of overbank or floodplain habitat, which generally provides high-quality rearing habitat for salmonids and other native fishes (e.g., Sacramento splittail). DFG created wetted surface area relationships using cross section data for the major SJR tributaries to characterize changes in habitat availability at specific river flows (DFG 2010b). For the major SJR tributaries, DFG analyzed cross-sectional data developed by USACE and calculated the estimated the relationships between wetted surface area and flow from the first upstream barrier downstream to each tributary's LSJR confluence. This information was used in conjunction with WSE model results to evaluate effects of flow on habitat in AQUA-3.

Peak Flows

As described in Chapter 3, *Alternatives Description*, the percent of unimpaired flow requirement, as specified by a particular LSJR alternative, would cease to apply during high flows or flooding to preserve public health and safety. The State Water Board would coordinate with federal, state, and local agencies to determine when it is appropriate to waive the requirements. Action stages for the major SJR tributaries are identified in Chapter 6, *Flooding, Sediment, and Erosion* (Table 6-4). These action stages are a reasonable proxy for the purposes of the SED analysis to describe when the unimpaired flow requirements might be waived as a result of public health and safety concerns. The WSE modeling performed for this chapter and other chapters uses monthly flow limits derived from observed flows above which the unimpaired flow requirement no longer applies. The modeling and incorporation of the monthly flow limits is further discussed in Appendix F.1, *Hydrologic and Water Quality Modeling*, and Appendix L, *Sensitivity Analyses*, compares the model results to those using the National Oceanic and Atmospheric Administration (NOAA) action stage. This information was incorporated in AQUA-6 and AQUA-8.

Water Temperature

Impacts of changes in water temperatures on Chinook salmon and Central Valley steelhead were evaluated using the San Joaquin River Basin-Wide Water Temperature Model (temperature model) developed by Resource Management Associates for CALFED using the USACE HEC-5Q simulation model (CalFED 2009). The temperature model provides a basin-wide evaluation of temperature response at 6-hour intervals for alternative conditions. The geographic extent of the model includes the Merced, Tuolumne, and Stanislaus River systems from their confluences with the LSJR to just upstream of the major reservoirs (Lake McClure, New Don Pedro Reservoir, and New Melones Reservoir, respectively). The downstream extent of the model is Mossdale on the LSJR. See Appendix F.1, *Hydrologic and Water Quality Modeling*, for a full discussion of this model and its application.

The State Water Board adjusted the temperature model by replacing several data inputs to the model using outputs from CALSIM II and the WSE model. All results were based on the frequency of modeled daily maximum water temperatures derived from the modeling results. The potential for significant impacts was determined through application of a daily water temperature model to LSJR Alternatives 2, 3, and 4 and quantitative assessment of changes in the frequency of potentially stressful water temperatures relative to baseline conditions. The analysis focuses on the same locations (compliance points), months, and critical life stages used for evaluating water management alternatives for the development of the temperature model (CalFED2009). These locations and months generally coincide with the occurrence of key life stages and maximum water temperatures potentially encountered by species within each geographic area and simulation year. This information is used to evaluate effects of temperature for LSJR Alternatives 2, 3, and 4 in AQUA-4 and AQUA-11.

SDWQ Alternatives

In general, most fish species identified in Table 7-2 spend the majority or a significant portion of their life history in the Bay-Delta and are accustomed to variations in salinity. Therefore, all indicator and representative species would be able to tolerate salinity changes within the 0.2 dS/m and 1.4 dS/m range, as these salinity levels are within historical salinity conditions of the southern Delta. As described in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*, reservoir releases are currently increased in order to meet the existing salinity objective of maintaining EC below 1.000 dS/m (1,000 µS/cm) for September–March and below 0.700 dS/m (700 µS/cm) for April–August in the SJR at Vernalis. The Vernalis EC objective would not change from the existing EC objective and is the same for all SDWQ alternatives. Changes in EC that may occur downstream of Vernalis are dependent on conditions at Vernalis and within the Delta. As modeled for baseline and the LSJR alternatives, additional water is not released from upstream reservoirs to meet EC objectives farther downstream in the Delta for the SJR at Brandt Bridge and Old River at Tracy Boulevard. Under the SDWQ alternatives, there would be no change in operations affecting Delta salinity relative to baseline, and merely changing the water quality objectives at these two locations is not expected to affect water quality in the Delta relative to baseline. Therefore, the historic range of salinity (between 0.200 and 1.200 dS/m [200 and 1,200 µS/cm]) is expected to remain unchanged under SDWQ Alternative 2 and SDWQ Alternative 3. Consequently, there would be no impact on aquatic resources associated with the SDWQ alternatives. The SDWQ alternatives are therefore not discussed further in the impact analyses.

7.4.3 Impacts and Mitigation Measures

AQUA-1: Changes in availability of warmwater species reservoir habitat resulting from changes in reservoir water levels

The LSJR alternatives could impact recreationally important warmwater reservoir species due to changes in the availability of habitat resulting from changes in reservoir levels associated with instream flow release adjustments that would be implemented under the LSJR alternatives. The major SJR tributary reservoirs (New Melones, New Don Pedro, and Lake McClure) support several warmwater species that inhabit surface waters and shallow areas near shore (the littoral zone) (USBR 2011). Water level fluctuations resulting from reservoir operations (for irrigation, power generation, reservoir recharge, flood control, downstream flow releases, etc.) can impact habitat quantity and quality, particularly in the shallow-water areas.

Water level fluctuations have a direct effect on largemouth bass and other warmwater fish that construct their nests in shallow water habitat (USBR 2011). Nearshore spawning species can be affected when reservoir levels rise with snowmelt capture. Rising water levels result in increased water depth of largemouth bass nests, exposing them to water temperatures that may be too cold for the developing eggs (USBR and DWR 2003). Cold water slows the development times of the eggs and larvae and, because eggs and larvae are highly vulnerable to predation or infection by fungi, a longer development time greatly reduces survival (USBR 2011). Extensive drawdown of reservoir water levels also results in declines in reservoir fish species populations through direct effects on spawning success (due to nest abandonment or stranding) and habitat availability for spawning and rearing life stages. The suitability of shallow-water habitat for largemouth bass spawning and rearing can also be affected by changes in reservoir water temperatures associated with water level fluctuations. Impacts of water temperatures resulting from reservoir water storage and release operations are addressed in AQUA-4.

Water level fluctuations also inhibit development of shoreline vegetation. Shoreline vegetation provides cover and feeding substrates for many warmwater fish species in reservoirs. The vegetation also stabilizes shoreline sediments, reducing erosion and sedimentation. Consequently, increases in water level fluctuations could affect most fish species in the reservoir indirectly through effects on vegetation (USBR and DWR 2003).

To assess impacts on warmwater fish species due to changes in habitat resulting from changes in reservoir levels under the LSJR alternatives, average changes to water levels for individual months April–September were evaluated. Evaluation of water level fluctuations was limited to April–September because this is the primary spawning, incubation, feeding, and growth period for warmwater species and, as a result, the period of time that warmwater fish would be affected by reservoir level fluctuations. A change in elevation of 15 feet on a monthly average during this period was considered to result in a substantial reduction in available habitat for warmwater fish, including largemouth bass (PG&E 2000; USBR 2011). This elevation change was chosen because typical spawning depths for largemouth bass range from surface to about 15 feet (USBR 2011), and a drop in elevation of 15 feet during warmwater fish spawning season could result in eggs becoming dewatered. A 10 percent increase in occurrence of 15 foot fluctuations (Tables 7-8a, b, and c) from baseline conditions was considered to be significant. A decrease in occurrence of water level fluctuations would result in a more stable environment for the spawning and rearing life stage of warmwater species and, consequently, would not be considered a significant impact.

Table 7-8a. Percent of Time Greater than 15 foot Fluctuation from Previous Month for New Melones Reservoir (Average)

	APR	MAY	JUN	JUL	AUG	SEP
Baseline	15	35	20	2	6	0
LSJR Alternative 2						
% Fluctuation	5	29	13	13	15	0
Difference between Baseline and LSJR Alternative 2	-10	-6	-7	11	9	0
LSJR Alternative 3						
% Fluctuation	6	17	10	7	6	0
Difference between Baseline and LSJR Alternative 3	-9	-18	-10	5	0	0
LSJR Alternative 4						
% Fluctuation	4	26	10	4	1	0
Difference between Baseline and LSJR Alternative 4	-11	-9	-10	2	-5	0

Note: negative numbers indicate a reduction in 15 foot fluctuations.

Any values highlighted in gray represent an exceedance of the 10% threshold.

Table 7-8b. Percent of Time Greater than 15 foot Fluctuation from Previous Month for New Don Pedro Reservoir (Average)

	APR	MAY	JUN	JUL	AUG	SEP
Baseline	5	22	29	35	38	0
LSJR Alternative 2						
% Fluctuation	4	30	12	32	33	1
Difference between Baseline and LSJR Alternative 2	-1	9	-17	-4	-5	1
LSJR Alternative 3						
% Fluctuation	1	18	13	18	7	1
Difference between Baseline and LSJR Alternative 3	-4	-4	-16	-17	-30	1
LSJR Alternative 4						
% Fluctuation	0	29	17	1	0	4
Difference between Baseline and LSJR Alternative 4	-5	7	-12	-34	-38	4

Note: negative numbers indicate a reduction in 15 foot fluctuations.

Table 7-8c. Percent of Time Greater than 15 foot Fluctuation from Previous Month for Lake McClure (Average)

	APR	MAY	JUN	JUL	AUG	SEP
Baseline	39	68	22	76	94	15
LSJR Alternative 2						
% Fluctuation	39	61	16	66	84	6
Difference between Baseline and LSJR Alternative 2	0	-7	-6	-10	-10	-9
LSJR Alternative 3						
% Fluctuation	22	48	20	44	78	2
Difference between Baseline and LSJR Alternative 3	-17	-21	-2	-32	-16	-12
LSJR Alternative 4						
% Fluctuation	10	50	17	33	70	1
Difference between Baseline and LSJR Alternative 4	-29	-18	-5	-43	-24	-13
Note: negative numbers indicate a reduction in 15 foot fluctuations.						

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

LSJR Alternative 2 would result in the changes in reservoir elevations shown in Tables 7-8a, b, and c. LSJR Alternative 2 is expected to have less-than-significant impacts on the availability of warmwater species reservoir habitat resulting from changes in reservoir water levels. New Melones is the only reservoir for which changes in reservoir elevation exceeded the identified threshold above (greater than a 10 percent increase in the occurrence of 15 foot fluctuations in reservoir levels). In New Melones Reservoir in July, LSJR Alternative 2 would result in a fluctuation of 11 percent, exceeding the 10 percent threshold by 1 percent. This minimal exceedance in the threshold is not expected to result in a significant impact on warmwater reservoir fish because the fluctuations in July would be offset by generally more stable conditions April–June (the largemouth bass spawning season). On average, monthly variation in reservoir water surface elevation would decrease by 6–10 percent during the spring spawning season and increase by 9–11 percent during the summer rearing season. While less stable summer water surface elevations may reduce survival and abundance of juvenile warmwater reservoir fish, these effects would be offset by more stable water levels during spring that are expected to increase spawning success of largemouth bass and other warmwater species dependent on nearshore habitat for spawning and early rearing. A greater number of juvenile fish would be produced and any loss of juveniles due to reservoir fluctuations would be comparable to baseline conditions. Impacts would be less than significant.

In New Don Pedro Reservoir in May, there would be water level fluctuations of more than 15 feet under LSJR Alternative 2; however, these fluctuations would not exceed the 10 percent threshold when compared to baseline (Table 7-8b). Thus, these fluctuations are not expected to result in significant impacts on nearshore spawning species. In Lake McClure, water level fluctuations of more than 15 feet did not occur more frequently under LSJR Alternative 2 and, thus, are not expected to result in significant impacts on warmwater fish species. Impacts would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

LSJR Alternative 3 would result in the changes in reservoir elevations shown in Tables 7-8a, b, and c). LSJR Alternative 3 is expected to have less-than-significant impacts on the availability of warmwater species reservoir habitat resulting from changes in reservoir water levels. Water level fluctuations of more than 15 feet are expected at New Melones Reservoir in July. However, these fluctuations would not exceed the 10 percent threshold when compared to baseline. Furthermore, these changes in reservoir water surface elevation would also result in generally more stable conditions during the largemouth bass spawning season (April–June); therefore, significant impact on warm water species are not expected. Water level fluctuations of more than 15 feet are not expected to occur more frequently at Lake McClure under LSJR Alternative 3 compared to baseline. Water levels fluctuations of more than 15 feet only occur 1 percent more often in in September for New Don Pedro Reservoir. Impacts would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

LSJR Alternative 4 would result in the changes in reservoir elevations shown in Tables 7-8a, b, and c. LSJR Alternative 4 is expected to have less-than-significant impacts on the availability of warmwater species reservoir habitat resulting from changes in reservoir water levels. Water level fluctuations of more than 15 feet are expected in New Melones Reservoir in July and New Don Pedro Reservoir in May and September. However, these fluctuations would not exceed 10 percent when compared to baseline and, therefore, are considered less than significant. Average monthly fluctuations exceeding 15 feet would occur less frequently when compared to baseline for all months at Lake McClure (Table 7-8c). Impacts would be less than significant.

AQUA-2: Changes in availability of coldwater species reservoir habitat resulting from changes in reservoir storage

The LSJR alternatives could impact recreationally important coldwater reservoir species (i.e. rainbow trout, kokanee) due to changes in the availability of coldwater habitat (hypolimnetic zone) caused by changes in reservoir levels. Changes in reservoir storage resulting from the LSJR alternatives could change the volume of cold water available in reservoirs to support reservoir coldwater fish species. The hypolimnetic zone forms in the deepest levels of reservoirs during thermal stratification that occurs during spring, summer, and early fall months. Surface water warmed by the air and solar radiation during the spring and summer floats on top of the cooler, denser water of the hypolimnetic zone. The depth of the warmer surface water layer can vary but is generally 15–30 feet deep in most California reservoirs (including New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure) (EA EST 1999). Any impacts on coldwater reservoir species habitat resulting from changes in reservoir storage would occur below this range. Reservoir drawdown affects temperature stratification of the reservoirs, thereby decreasing usable habitats for coldwater reservoir fishes.

In order to evaluate impacts on cold water storage and resulting habitat for coldwater fish species, end-of-September storage levels in New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure were compared to baseline. The end-of-September storage was used as a basis for comparison because it typically represents the month at the end of the summer and irrigation season when reservoir storage and coldwater habitat availability are at their lowest levels. While the amount of actual habitat cannot be quantified, the end-of-September storage levels are utilized as an indicator of the amount of summer habitat available to coldwater reservoir species. In the absence of quantitative information relating reservoir storage to effects on habitat availability for coldwater fish, the potential for significant impacts was assumed to exist if the median reservoir storage level in September is reduced by 10 percent or more relative to baseline. This is considered a reasonable threshold given the large seasonal and annual fluctuations in reservoir storage experienced by fish in reservoirs and the dependence of the reservoir fisheries on hatchery trout and salmon stocking programs. Tables 7-9a, b, and c, below identify the changes in end-of-September elevation for the three reservoirs compared to baseline.

Table 7-9a. Percent Change in End-of-September Elevations from Baseline for New Melones Reservoir

	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
Minimum	0	1	2
10%	1	-2	-2
20%	1	-1	1
30%	2	0	0
40%	1	-1	0
50%	2	0	1
60%	2	1	1
70%	3	0	0
80%	3	1	1
90%	1	-1	0
Maximum	0	0	0

Note: Negative percentages indicate a decrease in storage levels relative to baseline conditions.

Table 7-9b. Percent Change in End-of-September Elevations from Baseline for New Don Pedro Reservoir

	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
Minimum	0	2	5
10%	1	0	0
20%	2	2	1
30%	2	1	0
40%	1	0	-1
50%	2	0	0
60%	1	0	0
70%	0	-1	-1
80%	0	0	1
90%	0	1	1
Maximum	1	1	1

Note: Negative percentages indicate a decrease in storage levels relative to baseline conditions.

Table 7-9c. Percent Change in End-of-September Elevations from Baseline for Lake McClure

	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
Minimum	-2	-2	2
10%	8	7	6
20%	5	5	3
30%	4	2	1
40%	2	1	-1
50%	2	1	-1
60%	0	-1	-3
70%	0	-1	-2
80%	0	0	-1
90%	1	1	1
Maximum	3	3	2

Note: Negative percentages indicate a decrease in storage levels relative to baseline conditions.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

Median September storage levels are not expected to decrease, but rather increase by 2 percent relative to baseline for all three reservoirs (Tables 7-9a, b, and c). These percentages would correspond to a slight increase in the amount of summer habitat available to coldwater reservoir species. Impacts would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Median September storage levels are not expected to decrease, but rather increase slightly (by 1 percent) at Lake McClure, and remain similar to baseline at New Melones and New Don Pedro Reservoirs (Tables 7-9a, b, and c). The 1 percent increase at Lake McClure would correspond to a slight increase in the amount of summer habitat available to coldwater reservoir species. Therefore, any impact on the change in availability of coldwater species reservoir habitat resulting from changes in reservoir storage would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Median September storage levels are expected to increase slightly (by 1 percent) at New Melones Reservoir, remain similar to baseline at New Don Pedro Reservoir, and decrease slightly (by 1 percent) at Lake McClure (Tables 7-9a, b, and c). The 1 percent change at New Melones Reservoir and Lake McClure would correspond, respectively, to a slight increase and decrease in the amount of summer habitat available to coldwater reservoir species. These changes are not expected to result in substantial changes in the availability of coldwater reservoir species habitat. Therefore, any impact on the availability of coldwater species reservoir habitat resulting from changes in reservoir storage would be less than significant.

AQUA-3: Changes in quantity/quality of spawning, rearing, and migration habitat resulting from changes in flow

The LSJR alternatives could affect the quantity and quality of spawning, rearing, and migration habitat due to changes in flow. Relative to environmental impacts, such changes could impact indicator species and their habitats and sensitive natural communities. These impacts were assessed by evaluating the impact on the primary indicator species (Chinook salmon and steelhead) for each of the LSJR alternatives. The environmental requirements of these species are discussed in more detail in Section 7.2.1.

In general, impacts related to changes to flows on recreationally and commercially important nonnative fishes are not likely to be significant because their populations typically are large and resilient. Also, the potential for population-level impacts is low within the range of flows provided by the LSJR alternatives because these fish populations are regularly exposed to a similar flow range under baseline. Accordingly, impacts on nonnative recreational fish species are not evaluated further.

Impacts on the quality and quantity of spawning, rearing, and outmigrating habitat for salmonids due to changes in flows were evaluated by comparing changes in flows and wetted surface areas under the alternatives to baseline. These changes were determined through application of the State Water Board's Water Supply Effects (WSE) model to each of the alternatives and quantitative assessment of changes to instream flow and wetted surface area relative to baseline. Modeled median monthly flows for each of the LSJR alternatives were compared against modeled median baseline flows. Generally, increases in flows and wetted surface areas are expected to result in improved conditions for native aquatic species and decreases in flows and wetted surface areas are expected to result in degraded conditions (see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*). The determination of significant impacts for LSJR Alternatives 2, 3, and 4 was based on a reduction in monthly median flows of 10 percent. For the purposes of impact assessment, it is assumed that a change in median flows of 10 percent or more would be sufficient to result in a measurable or significant long-term response in populations. LSJR Alternatives 2, 3, and 4 provide for adaptive management of flows to maximize protection of fish and wildlife. Accordingly, where reductions in median monthly flows were greater than 10 percent, median flows for the entire February–June period were evaluated to determine impacts. Because LSJR Alternatives 2, 3, and 4 provide for adaptive management , it was assumed that if flows were reduced in any one month that as long as the median flow for the entire February–June period were not less than baseline conditions, flows would be adaptively managed to avoid impacts fish and wildlife. Evaluation of the cumulative distribution for the total flow quantities is presented in Appendix F.1, *Hydrologic and Water Quality Modeling*.

Expected median monthly flows under baseline conditions and the LSJR alternatives are presented in Figures 7-4 through 7-7 for the SJR and its major tributaries, and expected changes in wetted surface area are presented in Table 7-10. Baseline and the LSJR alternatives are then summarized as they relate to spawning, rearing, and outmigrating habitat. Because the SJR at Vernalis does not provide summer rearing or spawning and incubation habitat, the SJR is not included in the assessment for these habitats. Data for this analysis has been included in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*; Appendix F.1; and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*.

Table 7-10. Percent Change in Median Wetted Surface Area for LSJR Alternatives 2, 3, and 4 Relative to Baseline

% Change in Median Surface Areas												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Stanislaus												
LSJR Alternative 2	0	0	0	0	5	-1	-15	-10	-3	0	0	0
LSJR Alternative 3	0	0	0	0	5	2	-5	5	8	0	0	0
LSJR Alternative 4	0	0	0	0	7	7	5	17	18	0	0	0
Tuolumne												
LSJR Alternative 2	0	0	1	1	2	9	-11	4	21	0	0	0
LSJR Alternative 3	0	0	0	1	14	16	9	40	56	0	0	0
LSJR Alternative 4	0	0	0	1	27	28	28	54	91	0	0	0
Merced												
LSJR Alternative 2	1	0	0	2	0	-8	-12	19	18	0	0	0
LSJR Alternative 3	0	0	1	1	3	12	17	73	59	0	0	0
LSJR Alternative 4	0	0	0	0	12	31	47	101	99	0	0	0

Note: Gray indicates a decrease greater than 10%.

Baseline

Modeled baseline flows and associated habitat conditions for the indicator species (fall-run Chinook salmon and steelhead) and their key life stages are summarized below. As described in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*, these flows reflect current flow management operations and regulatory requirements in each of major tributaries, including Stanislaus River flow requirements in accordance with the NMFS BO.

Juvenile Rearing and Outmigration

In the Stanislaus River, median values of modeled baseline flows at Goodwin Dam ranged from 364 to 1,458 cfs February–June, representing 29–45 percent of median unimpaired spring flows (Figure 7-4a). This corresponds to a cumulative distribution of flow (i.e., the range of flows distributed between the minimum flow as measured by thousand acre-feet [TAF] and the maximum flow over the entire 82-year historical modeling period) of approximately 40 percent of the average unimpaired flow February–June (Figure 7-4b). With continuation of the NMFS BO, USBR is required to make releases from Goodwin Dam according to the Stanislaus River flow schedule discussed in Section 7.2.2 of this chapter. The flow schedule includes maintaining minimum base flows and adaptively managing pulse flows during the late winter and spring (February–June) to maintain steelhead habitat and provide migratory cues to facilitate smolt outmigration. Channel forming and maintenance flows in the 3,000–5,000 cfs range are also required in above-normal and wet years to maintain spawning and rearing habitat quality. In the Tuolumne River, median values of modeled baseline flows at La Grange Dam ranged from 75 to 1,080 cfs February–June, representing 1–24 percent of median unimpaired spring flows (Figure 7-5a). This represents a cumulative distribution of flow approximately 24 percent of the average unimpaired February–June flow (Figure 7-5b). Based on the general shape of wetted-area versus flow curves for the Tuolumne River, floodplain inundation and potential benefits associated with access to floodplain habitat appear to occur at flows greater than 4,000 cfs (Figure 7-2), which would be expected 12 percent of the time in February and 13 percent of the time in March under baseline conditions.

In the Merced River, median values of modeled baseline flows at Crocker-Huffman Dam ranged from about 286 to 707 cfs February–June, representing 12–49 percent of median unimpaired spring flows (Figure 7-6a). This represents a cumulative distribution of flow of approximately 27 percent of the average unimpaired flow February–June (Figure 7-6b). Based on the general shape of wetted-area versus flow curves for the Merced River, floodplain inundation and potential benefits associated with access to floodplain habitat appears to occur at flows greater than 3,000 cfs (Figure 7-3), which would be expected 11 percent of the time in February and 6 percent of the time in March under baseline conditions.

In the SJR, median values of modeled baseline flows at Vernalis ranged from about 2,379 to 5,213 cfs February–June, representing 15–54 percent of median unimpaired spring flows (Figure 7-7a). This represents a cumulative distribution of flow of approximately 29 percent of the average unimpaired February–June (Figure 7-7a) flow. March and April flows at Vernalis, which approximate the period in which historical flows were most highly correlated to adult recruitment in the three SJR tributaries 1980–2008 (Mesick unpublished data), was on average approximately 6,500 cfs. Because flow in the SJR must reach between 10,000 and 25,000 cfs for floodplain inundation to result (CDBEC 2010), floodplain inundation would not occur at flows of 6,500 cfs.

Summer Rearing

In the Stanislaus River, median values of modeled baseline flows at Goodwin Dam during the Chinook salmon and steelhead summer rearing season in June, July, and August were 449, 322, and 283 cfs, respectively, representing 16, 58, and 186 percent of median unimpaired flows, respectively (Figure 7-4a). Under the NMFS BO, USBR is required to make releases from Goodwin Dam to meet minimum flows according to the flow schedule described in Section 7.2.2 of this chapter. The flow schedule includes maintaining minimum flows and adaptively managing the cold water supply in New Melones Reservoir to provide suitable temperatures for steelhead rearing through the summer.

In the Tuolumne River, the median value of modeled baseline flows at La Grange Dam during the Chinook salmon and steelhead summer rearing season in June, July, and August was 75 cfs, representing 1, 7, and 26 percent of median unimpaired flows in these months, respectively (Figure 7-5a).

In the Merced River, median values of modeled baseline flows at Crocker-Huffman Dam during the Chinook salmon and steelhead summer rearing season in June, July, and August were 286, 233, and 200 cfs, respectively, representing 12, 44, and 166 percent of median unimpaired flows in those months, respectively (Figure 7-6a).

Adult Migration

October is a key month for attraction and upstream migration of adult Chinook salmon and steelhead in the rivers. In the Stanislaus River, the median value of modeled baseline flows at Goodwin Dam in October was 880 cfs, representing 686 percent of the median unimpaired flow (Figure 7-4a). Modeled baseline flows reflect current flow management operations and regulatory requirements, including continuation of pulse flows in October to attract adult steelhead in accordance with the NMFS BO.

In the Tuolumne River, the median value of modeled baseline flows at La Grange Dam in October was 215 cfs, representing 121 percent of the median unimpaired flow (Figure 7-5a).

In the Merced River, the median value of modeled baseline flows at Crocker-Huffman Dam in October was 371 cfs, representing 458 percent of the median unimpaired flow (Figure 7-6a).

In the SJR, the median October flow at Vernalis is 2,730 cfs, which is approximately 450 percent of the median unimpaired flow.

Spawning and Incubation

In the Stanislaus River, median values of modeled baseline flows at Goodwin Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were 880 cfs in October, 250 cfs in November, 255 cfs in December, 226 cfs in January, 364 cfs in February, and 663 cfs in March (Figure 7-4a). The median baseline flows ranged from 29 percent of median unimpaired flow in February to 686 percent of median unimpaired flow in October.

In the Tuolumne River, median values of modeled baseline flows at La Grange Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were 215 cfs in October, 180 cfs in November, 240 cfs in December, 300 cfs in January, 300 cfs in February, and 353 cfs in March (Figure 7-5a). The median baseline flows ranged from 14 percent of median unimpaired flow in February and March to 121 percent of median unimpaired flow in October.

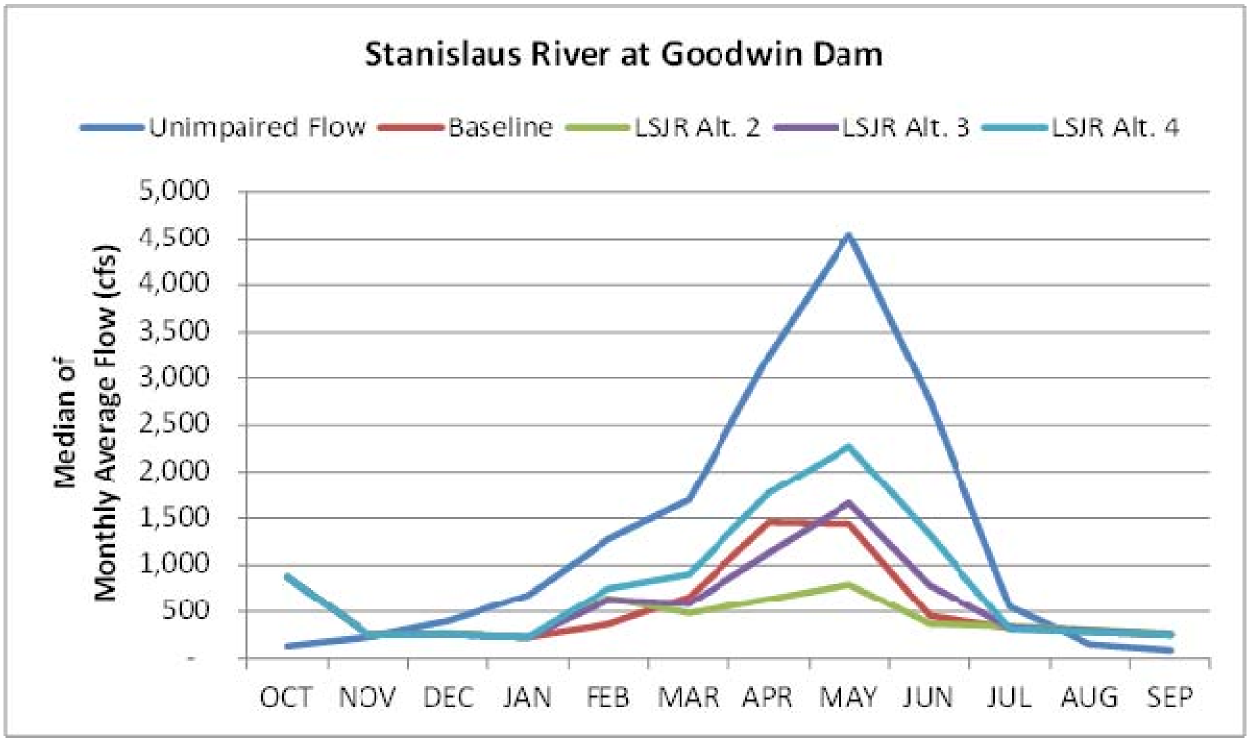


Figure 7-4a. Median Monthly Flows in the Stanislaus River at Goodwin Dam for Baseline, LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) and Unimpaired Flow for 1922–2003 (cubic feet per second [cfs])

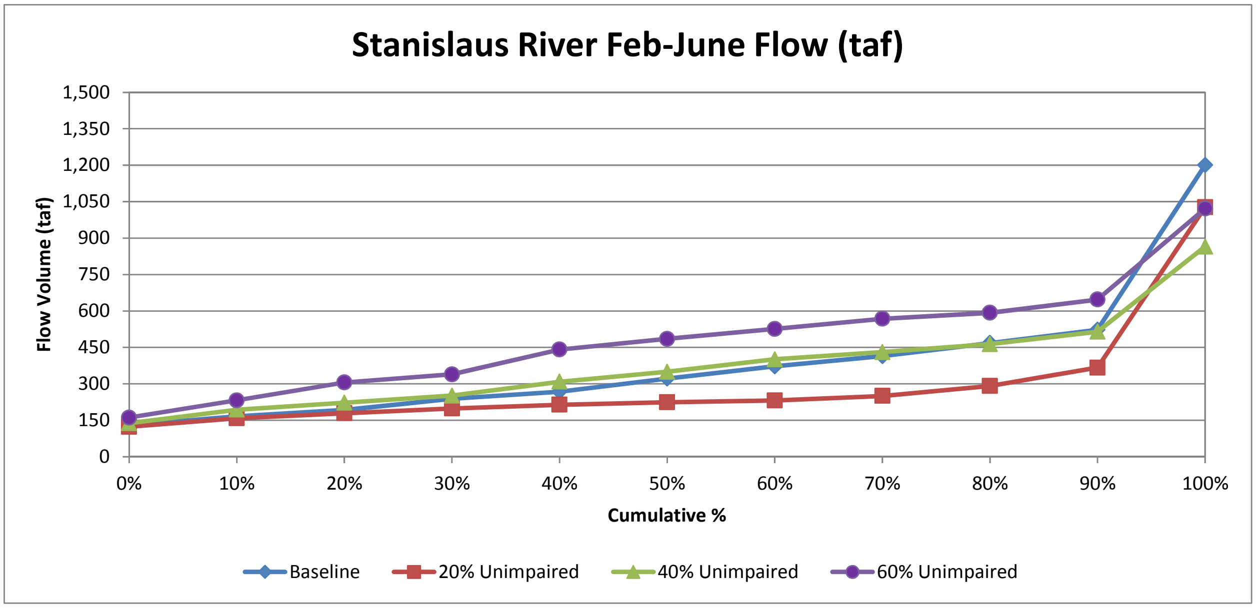


Figure 7-4b. Cumulative Distributions of the Stanislaus River February–June Flow Volumes (thousand acre-feet [taf]) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the Baseline for 1922–2003

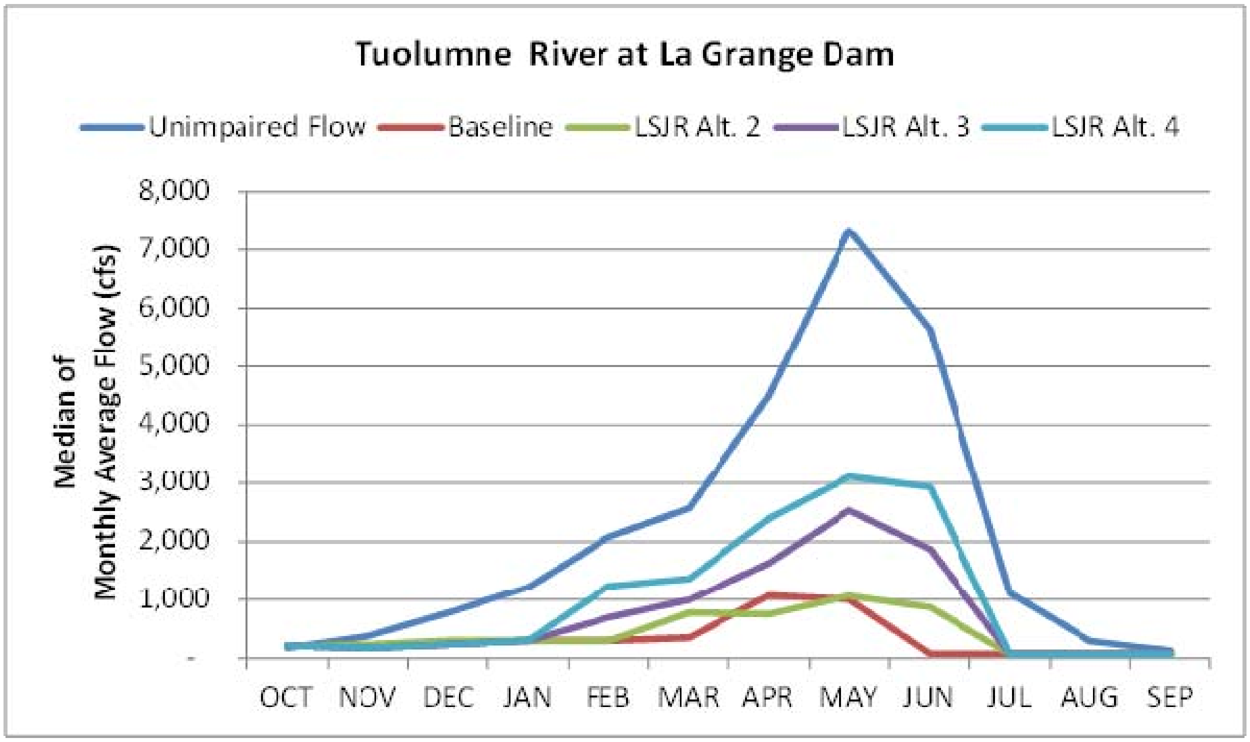


Figure 7-5a. Median Monthly Flows in the Tuolumne River at La Grange Dam for Baseline, LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow), and Unimpaired Flow (cubic feet per second [cfs])

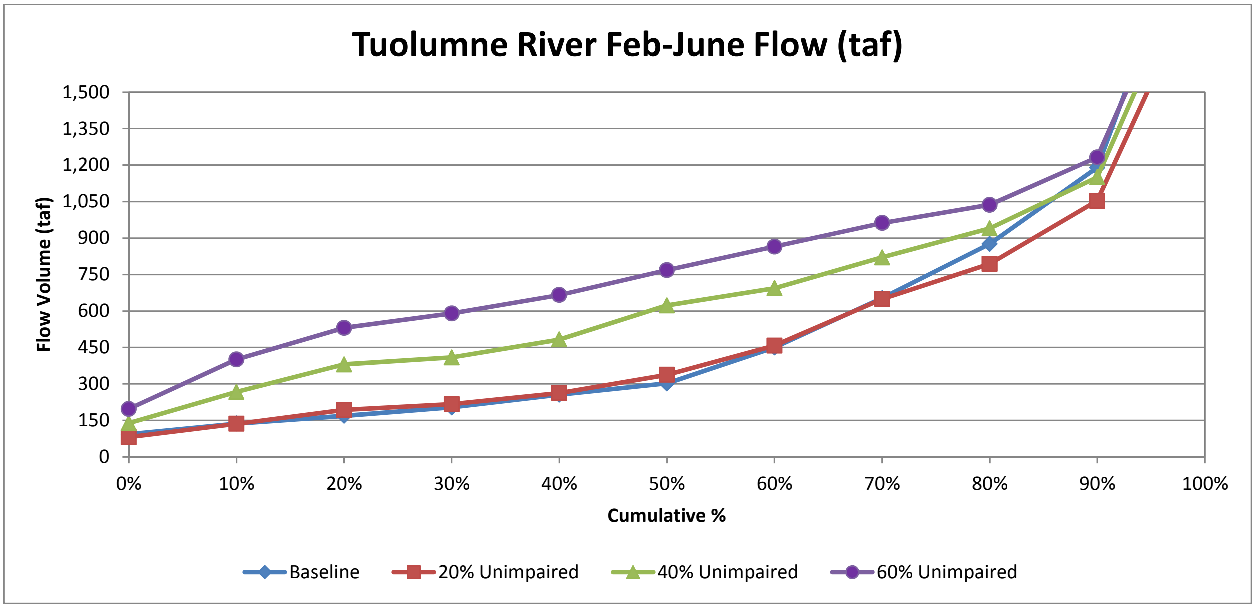


Figure 7-5b. Cumulative Distributions of the Tuolumne River February–June Flow Volume (thousand acre-feet [taf]) for Baseline and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

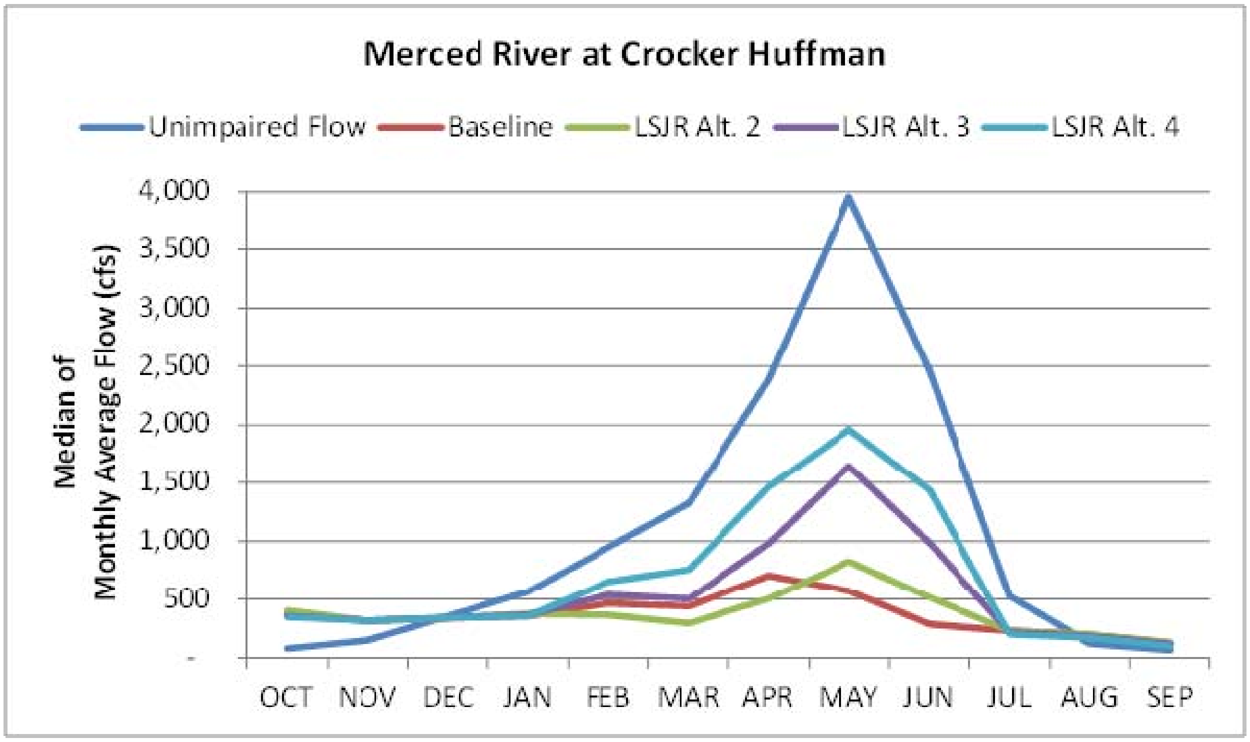


Figure 7-6a. Median Monthly Flows in the Merced River at Crocker-Huffman Dam for Baseline, LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow), and Unimpaired Flow for 1922–2003 (cubic feet per second [cfs])

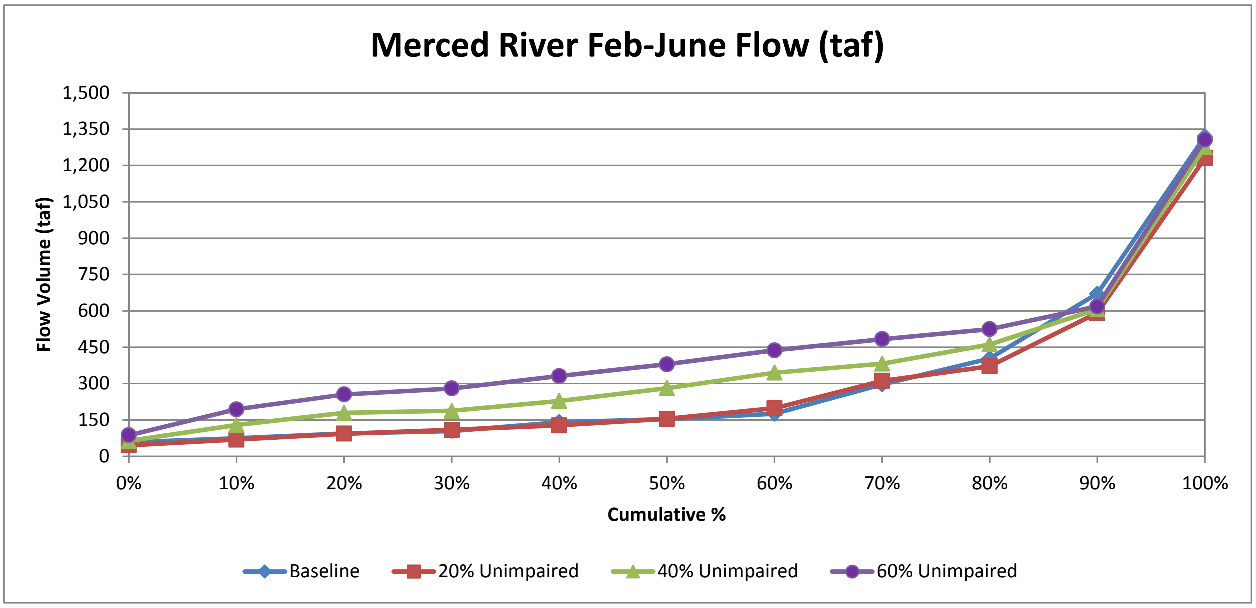


Figure 7-6b. Cumulative Distributions of the Tuolumne River February–June Flow Volume (thousand acre-feet [taf]) for Baseline and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

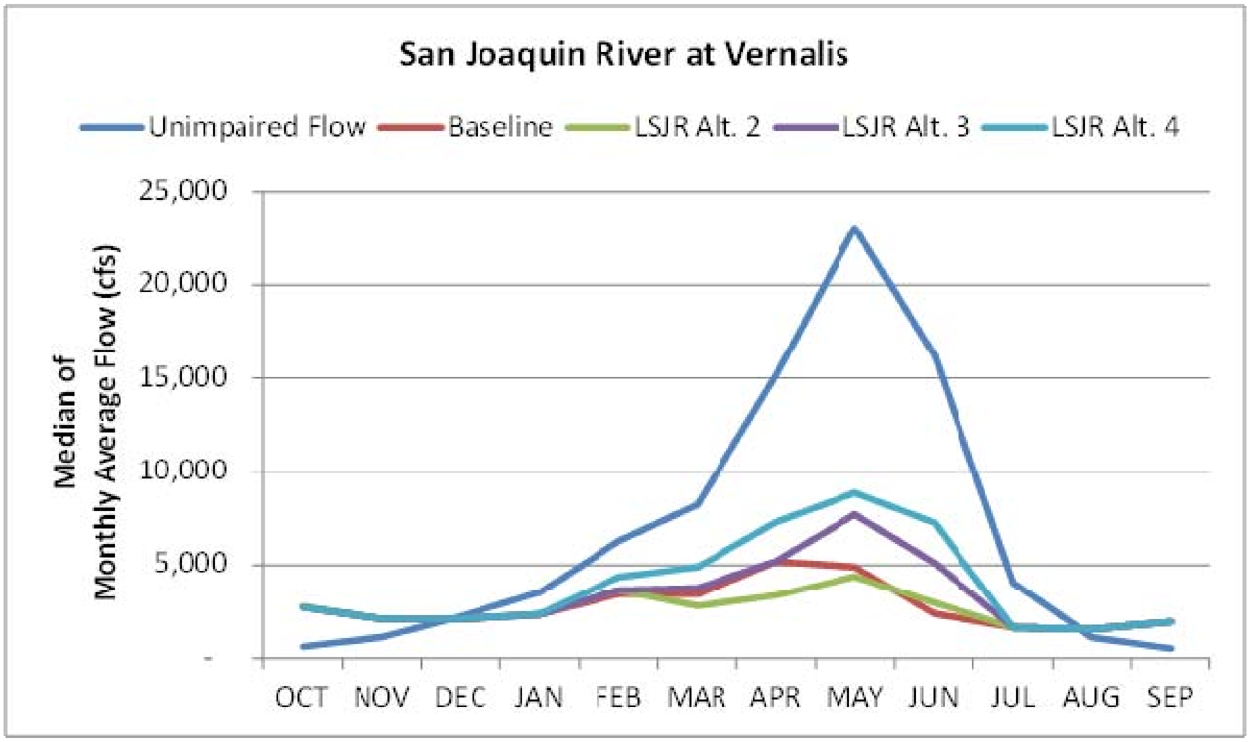


Figure 7-7a. Median Monthly Flows in the San Joaquin River at Vernalis for Baseline, LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow), and Unimpaired Flow for 1922–2003 (cubic feet per second [cfs])

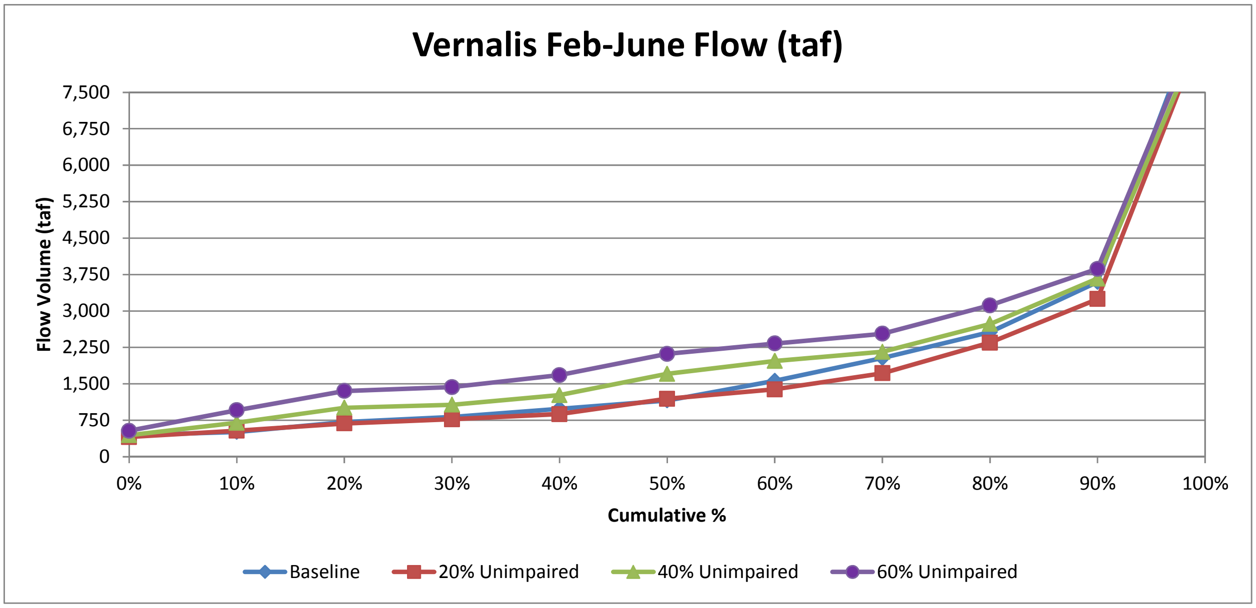


Figure 7-7b. Cumulative Distributions at Vernalis February–June Flow Volume (thousand acre-feet [taf]) for Baseline and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow), and Unimpaired Flow for 1922–2003

In the Merced River, median values of modeled baseline flows at Crocker-Huffman Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were 371 cfs in October, 315 cfs in November, 337 cfs in December, 359 cfs in January, 467 cfs in February, and 443 cfs in March (Figure 7-6a). The median baseline flows ranged from 34 percent of median unimpaired flow in March to 458 percent of median unimpaired flow in October.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

Juvenile Rearing and Outmigration

Under LSJR Alternative 2, median flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead rearing and outmigration period ranged from 358 to790 cfs February–June, representing 13–54 percent of median unimpaired flows in these months (Figure 7-4a). This corresponds to a cumulative distribution of flow of approximately 28 percent of the average unimpaired flow February–June. Relative to median baseline flows, LSJR Alternative 2 would result in a 48 percent increase in flows in February, an 8 percent decrease in flows in March, a 56 percent decrease in flows in April, a 45 percent decrease in flows in May, and a 20 percent decrease in June. These modeling results indicate that LSJR Alternative 2 would substantially reduce the magnitude and frequency of spring outmigration flows. Higher flows in February would potentially increase the availability (wetted area) of rearing habitat by 5 percent (Table 7-10), but the potential negative effects of reduced flow in April and May on smolt survival would likely override any positive effects of higher flows earlier in the season. Reduced flows in the Stanislaus River relative to baseline reflect the relatively high baseline flows in April, May, and June resulting from implementation of the mandated pulse flows required by the NMFS BO. As shown in Figure 7-4b, the total amount of water that would be released in the February–June period under LSJR Alternative 2 is substantially lower than the volume of water released under baseline conditions in the majority of years, which is approximately 40 percent of the average unimpaired flow. Consequently, there would likely be insufficient water available in most years to adaptively manage flows to improve spring flow for outmigrating salmonids. Therefore, flow impacts on rearing and outmigrating juvenile salmon and steelhead in the Stanislaus River under LSJR Alternative 2 would be significant.

The NMFS BO flows required on the Stanislaus River are included in the baseline. However, these flows are not included in the WSE modeling of the LSJR alternatives. Instead, the WSE modeling of the LSJR alternatives assumes that a certain percent (i.e., 20, 40, or 60 percent) of unimpaired flow would be met, which may be lower or higher than the NMFS BO flows. As a result, when the WSE model results are compared to baseline, the modeling shows some flow reductions in the Stanislaus River. However, because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the impacts of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses*. Consequently, impacts would be significant as described above.

Under LSJR Alternative 2, median flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead rearing and outmigration period were 293 cfs in February, 780 cfs in March, 764 cfs in April, 1,073 cfs in May, and 871 cfs in June, representing 14–30 percent of median unimpaired flows in these months (Figure 7-5a). This corresponds to a cumulative distribution of flow of approximately 26 percent of the average unimpaired flow February–June. Relative to baseline flows, Alternative 2 would result in a 2 percent decrease in the February median flow, a 121 percent increase in the March median flow, a 29 percent decrease in flows in April median flow, a 6 percent increase in the May median flow, and a 91 percent increase in the June median flow . While flows may be lower in certain months when applying a monthly criterion of 20 percent of unimpaired flow, under LSJR Alternative 2, the total amount of water that would be released in the February–June period is the same volume of water released under baseline conditions in the majority of years (Figure 7-5b). As a result, flows could be adaptively managed under LSJR Alternative 2 to avoid any impacts on fish that could result from implementation of a monthly criterion. Accordingly, impacts on the Tuolumne River on rearing and outmigrating juveniles are expected to be less than significant. Higher flows in March would potentially increase the availability of rearing habitat based on a 9 percent increase in median wetted area (Table 7-10); however, little or no change (0–3 percent) would be expected to occur in the frequency of late winter (February–March) flows associated with floodplain inundation based on modeled flows at Modesto and an inundation threshold of 4,000 cfs. While higher late winter flows would be expected to improve rearing conditions for juvenile salmonids, these benefits would likely be offset by potentially lower survival of emigrating smolts in years with lower April flows. Therefore, the overall impact on smolt production in the Tuolumne River would be less than significant.

Under LSJR Alternative 2, median flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead rearing and outmigration period were 198 cfs in February, 248 cfs in March, 457 cfs in April, 806 cfs in May, and 505 cfs in June, representing 19–21 percent of median unimpaired flows in these months (Figure 7-6a). This corresponds to a cumulative distribution of flow of approximately 24 percent of the average unimpaired flow February–June. Relative to baseline, flows under LSJR Alternative 2 would be 58 percent lower than the February median flow, 44 percent lower than the March median flow, 35 percent lower than the April median flow, and 40 percent lower than the May median flow. These modeling results indicate that LSJR Alternative 2 would reduce the frequency and magnitude of late winter and spring flows. Lower flows in late winter would potentially reduce the availability of rearing habitat for juvenile salmonids based on an 8 percent decrease in median wetted area in March (Table 7-10). As shown in Figure 7-6b, the total amount of water that would be released in the February–June period under LSJR Alternative 2 is the same volume of water released under baseline conditions in the majority of years. As a result, flows on the Merced River could be adaptively managed under LSJR Alternative 2 to avoid any impacts on fish from implementation of a monthly criterion. Accordingly, impacts on rearing and outmigrating juveniles in the Merced River would be less than significant.

Under LSJR Alternative 2, median flows in the SJR at Vernalis during the Chinook salmon and steelhead rearing and outmigration period were approximately 3,900 cfs in February, 3,200 cfs in March, 3,400 cfs in April, 4,400 cfs in May, and 2,972 cfs in June, representing 18–61 percent of median unimpaired flows in these months (Figure 7-7a). This corresponds to a cumulative distribution of flow of approximately 29 percent of the average unimpaired flow February–June.

Relative to baseline, median monthly flows under Alternative 2 would be 13 percent higher in February, 7 percent lower in March, 36 percent lower in April, 10 percent lower in May, and 20 percent higher in June. Based on historical relationships between spring flows at Vernalis, abundance of smolts entering the Delta, and survival of smolts through the Delta, lower spring flows in the SJR at Vernalis under Alternative 2, especially in April, would be expected to reduce smolt abundance and survival to the estuary. There would not be adequate flow available throughout the February–June period allowing for adaptive management to reduce impacts on fish on the SJR at Vernalis that may occur on a monthly basis. Impacts on rearing and outmigrating juveniles on the SJR at Vernalis would be significant.

Summer Rearing

Under LSJR Alternative 2, median flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead summer rearing season in June, July, and August were 358, 324, and 283 cfs, representing 13, 58, and 186 percent of median unimpaired flows, respectively (Figure 7-4a). Relative to baseline, LSJR Alternative 2 would result in a 20 percent decrease in the June median flow and little to no change (0–1 percent) in June and July median flows. The decrease in June median flow would be expected to reduce available summer rearing habitat (Table 7-10). As described above for Juvenile Rearing and Outmigration, the volume of water released under baseline conditions in the majority of years as a result of the NMFS BO is approximately 40 percent of the average unimpaired flow. Consequently, there would likely be insufficient water available in most years to adaptively manage flows under LSJR Alternative 2 to improve spring flow for summer rearing. Therefore, flow impacts on in the Stanislaus River under LSJR Alternative 2 would be significant. Also described above, when the WSE model results are compared to baseline (including the NMFS BO), the modeling shows some reductions in flows in the Stanislaus River. However, because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the impacts of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.* Impacts on summer rearing conditions for steelhead would be significant.

Under Alternative 2, median flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead summer rearing season in June, July, and August were 871, 75, and 75 cfs, representing 15, 7, and 26 percent of median unimpaired flows, respectively (Figure 7-5a). Relative to baseline, LSJR Alternative 2 would result in a tenfold increase in the June median flow and little to no change in July and August flows. The substantially higher flows in June may increase the amount of summer rearing habitat available to juvenile steelhead based on a 21 percent increase in median wetted area in June (Table 7-10). This would be a less than-significant-impact on summer rearing habitat in the Tuolumne River.

Under LSJR Alternative 2, median flows during the Chinook salmon and steelhead summer rearing season in the Merced River at Crocker-Huffman Dam in June, July, and August were 505, 250, and 200 cfs, representing 21, 47, and 165 percent of median unimpaired flows, respectively (Figure 7-6a). Relative to baseline, LSJR Alternative 2 would result in a 77 percent increase in the June median flow, an 8 percent increase in the July median flow, and no change in the August median flow. The higher flows in June may increase the amount of summer rearing habitat available to juvenile steelhead based on an 18 percent increase in median wetted area in June (Table 7-10). This would be a less-than-significant impact on summer rearing habitat in the Merced River.

Adult Migration

Under LSJR Alternative 2, modeled flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead adult migration season in October were nearly identical to baseline flows (Figure 7-4a). Impacts would be less than significant.

Under LSJR Alternative 2, modeled flows indicate there would be virtually no impact on the frequency and magnitude of flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead adult migration season in October relative to baseline (Figure 7-5a). Impacts would be less than significant.

Under LSJR Alternative 2, the median October flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead adult migration season are generally expected to be similar to baseline (Figure 7-6). Furthermore, as described in AQUA-4, water temperatures would not be substantially affected relative to baseline. Impacts would be less than significant.

Under LSJR Alternative 2, there would be little or no change during the Chinook salmon and steelhead adult migration season in the magnitude of October flows in the SJR at Vernalis (Figure 7-7a). Impacts would be less than significant.

Spawning and Incubation

Under LSJR Alternative 2, modeled flows in the Stanislaus River at Goodwin Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were nearly identical to baseline flows in October–January, generally higher than baseline flows in February, and generally lower than baseline flows in March (Figure 7-4a). The overall effect on spawning habitat availability was negligible based on differences in median wetted area in these months (Table 7-10). Therefore, LSJR Alternative 2 would have a less-than-significant impact on Chinook salmon and steelhead spawning habitat availability in the Stanislaus River. In addition, as discussed above, because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the impacts of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.* Consequently, impacts would remain less than significant.

Under LSJR Alternative 2, the model results indicate that there would be little effect on spawning habitat availability in the Tuolumne River during the primary Chinook salmon and steelhead spawning and incubation period (October–March) based on the differences in modeled flows and wetted areas in the river below La Grange Dam (Figure 7-5a, Table 7-10). Impacts would be less than significant.

Under LSJR Alternative 2 in the Merced River, median values of modeled baseline flows at Crocker-Huffman Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were very similar to baseline conditions October–January. Relative to baseline, median flows under LSJR Alternative 2 were 58 percent lower in February, and 44 percent lower in March (Figure 7-6a). However, this would result in small differences in median wetted areas in these months (Table 7-10). Further, as discussed above, under LSJR Alternative 2, flows on the Merced River would be adaptively managed to maximize protection for salmonids. Accordingly, since the total quantity of water available during the February–June time frame is the similar to baseline, impacts would not be expected from reductions in flow during that time frame.

As described above, LJSR Alternative 2 would have significant impacts on indicator species during the juvenile rearing and outmigration life stages and summer rearing life stage in the Stanislaus River and/or in the SJR at Vernalis. An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Regs., tit. 23, § 3777(b)(3)). In order to reduce significant impacts identified above, additional flow would be needed in the Stanislaus River and in the SJR at Vernalis. Evaluating the effects of more flow is part of other alternatives (i.e., LSJR Alternative 3 and 4) and is separately considered in this document. Requiring additional flow cannot be independently applied under LSJR Alternative 2 as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow). As noted above, the flows required in the Stanislaus River and SJR at Vernalis under LSJR Alternative 2 would be much less when compared to baseline, thus they could not be adaptively managed to provide additional flows in the spring time that would be appropriate for rearing and outmigrating juvenile salmon and steelhead. Replacing aquatic habitat through restoration could possibly offset impacts of the lower flows expected under LSJR Alternative 2. In the program of implementation, the State Water Board identifies actions by other agencies, which include habitat restoration actions (floodplain restoration, gravel enhancement, riparian vegetation management, passage etc.); hatchery management; predator control; water quality measures; ocean/riverine harvest measures; and recommendations for changes to flood-control curves. However, because of the timing and overall volume of reduction of flows in the Stanislaus River and SJR at Vernalis it is unlikely restoration actions by other agencies would serve to mitigate the impacts of reduced flows on rearing and outmigrating juvenile salmon and steelhead. Impacts would remain significant and unavoidable.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Juvenile Rearing and Outmigration

Under LSJR Alternative 3, median flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead rearing and outmigration period were approximately 600 cfs in February and March, 1,138 cfs in April, 1,664 cfs in May, and 801 cfs in June, representing 29–49 percent of median unimpaired flows in these months (Figure 7-4a). This corresponds to a cumulative distribution of flow of approximately 43 percent of the average unimpaired flow February–June. Relative to median baseline flows, LSJR Alternative 3 would result in 73 percent higher flows in February, 10 percent lower flows in March, 22 percent lower flows in April, 16 percent higher flows in May, and 44 percent higher flows in June. Based on changes in wetted area in February and March (Table 7-10), the impact of LSJR Alternative 3 on rearing habitat availability would be small. The model results indicate that rearing and outmigrating juvenile salmon and steelhead would experience lower flows in March and April and higher flows in May relative to baseline. As shown in Figure 7-4b, the total amount of water that would be released in the February–June period under LSJR Alternative 3 is equal to or higher than the volume of water released under baseline conditions in most years. Consequently, although model results indicate frequent reductions in monthly flows in April, the overall availability of water appears to be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. For example, this could be accomplished by shifting releases from February and March and/or May and June to April whenever adverse flows and water temperatures are predicted in April. Consequently, with successful implementation of adaptive flow and temperature management on the Stanislaus River, flow impacts on rearing and outmigrating juvenile salmon and steelhead under LSJR Alternative 3 would be less than significant.

Under LSJR Alternative 3, modeled flows in the Tuolumne River at La Grange Dam generally increase during the Chinook salmon and steelhead rearing and outmigration period; median flows were approximately 693 cfs in February, 1,006 cfs in March, 1,636 cfs in April, 2,543 cfs in May, and 1,874 cfs in June, representing 33–39 percent of median unimpaired flows in these months (Figure 7-5a). This corresponds to a cumulative distribution of flow of approximately 49 percent of the average unimpaired flow February–June. The model results indicate that flows would be substantially higher than baseline flows in all months, ranging from 52 percent higher in April to 185 percent higher in March. Furthermore, under LSJR Alternative 3, the total amount of water that would be released in the February–June period is a greater volume of water released under baseline conditions in the majority of the years (Figure 7-5b). Alternative 3 would be expected to increase smolt production in the Tuolumne River in many years as a result of increased rearing habitat capacity and improved flow and temperature conditions during outmigration (see AQUA-4). In February and March, higher flows would increase the median wetted area of the river by 14–15 percent (Table 7-10) and increase the frequency and extent of floodplain inundation in these months. In addition to long-term benefits to salmonids, LSJR Alternative 3 is also expected to benefit other native fish species and provide broader ecosystem benefits as a result of the more natural (more unimpaired) late winter and spring flow pattern. Therefore, LSJR Alternative 3 would have less-than-significant impacts on salmonids and other native fish species in the Tuolumne River.

Under LSJR Alternative 3, modeled flows in the Merced River at Crocker-Huffman Dam generally increase during the Chinook salmon and steelhead rearing and outmigration period; median flows were approximately 350 cfs in February, 450 cfs in March, 900 cfs in April, 1,600 cfs in May, and 983 cfs in June, representing 34–41 percent of median unimpaired flows in these months (Figure 7-6a). This corresponds to a cumulative distribution of flow of approximately 43 percent of the average unimpaired flow February–June. Relative to baseline, median flows under LSJR Alternative 3 were 24 percent lower in February, the same in March, 26 percent higher in April, 179 percent higher in May, and 71 percent higher in June. Furthermore, under LSJR Alternative 2, the total amount of water that would be released in the February–June period is a greater volume of water released under baseline conditions in the majority of the years (Figure 7-6b). Overall, LSJR Alternative 3 would be expected to improve rearing and outmigration conditions for juvenile salmonids. Based on modeled flows at Stevinson, median wetted area of the river would increase by 3 percent in February and 12 percent in March (Table 7-10), potentially increasing the quantity and quality of rearing habitat in these months. Higher flows and lower water temperatures (see AQUA-4) in April and May would contribute to increased smolt production, and the more natural (more unimpaired) late winter and spring flow pattern would benefit other native fish species through direct and indirect effects on habitat quantity and quality. This represents a less than significant impact on salmonids and other native fishes in the Merced River.

Under LSJR Alternative 3, median flows in the SJR at Vernalis during the Chinook salmon and steelhead rearing and outmigration period were approximately 3,800 cfs in February and March, 5,200 cfs in April, 7,700 cfs in May and 5,121 cfs in June, representing 33-60 percent of median unimpaired flows in these months (Figure 7-7a). This corresponds to a cumulative distribution of flow of approximately 42 percent of the average unimpaired flow February–June. Relative to baseline, median monthly flows under LSJR Alternative 3 would be 10 percent higher in February and March, unchanged in April, 57 percent higher in May, and 53 percent higher in June. Furthermore, under LSJR Alternative 3 the total amount of water that would be released in the February–June period is of greater volume than that released under baseline conditions in the majority of the years (Figure 7-7b). Based on historical relationships between spring flows at Vernalis, abundance of smolts entering the Delta, and survival of smolts through the Delta, higher spring flows in the SJR at Vernalis under LSJR Alternative 3, especially in May, would be expected to have a positive effect on long-term trends in smolt abundance, potentially increasing abundance of adult populations. Impacts associated with increased spring flows in the tributaries and in the SJR under LSJR Alternative 3 would be less than significant.

Summer Rearing

Under LSJR Alternative 3, median flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead summer rearing season were approximately 800 cfs in June and 300 cfs in July and August, representing 29 percent, 58 percent, and 186 percent of median unimpaired flows, respectively (Figure 7-4a). Relative to baseline, median flows under LSJR Alternative 3 were 78 percent higher in June and unchanged in July and August. Higher flows in June may increase the amount of summer rearing habitat available to juvenile steelhead by increasing the wetted area of the river (Table 7-10) and the longitudinal extent of suitable water temperatures (see AQUA-4), although the benefits would likely be limited because the projected flows and habitat conditions in July and August would be similar to baseline conditions. Overall, LSJR Alternative 3 would have less-than-significant impacts on summer rearing habitat in the Stanislaus River.

Under LSJR Alternative 3, median flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead summer rearing season were approximately 1,900 cfs in June and 75 cfs in July and August, representing 33 percent, 7 percent, and 26 percent of median unimpaired flows, respectively (Figure 7-5a). Relative to baseline, LSJR Alternative 3 would result in a twenty-four-fold increase in the median June flow and no change in July and August. Higher flows in June would substantially increase the amount of summer rearing habitat available to juvenile steelhead based on a 56 percent increase in median wetted area (Table 7-10). However, as with the Stanislaus River, the potential benefits of higher flows to juvenile steelhead in June would be limited by the return to baseline flows in July and August. Overall, LSJR Alternative 3 would have less-than-significant impacts on summer rearing habitat in the Tuolumne River.

Under LSJR Alternative 3, median flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead summer rearing season were approximately 1,000 cfs in June, 250 cfs in July, and 200 cfs in August, representing 40, 47, and 165 percent of median unimpaired flows, respectively (Figure 7-6a). Relative to baseline, LSJR Alternative 3 would result in a 2.5-fold increase in the median June flow, an 8 percent increase in the median July flow, and no change in the August median flow. Higher flows in June would increase the extent of summer rearing habitat available to juvenile steelhead based on the predicted wetted area (Table 7-10) and temperature effects (see AQUA-4). However, limited benefits to juvenile steelhead production would be expected because the projected flows and habitat conditions in July and August would be similar to baseline conditions. Overall, LSJR Alternative 3 would have less-than-significant impacts on summer rearing habitat in the Merced River.

Adult Migration

Under LSJR Alternative 3, modeled flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead adult migration season in October would remain unchanged relative to baseline (Figure 7-4a). Impacts would be less than significant.

Under LSJR Alternative 3, modeled results in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead adult migration season were similar to those under baseline (Figure 7-5a), resulting in little or no effect on adult salmon and steelhead during their upstream migration to spawning areas in the Tuolumne River. Impacts would be less than significant.

Under LSJR Alternative 3, modeled flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead adult migration season in October is also expected to be similar to baseline (Figure 7-6a). Impacts would be less than significant.

Under LSJR Alternative 3, there would be little or no change during the Chinook salmon and steelhead adult migration season in the magnitude of October flows in the SJR at Vernalis under LSJR Alternative 3 (Figure 7-7a). Impacts would be less than significant.

Spawning and Incubation

Under LSJR Alternative 3, modeled flows in the Stanislaus River at Goodwin Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) would remain largely unchanged with generally higher flows in February and generally lower flows in March relative to baseline (Figure 7-4a). The overall effect on the quality and quantity of spawning and incubation habitat would be minor based on the differences in median wetted area in these months (Table 7-10). Therefore, LSJR Alternative 3 would have a less-than-significant impact on Chinook salmon and steelhead spawning and incubation life stages in the Stanislaus River.

Under LSJR Alternative 3, there would result in little or no change in flow or wetted area of the Tuolumne River during the primary Chinook salmon spawning months (October–November) (Figure 7-5a, Table 7-10). However, higher flows in February and March would potentially increase the amount of spawning habitat available to steelhead, which spawn primarily January–March. Therefore, the impacts of LSJR Alternative 3 on Chinook salmon and steelhead spawning and incubation would be less than significant.

Under LSJR Alternative 3, median monthly flows in the Merced River at Crocker-Huffman Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were approximately the same as baseline October–January, 350 cfs in February, and 450 cfs in March. Median flows were 0–25 percent lower October–February and unchanged in March relative to baseline (Figure 7-6a). The impact of reduced flows on habitat availability would be less than significant based on the small differences in wetted areas (Table 7-10) and water temperatures in these months (see AQUA-4). Therefore, LSJR Alternative 3 would have a less-than-significant impact on Chinook salmon and steelhead spawning and incubation in the Merced River.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Juvenile Rearing and Outmigration

Under LSJR Alternative 4, flows in the Stanislaus River at Goodwin Dam would generally increase during the Chinook salmon and steelhead rearing and outmigration period (February–June) in a pattern consistent with the natural unimpaired hydrograph (Figure 7-4a). Median monthly flows were approximately 750 cfs in February, 900 cfs in March, 1,800 cfs in April, 2,300 in May, and 1,343 cfs in June, representing 49–59 percent of median unimpaired flows in these months. This corresponds to a cumulative distribution of flow of approximately 60 percent of the average unimpaired flow February–June. Relative to baseline, median monthly flows under LSJR Alternative 4 would increase by 107 percent in February, 37 percent in March, 22 percent in April, 60 percent in May, and 67 percent in June. Furthermore, under LSJR Alternative 4 the total amount of water that would be released in the February–June period would greatly increase when compared to the volume of water released under baseline conditions in the majority of the years (Figure 7-4b). Overall, the modeling results indicate that LSJR Alternative 4 would result in long-term increases in smolt production in the Stanislaus River as a result of greater rearing habitat capacity (Table 7-10) and improved flow and temperature conditions (see AQUA-4) during the late winter and spring rearing and outmigration period. In addition, the more natural (more unimpaired) late winter–spring flow pattern would benefit other native fish species through direct and indirect effects on habitat quantity and quality. Therefore, LSJR Alternative 4 would have less-than-significant impacts on salmonids and other native fishes in the Stanislaus River.

Under LSJR Alternative 4, flows in the Tuolumne River at La Grange Dam would be higher on average and exhibit a more natural (unimpaired) pattern during the Chinook salmon and steelhead rearing and outmigration period. Median monthly flows were approximately 1,200 cfs in February, 1,400 cfs in March, 2,400 cfs in April, 3,100 cfs in May, and 2,939 cfs in June, representing 42–60 percent of median unimpaired flows in these months (Figure 7-5a). This corresponds to a cumulative distribution of flow of approximately 60 percent of the average unimpaired flow February–June. These flows were 122–314 percent higher than median baseline flows, resulting in substantial increases in potential rearing area (Table 7-10) and improvements in flow and temperature conditions (see AQUA-4) during the late winter and spring rearing and outmigration period. Furthermore, under LSJR Alternative 4, the total amount of water that would be released in the February–June period would greatly increase when compared to the volume of water released under baseline conditions in the majority of the years (Figure 7-5b). Overall, these conditions are expected to result in long-term increases in salmon and steelhead smolt production and benefits to other native fish species through direct and indirect effects on habitat quantity and quality. Therefore, LSJR Alternative 4 would have less-than-significant impacts on salmonids and other native fishes in the Tuolumne River.

Under LSJR Alternative 4, long-term increases in salmon and steelhead smolt production would also be expected in the Merced River in response to the changes in the magnitude of late winter and spring flows during the Chinook salmon and steelhead rearing and outmigration period. Median monthly flows were approximately 450 cfs in February, 700 cfs in March, 1,400 cfs in April, 2,000 cfs in May, and 1,466 cfs in June, representing 50–57 percent of median unimpaired flows in these months (Figure 7-6a). Relative to baseline, median monthly flows were 1 percent higher in February, 59 percent higher in March, 92 percent higher in April, 242 percent higher in May, and 80 percent higher in June. Furthermore, under LSJR Alternative 4, the total amount of water that would be released in the February–June period would greatly increase when compared to the volume of water released under baseline conditions in the majority of the years (Figure 7-6b). These flows would substantially increase the wetted area of the river (Table 7-10) and potentially increase the frequency and extent of floodplain inundation. For example, based on modeled flows at Stevinson, the median wetted area of the river would increase by 12 percent in February and 31 percent in March, potentially increasing the rearing capacity of the lower river for juvenile Chinook salmon prior to outmigration. These benefits would be further magnified by increasing flows through the spring and improving the environmental conditions and natural migration cues for smolt development and outmigration. Therefore, LSJR Alternative 4 would have less-than-significant impacts on salmonids and other native fishes in the Merced River.

Under LSJR Alternative 4, median flows in the SJR at Vernalis during the Chinook salmon and steelhead rearing and outmigration period were approximately 4,400 cfs in February, 4,900 cfs in March, 7,300 cfs in April, 8,900 cfs in May, and 7,270 cfs in June, representing 39-69 percent of median unimpaired flows in these months (Figure 7-7a). This corresponds to a cumulative distribution of flow (i.e., the range of flows distributed between the minimum flow as measured by TAF and the maximum flow over the entire 82-year historical modeling period) of approximately 52 percent of the average unimpaired flow February–June. Relative to baseline, median monthly flows under LSJR Alternative 4 would be 28 percent higher in February, 43 percent higher in March, 40 percent higher in April, 81 percent higher in May, and 67 percent higher in June. Furthermore, under LSJR Alternative 4, the total amount of water that would be released in the February–June period would greatly increase when compared to the volume of water released under baseline conditions in the majority of the years (Figure 7-7b). Based on historical relationships between spring flows at Vernalis, abundance of smolts entering the Delta, and survival of smolts through the Delta, higher spring flows in the SJR at Vernalis under LSJR Alternative 4 would be expected to have a substantial positive effect on long-term trends in SJR Chinook salmon smolt abundance, potentially increasing abundance of adult populations. Impacts associated with increased spring flows in the SJR under LSJR Alternative 4 would be less than significant.

Summer Rearing

Under LSJR Alternative 4, median flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead summer rearing season were approximately 1,300 cfs in June and 300 cfs in July and August, representing 49 percent, 58 percent, and 186 percent of median unimpaired flows, respectively (Figure 7-4a). Relative to baseline, the median June flow increased by nearly 200 percent, while the flows in July and August remained unchanged. Similar to LSJR Alternative 3, the potential benefits of higher flows in June would likely be limited because projected flows and water temperatures in July and August would be similar to baseline. Overall, LSJR Alternative 4 would have less-than-significant impacts on summer rearing conditions in the Stanislaus River.

Under LSJR Alternative 4, median flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead summer rearing season were approximately 2,900 cfs in June and 75 cfs in July and August, representing 52 percent, 7 percent, and 26 percent of median unimpaired flows, respectively (Figure 7-5a). Relative to baseline, the median June flow increased by 3,800 percent, while the flows in July and August remained unchanged. Although higher flows in June would substantially improve the extent of suitable rearing habitat for steelhead, the overall effect on juvenile production would likely be limited by habitat constraints later in the summer. Overall, LSJR Alternative 4 would have less-than-significant impacts on summer rearing conditions in the Tuolumne River.

Under LSJR Alternative 4, median flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead summer rearing season were approximately 1,500 cfs in June, 250 cfs in July, and 200 cfs in August, representing 60, 47, and 165 percent of median unimpaired flows, respectively (Figure 7-6a). Relative to baseline, LSJR Alternative 4 would result in a 400 percent increase in the median June flow, an 8 percent increase in the median July flow, and no change in the median August flow. Overall, LSJR Alternative 4 would have less-than-significant impacts on summer rearing conditions in the Merced River.

Adult Migration

Under LSJR Alternative 4, flows in the Stanislaus River at Goodwin Dam during the Chinook salmon and steelhead adult migration season in October would remain unchanged relative to baseline (Figure 7-4a). Therefore, LSJR Alternative 4 would have no impact.

Under LSJR Alternative 4, flows in the Tuolumne River at La Grange Dam during the Chinook salmon and steelhead adult migration season in October would be similar to those under baseline (Figure 7-5a), resulting in a less-than-significant impact.

Under LSJR Alternative 4, the modeled flows in the Merced River at Crocker-Huffman Dam during the Chinook salmon and steelhead adult migration season in October were similar to those under LSJR Alternative 3 (Figure 7-6a). The impact on migrating adult salmon and steelhead would be less-than-significant because it is expected that suitable passage and water temperature conditions (see AQUA-4) would be maintained.

Under LSJR Alternative 4, there would be little or no change during the Chinook salmon and steelhead adult migration season in the magnitude of October flows in the SJR at Vernalis (Figure 7-7a). Impacts would be less than significant.

Spawning and Incubation

Under LSJR Alternative 4, modeled flows in the Stanislaus River at Goodwin Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) would remain largely unchanged except for generally higher flows in February and March (Figure 7-4a). The overall impact on the quantity and quality of spawning and incubation habitat would be less than significant based on the differences in median wetted area in these months (Table 7-10).

Under LSJR Alternative 4, the modeled flows in the Tuolumne River at La Grange Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were similar to those under LSJR Alternative 3 (Figure 7-5a). Therefore, the impacts of LSJR Alternative 4 on Chinook salmon and steelhead spawning and incubation in the Tuolumne River would be less than significant.

Under LSJR Alternative 4, modeled flows in the Merced River at Crocker-Huffman Dam during the primary Chinook salmon and steelhead spawning and incubation period (October–March) were similar to those under LSJR Alternative 3 except for generally higher flows in February and March (Figure 7-6a). Impacts on spawning habitat availability are not expected based on the differences in median wetted area in these months (Table 7-10). However, steelhead that spawn in February and March may benefit from projected increases in flow and wetted area in these months. Therefore, the impacts of LSJR Alternative 4 on Chinook salmon and steelhead spawning and incubation in the Merced River would be less than significant.

AQUA-4: Changes in exposure of fish to stressful water temperatures resulting from changes in reservoir storage and releases

Water temperature is recognized as a primary stressor for Chinook salmon and steelhead in the SJR Basin. Exposure of these species to elevated water temperatures can cause thermal stress and lead to reductions in survival through a number of direct and indirect effects. These effects can be generally characterized as (1) chronic effects related to changes in growth, disease resistance, swimming performance, and other biological functions over relatively long periods, and (2) acute effects related to the thermal tolerance of fish to lethal temperatures over relatively short periods (Sullivan et al. 2000). The suitability of water temperatures for fish can generally be defined by optimal, suboptimal, and lethal ranges based on their chronic and acute responses to thermal stress under laboratory and field conditions. Optimal water temperatures are those that cause no significant impacts, suboptimal temperatures are associated with chronic effects and cause increasing thermal stress as water temperatures approach lethal levels, and lethal temperatures are those that cause acute effects (e.g., severe impairment or death). The duration of exposure to suboptimal and lethal temperatures must also be considered in determining the potential for significant impacts.

The temperature thresholds used in this analysis are based on the thermal criteria used in the LSJR Water Temperature Model and Analysis (see Section 7.4.2) to address the effects of the LSJR alternatives on habitat quantity and quality of Chinook salmon and steelhead in the Stanislaus, Tuolumne, and Merced Rivers and LSJR (Deas et al. 2004; CalFED 2009). Two temperature thresholds were used to define optimal, suboptimal, and lethal water temperature ranges for Chinook salmon and steelhead life stages: (1) 2003 USEPA-recommended temperature criteria for protection of salmonid designated uses (7-day average of the daily maximum [7DADM] temperatures), and (2) literature-based upper incipient lethal temperatures (daily maximum water temperatures) (Table 7-11). These criteria were developed for the purpose of comparing simulated alternatives and should not be construed as agreed-upon criteria in establishing temperature policy in the SJR Basin (Deas et al. 2004).

Table 7-11. Chinook Salmon Water Temperature Criteria (°F) by Month and Reach/Location (Deas et al. 2004; Guignard 2001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Location	RB	RB	CON	CON	CON	CON	CON	KF	KF	CON	RB	RB
Criteria	54	54	55	55	55	55	60	60	60	54	54	54

RB- Riverbank (River Mile 33): Spawning and egg incubation October–February
CON- Confluence (River Mile 0): Juvenile rearing/outmigration/smoltification March–June; Adult migration in September
KF- Knights Ferry (River Mile 54): Juvenile rearing in July and August

USEPA-recommended criteria were used to define the upper limits of the optimal temperature ranges for adult migration, spawning and incubation, juvenile rearing and outmigration (including smolts), and juvenile summer rearing (Table 7-11). These criteria serve to identify the occurrence of long-duration events (days to weeks) that can cause chronic effects. Impacts of exposure to these suboptimum water temperatures depend on the magnitude of water temperatures within this range and duration of exposure. USEPA criteria are intended to be applied to the warmest week of the year (typically in mid- to late summer) and the lowest downstream extent of the critical life stages to provide year-round protection to salmonids (USEPA 2003). Accordingly, in applying these temperature criteria to the modeling results, an increase of a week (7 days) or more in the frequency of daily maximum water temperatures exceeding these thresholds was used to determine the significance of impacts.

The upper incipient lethal temperatures (daily maximum water temperatures) were used to define the point at which water temperatures can cause direct mortality or severe impairment leading to death (Table 7-11). These criteria serve to identify the occurrence of short-duration events (hours) that can cause acute effects. In applying these thresholds to the modeled results, an increase of a day or more in the frequency of daily maximum water temperatures exceeding these thresholds was used to determine the significance of impacts.

Predicted changes in exposure of Chinook salmon and steelhead life stages to suboptimal or lethal water temperatures were evaluated by comparing the modeling results for each LSJR alternative with the baseline. Exceedance tables were prepared to determine the frequency or duration of time that the temperature thresholds were exceeded under the baseline and LSJR alternatives (Tables 7-12 through 7-15). These tables present the cumulative distribution of daily maximum water temperatures (percent of time that specified water temperatures were exceeded) for each month over the 1980–2003 modeling period.

Baseline

Water temperatures in the LSJR are typically in equilibrium with air temperatures during the hottest summer months. In the spring and fall, LSJR temperatures are influenced to some extent by inflows and water temperatures from the major tributaries. Reservoir operations have led to elevated water temperatures in the spring, which have been identified as a major factor contributing to reduced survival and abundance of juveniles and subsequent returns of spawning adults to the LSJR and the three major tributaries.

For steelhead and resident rainbow trout, excessively warm summer temperatures in the tributaries act to limit *O. mykiss* population abundance by restricting suitable summer rearing habitat to the cooler uppermost reaches of accessible habitat immediately downstream of the rim dams. Consequently, the amount of suitable habitat may be insufficient to sustain healthy population levels of *O. mykiss* (DFG 2007). The expected temperature conditions under the baseline are summarized in Tables 7-12a–d for each river and then discussed with respect to species life stages below.

Table 7-12a. Baseline Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Stanislaus River for Each Month of the 1980–2003 Modeling Period

Baseline	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	42.6	45.5	48.7	50.6	54.1	52.5	52.8	53.9	53.7	50.9	48.7	42.7
0.1	46.0	48.5	50.6	55.1	58.8	55.7	59.0	57.2	60.2	54.5	50.9	47.1
0.2	46.9	49.5	52.0	56.5	59.8	57.3	61.4	60.3	64.9	55.4	52.1	48.2
0.3	47.9	50.1	52.8	57.6	60.6	58.6	63.0	62.0	68.2	56.3	53.3	48.8
0.4	48.4	50.8	53.7	58.3	61.3	59.5	63.9	62.7	70.1	57.2	54.0	49.5
0.5	49.0	51.4	54.5	59.0	62.1	61.7	64.5	63.6	71.2	58.0	54.8	50.0
0.6	49.5	52.2	55.2	59.9	63.0	63.0	65.4	64.4	72.2	59.3	55.5	50.5
0.7	50.2	53.2	55.8	61.0	64.3	64.3	66.3	65.2	73.3	61.2	56.3	51.3
0.8	50.9	54.1	56.6	62.7	66.6	65.4	67.4	66.0	74.1	64.1	57.4	51.9
0.9	51.8	55.3	57.9	65.3	69.1	66.8	69.7	67.1	75.4	67.2	58.8	52.7
Max	55.1	60.4	65.1	71.3	77.0	79.2	75.0	85.9	81.4	76.8	66.7	55.4
Avg	49.0	51.8	54.5	59.6	63.1	61.5	64.3	63.6	69.7	59.7	54.9	50.0

Notes:

Dark gray represents a temperature that exceeds a lethal USEPA criterion.

White represents a temperature that exceeds suboptimal temperatures .

Light gray represents a temperature that is within suboptimal temperatures.

Table 7-12b. Baseline Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Tuolumne River for each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	43.2	47.7	49.6	51.4	53.5	50.1	51.6	55.6	53.9	52.3	51.8	49.9
0.1	45.9	50.4	52.5	54.5	58.1	51.4	53.0	58.5	63.3	53.1	52.8	51.4
0.2	47.2	51.0	53.4	55.9	59.5	52.1	54.4	59.4	68.3	53.6	53.2	51.9
0.3	48.1	51.6	54.5	57.1	60.8	53.8	57.7	60.0	70.3	54.0	53.5	52.2
0.4	48.7	52.3	55.7	58.3	62.0	58.8	59.7	60.6	71.8	54.2	53.8	52.5
0.5	49.2	53.1	57.1	59.6	63.9	65.0	64.2	63.7	73.3	54.7	54.0	52.7
0.6	49.7	53.9	58.8	61.9	65.8	68.7	69.8	68.6	74.4	55.2	54.2	53.0
0.7	50.2	54.7	60.7	64.1	67.7	70.4	71.5	70.2	76.0	55.7	54.6	53.2
0.8	51.0	55.9	62.3	65.7	69.8	71.5	73.2	71.6	77.1	56.1	55.0	53.5
0.9	52.0	58.0	64.3	67.7	72.3	73.1	74.6	73.2	78.6	56.6	55.7	54.1
Max	55.7	63.6	70.8	73.1	78.5	81.4	78.4	75.9	84.3	77.9	57.2	56.7
Avg	49.1	53.6	57.9	60.6	64.6	62.8	64.3	65.1	72.2	55.2	54.1	52.7

Notes:

Dark gray represents a temperature that exceeds a lethal USEPA criterion.

White represents a temperature that exceeds suboptimal temperatures.

Light gray represents a temperature that is within suboptimal temperatures.

Table 7-12c. Baseline Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Merced River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	39.5	43.5	44.3	41.8	51.6	51.4	56.1	59.2	61.6	44.4	47.4	44.4
0.1	43.4	46.3	47.2	55.7	61.3	55.5	58.9	62.0	66.6	54.0	51.3	47.3
0.2	45.9	47.3	48.3	59.3	63.4	57.1	60.0	63.1	69.3	56.5	52.8	48.4
0.3	46.8	48.0	49.3	61.3	65.1	63.4	65.4	64.1	70.9	58.7	53.7	49.0
0.4	47.5	48.5	50.5	62.7	67.2	65.8	68.5	67.9	73.4	59.4	54.7	49.7
0.5	48.1	49.0	51.8	63.8	69.0	67.2	70.2	70.8	75.7	60.2	55.5	50.3
0.6	48.8	49.8	53.5	64.9	71.0	68.6	71.8	72.4	77.3	61.1	56.4	51.2
0.7	49.9	50.9	54.5	66.1	72.7	69.5	73.7	75.0	78.5	62.1	57.5	52.1
0.8	51.5	51.6	55.1	67.8	74.6	70.4	75.6	76.0	79.5	65.6	59.0	53.3
0.9	52.2	52.7	56.1	69.8	76.6	71.9	77.8	77.3	80.8	67.3	61.7	54.5
Max	53.7	56.5	58.9	82.1	82.8	83.5	84.8	81.8	87.4	80.2	65.8	58.9
Avg	48.0	49.3	51.8	63.5	69.0	65.4	69.0	70.0	74.5	60.1	56.0	50.7

Notes:
Dark gray represents a temperature that exceeds lethal a USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-12d. Baseline Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the LSJR for Each Month of the 1980–2003 Modeling Period

Baseline	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.8	47.7	53.3	54.0	59.9	59.1	66.2	67.1	66.1	57.3	47.9	42.2
0.1	44.4	50.6	57.3	59.9	63.9	67.3	70.4	71.8	73.1	64.0	52.9	47.9
0.2	45.9	51.9	58.7	61.5	65.0	68.7	72.6	74.1	74.6	65.5	54.5	48.8
0.3	47.1	52.9	59.7	62.5	66.5	70.2	75.9	75.3	75.4	66.6	55.9	49.7
0.4	47.9	53.7	60.9	63.3	67.5	72.2	77.2	76.2	76.2	67.6	57.0	50.4
0.5	48.7	54.5	61.8	64.3	68.5	73.8	78.1	76.7	77.2	68.5	58.1	51.1
0.6	49.5	55.1	62.5	65.1	69.5	74.9	78.9	77.4	77.8	69.7	58.9	51.6
0.7	50.3	56.1	63.3	66.2	70.6	75.9	79.7	78.0	78.5	70.6	60.2	52.3
0.8	51.1	57.2	64.3	67.5	71.7	77.2	80.4	78.6	79.5	72.2	61.5	52.9
0.9	52.3	58.7	65.7	69.3	73.9	78.9	81.2	79.6	80.6	73.8	63.0	53.9
Max	55.9	63.1	70.9	73.4	79.9	83.5	83.7	83.6	84.5	84.3	66.0	57.6
Avg	48.6	54.5	61.6	64.4	68.7	73.2	77.0	76.3	76.9	68.7	57.9	50.9

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Juvenile Rearing and Outmigration

Under modeled baseline conditions, water temperatures potentially causing thermal stress in rearing and outmigrating juvenile salmon and steelhead frequently occur during the spring months in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR. Maximum daily water temperatures met the USEPA-recommended criterion for juvenile rearing (<61°F) on most days in January and February (Tables 7-12a–d). Water temperatures frequently exceeded the USEPA criterion for smoltification (<57°F) by April in the lower reaches of these rivers, and generally increased in magnitude and frequency as spring progressed. Maximum water temperatures on all rivers approached, but only rarely exceeded, lethal levels for juveniles (84°F) by the end of spring.

Summer Rearing

Under modeled baseline conditions, maximum daily water temperatures met the USEPA-recommended criterion for summer rearing (<61°F) <10–40 percent of the time in June–August (depending on location and month) in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-12a–d). Water temperatures exceeded lethal levels for juveniles (84°F) <10 percent of the time in the Stanislaus and Merced Rivers and 0 percent of the time in the Tuolumne River and LSJR.

Adult Migration

Under modeled baseline conditions, water temperatures in September exceed suitable levels for adult salmon and steelhead migration in most years in the LSJR and the major tributaries. Maximum daily water temperatures at the confluences of the Stanislaus, Tuolumne, and Merced Rivers met the USEPA-recommended criterion for adult migration (<64°F) ≤10 percent of the time, (Tables 7-12a–d). Water temperatures potentially causing mortality or creating a migration barrier for adult salmon in September (>70°F) occurred 60-70 percent of the time in the Stanislaus, Tuolumne, Merced Rivers. In the LSJR, water temperatures potentially causing mortality or creating a migration barrier for adult salmon in September occurred greater than 90 percent of the time.

Spawning and Incubation

Under modeled baseline conditions, suitable water temperatures for Chinook salmon spawning and incubation in the Stanislaus, Tuolumne, and Merced Rivers generally did not occur until late October or November. Maximum daily water temperatures in October met the USEPA-recommended spawning and incubation criterion (<55°F) 50 percent of the time in the Tuolumne River and 10 percent of the time in the Stanislaus and Merced Rivers (Tables 7-12a–d). In November, this criterion was met 70 percent of the time in the Tuolumne River and 40–50 percent of the time in the Stanislaus and Merced Rivers. Water temperatures exceeding lethal levels for Chinook salmon spawning and incubation (62°F) would occur <10-30 percent of the time in October, <10 percent of the time in November, and 0 percent of the time in December in the Stanislaus, Tuolumne, and Merced Rivers. For the LSJR, maximum daily water temperatures in October exceeded the USEPA-recommended spawning and incubation criterion (<55°F), but met the criterion 20–30 percent of the time in November. Water temperatures exceeding lethal levels for Chinook salmon spawning and incubation (62°F) would occur >90 percent of the time in October and <20 percent of the time in November.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

The expected temperature conditions under LSJR Alternative 2 are summarized in Tables 7-13a–d for each river and then discussed with respect to species life stages below.

Table 7-13a. LSJR Alternative 2 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Stanislaus River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	42.6	44.8	48.7	50.8	57.0	52.4	52.7	54.0	54.1	51.2	48.9	42.4
0.1	45.9	48.3	50.8	57.5	61.0	56.2	57.8	57.5	60.6	54.3	50.7	46.9
0.2	46.8	49.2	52.6	59.3	62.5	58.8	61.5	60.4	64.9	55.3	51.9	48.1
0.3	47.9	50.0	53.6	60.7	63.6	60.5	62.4	61.6	68.2	56.0	53.0	48.7
0.4	48.4	50.6	54.4	61.8	64.6	61.6	63.3	62.3	69.9	56.8	53.8	49.4
0.5	48.9	51.0	55.0	62.8	65.7	63.0	63.8	63.1	71.2	57.5	54.5	50.0
0.6	49.5	51.4	55.7	63.7	66.9	64.2	64.4	63.7	72.0	58.8	55.2	50.5
0.7	50.2	52.1	56.5	64.6	67.9	65.8	65.1	64.6	73.2	61.1	56.1	51.2
0.8	50.8	53.0	57.7	65.6	69.6	67.3	66.2	65.8	74.1	64.0	57.2	51.8
0.9	51.8	53.8	58.7	66.9	71.3	69.0	68.1	66.7	75.2	67.6	58.5	52.6
Max	55.1	58.1	65.4	70.5	78.6	80.6	74.5	70.5	81.7	77.0	66.7	55.1
Avg	48.9	51.1	55.1	62.4	66.0	63.0	63.6	62.7	69.7	59.5	54.7	49.8

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-13b. Alternative 2 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Tuolumne River for Each Month Of The 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	43.2	47.6	49.7	51.4	52.7	50.1	51.4	54.8	53.9	51.9	51.8	49.9
0.1	45.8	50.4	52.5	54.4	58.0	51.2	52.7	58.4	61.1	52.8	52.7	51.4
0.2	47.2	51.0	53.4	56.1	59.4	52.1	53.9	59.3	64.5	53.4	53.2	51.8
0.3	48.0	51.6	54.3	57.8	60.4	53.3	57.6	59.9	68.9	53.8	53.5	52.1
0.4	48.7	52.2	55.1	59.3	61.3	54.5	59.7	60.5	71.4	54.1	53.8	52.4
0.5	49.3	52.9	56.3	60.9	62.4	56.4	62.2	63.6	73.0	54.7	54.1	52.8
0.6	49.8	53.6	58.2	62.1	63.8	58.2	69.8	68.7	74.3	55.3	54.5	53.1
0.7	50.4	54.5	60.3	63.2	65.1	61.2	71.1	70.2	76.0	55.7	55.1	53.3
0.8	51.2	56.2	62.2	64.2	66.8	64.0	72.8	71.7	77.1	56.1	55.8	53.6
0.9	52.2	58.6	64.0	66.1	69.0	70.2	74.5	73.2	78.6	57.5	56.5	54.5
Max	55.7	63.7	70.1	70.7	75.4	85.7	77.8	75.7	84.3	77.8	59.4	56.2
Avg	49.2	53.6	57.6	60.5	63.1	58.9	64.0	65.1	71.4	55.3	54.4	52.8

Notes:

Dark gray represents a temperature that exceeds lethal a USEPA criterion.

White represents a temperature that exceeds suboptimal temperatures.

Light gray represents a temperature that is within suboptimal temperatures.

Table 7-13c. LSJR Alternative 2 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Merced River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.4	40.7	44.8	47.5	55.1	51.4	55.9	59.2	61.5	46.6	47.2	44.5
0.1	43.5	43.6	47.8	57.0	61.2	55.6	58.9	62.0	66.5	55.2	51.2	47.3
0.2	45.8	44.7	48.8	59.6	63.2	57.1	60.1	63.1	69.1	57.7	52.5	48.4
0.3	46.8	47.1	50.8	61.9	64.6	61.5	64.9	64.1	70.9	58.4	53.4	48.9
0.4	47.6	47.8	52.6	63.3	65.6	63.5	68.1	67.5	73.3	58.9	54.5	49.6
0.5	48.1	48.4	53.5	64.4	66.8	64.9	70.0	70.3	75.7	59.4	55.5	50.1
0.6	49.4	49.1	54.2	65.6	68.0	66.5	71.4	72.2	77.1	60.5	56.1	51.1
0.7	50.4	50.4	55.4	66.4	69.5	68.2	73.6	74.5	78.4	61.3	56.8	51.9
0.8	51.6	51.5	56.3	67.3	70.8	69.4	75.4	75.8	79.5	62.3	58.1	53.0
0.9	52.6	52.5	57.3	68.5	72.5	70.6	77.0	77.0	80.8	63.7	59.6	54.1
Max	53.7	57.4	59.7	74.2	78.0	80.4	84.6	80.0	87.8	80.2	63.2	58.7
Avg	48.2	48.4	52.9	63.6	66.9	64.0	68.8	69.7	74.5	59.4	55.3	50.5

Notes:

Dark gray represents a temperature that exceeds a lethal USEPA criterion.

White represents a temperature that exceeds suboptimal temperatures.

Light gray represents a temperature that is within suboptimal temperatures.

Table 7-13d. LSJR Alternative 2 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the LSJR for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.8	47.7	53.8	53.9	59.0	59.3	66.2	67.1	66.7	57.3	47.9	42.2
0.1	44.4	50.8	57.4	59.2	62.2	66.1	70.1	71.8	73.1	64.0	52.9	47.9
0.2	45.9	51.9	58.7	60.3	63.3	67.2	72.3	74.2	74.6	65.5	54.5	48.8
0.3	47.2	52.9	59.8	61.4	64.1	68.1	75.1	75.3	75.4	66.6	55.9	49.7
0.4	47.9	53.7	60.9	62.2	64.9	68.9	76.6	76.2	76.2	67.6	57.0	50.4
0.5	48.8	54.5	61.7	62.8	65.7	69.7	77.6	76.7	77.2	68.5	58.1	51.1
0.6	49.5	55.2	62.5	63.3	66.4	70.9	78.5	77.4	77.8	69.7	58.9	51.6
0.7	50.3	56.2	63.2	63.9	67.2	72.9	79.2	78.0	78.5	70.6	60.2	52.3
0.8	51.1	57.3	64.1	64.9	68.3	74.7	79.9	78.6	79.5	72.2	61.5	52.9
0.9	52.3	58.8	65.7	66.1	69.9	77.4	80.8	79.5	80.6	73.8	63.0	53.9
Max	55.8	63.2	70.3	72.8	74.5	82.0	83.2	83.3	84.5	84.3	66.0	57.6
Avg	48.6	54.6	61.5	62.7	65.8	70.7	76.5	76.3	76.9	68.7	57.9	50.9

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Juvenile Rearing and Outmigration

Under LSJR Alternative 2, water temperatures potentially causing thermal stress in juvenile salmon and steelhead during the spring rearing and outmigration period (April–June) would be expected to increase in the Stanislaus River relative to baseline. The frequency of modeled water temperatures exceeding the USEPA-recommended criterion for juvenile rearing and outmigration (61°F or 57°F, depending on location and month) increased by over 10 percent relative to baseline (Table 7-13a). Median maximum daily water temperatures at the confluence of the Stanislaus River were approximately 3.5°F higher than baseline temperatures in April and May and 1.3 F higher in June. The daily modeling results indicate that there would be 10 years in which spring water temperatures exceed 57°F for an additional week or more. As discussed under AQUA-3, the ability to moderate these effects by adaptively managing reservoir releases through the rearing and outmigration season would be limited by overall reductions in the total amount of water available for release in most years. Therefore, water temperature impacts on rearing and outmigrating juvenile salmon and steelhead in the Stanislaus River under LSJR Alternative 2 are significant.

The NMFS BO flows on the Stanislaus River are included in the baseline. However, these flows are not included in the WSE modeling of the LSJR alternatives. Instead, the WSE modeling of the LSJR alternatives assumes that a certain percent (i.e., 20, 40, or 60 percent) of unimpaired flow would be met, which may be lower or higher than the NMFS BO flows. As a result, when the WSE model results are compared to baseline, the modeling shows some reductions in flows on the Stanislaus River. However, because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the impacts of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.* No substantial changes occurred in the frequency of suboptimal water temperatures in the Tuolumne and Merced Rivers and the LSJR in April and May (Table s7-13b, c, and d). In June, the only substantial change occurred in the Tuolumne River where water temperatures exceeding the USEPA-recommended criterion (61°F) decreased in frequency by 20 percent and median water temperature decreased by 8.6°F relative to baseline temperatures. Therefore, water temperature impacts on rearing and outmigrating juvenile salmon and steelhead in the Tuolumne and Merced Rivers and the LSJR under LSJR Alternative 2 would be less than significant.

Summer Rearing

Under LSJR Alternative 2, juvenile steelhead in the Stanislaus River would experience higher water temperatures in June. The frequency of June water temperatures exceeding the USEPA-recommended criterion for summer rearing (61°F) increased by 10 percent relative to baseline (Table 7-13a). The median maximum daily water temperature was 1.3°F higher than the median baseline temperature, and there were 6 years in which water temperatures exceeded 61°F for an additional week or more. Little change occurred in the frequency of suboptimal temperatures in July and August relative to baseline. Based on the temperature increases in June, water temperature impacts on rearing steelhead in the Stanislaus River are considered significant. As discussed above, because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely as a result of the LSJR alternatives. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the impacts of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.*

Summer temperatures under LSJR Alternative 2 in the Tuolumne and Merced Rivers decreased relative to baseline temperatures. In the Tuolumne River, the frequency of June water temperatures exceeding the USEPA-recommended criterion for summer rearing (61°F) decreased by 20 percent, and the median water temperature decreased by 8.6°F (Table 7-13b). In the Merced River, the median water temperature decreased by 2.3°F in June(Table 7-13c). Water temperatures in July and August were only slightly lower than baseline temperatures. Summer water temperatures in the LSJR would continue to be unsuitable for juvenile salmonids under LSJR Alternative 2. When compared to baseline, the frequency of June water temperatures exceeding the USEPA recommended criterion for summer rearing remained >90 percent for Alternative 2; however, the median water temperature decreased by 4.1°F. Median water temperatures in July were slightly below baseline, and there was no appreciable change in temperatures between baseline and LSJR Alternative 2 in August. Although water temperatures for rearing steelhead would be improved in June, especially in the Tuolumne River, the benefits would likely be limited because the extent of suitable rearing habitat would continue to be limited by late summer water temperatures. Overall, LSJR Alternative 2 would likely have a less-than-significant impact on summer rearing conditions for juvenile steelhead in the Tuolumne and Merced Rivers and the LSJR.

Adult Migration

Under LSJR Alternative 2, no substantial changes would be expected in the frequency of optimal, suboptimal, and lethal water temperatures for upstream migrating adults in September in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-13a-d). Therefore, water temperature impacts on migrating adult salmon and steelhead would be less than significant.

Spawning and Incubation

Under LSJR Alternative 2, there would be no substantial changes in the frequency of optimal, suboptimal, and lethal water temperatures for Chinook salmon spawning and incubation life stages October–December in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-13a-d). Therefore, water temperature impacts on spawning and incubation life stages would be less than significant.

As described above, LSJR Alternative 2 would result in significant impacts on juvenile rearing and outmigration and summer rearing on the Stanislaus River. An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Rags., tit. 23, § 3777(b)(3)). Potential measures that may be implemented to minimize water temperature impacts on salmonids and other fish species include: (1) development and implementation of a coldwater pool management program designed to maintain best available water temperatures for sensitive fish species and life stages, and (2) working cooperatively with local stakeholders to implement riparian restoration strategies designed to increase shading and improve water temperatures during critical periods (e.g., April–May). The program of implementation for LSJR Alternative 2 states that during the implementation proceeding for the plan amendments, the State Water Board may establish requirements, including minimum reservoir carryover storage or other requirements, to assure that implementation of LSJR flows pursuant to the plan amendments does not have adverse impacts on coldwater pool levels and related fisheries impacts. In addition, the program of implementation also includes recommendations for riparian restoration to minimize temperature concerns in the plan area. However, the effectiveness of these measures would depend on the downstream extent to which water temperatures can be controlled during these critical periods. Given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset potential temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Consequently, significant impacts may still occur under LSJR Alternative 2 with the implementation of these measures. Additional flow in the Stanislaus River during these times of high temperatures could also reduce significant temperature impacts. However, evaluating the impacts of more flow to potential reduce temperatures is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 or reducing the significant impacts identified above cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Impacts would remain significant and unavoidable.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

The expected temperature conditions under LSJR Alternative 3 are summarized in Tables 7-14a–d for each river and then discussed with respect to species life stages below.

Table 7-14a. LSJR Alternative 3 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Stanislaus River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	42.6	44.7	48.7	51.2	54.8	52.7	52.9	53.8	54.1	51.2	49.0	42.5
0.1	45.7	48.2	50.9	55.7	58.4	54.7	58.6	57.5	60.6	54.5	50.9	47.1
0.2	46.9	49.2	52.1	57.0	59.8	56.5	61.0	60.5	65.1	55.3	52.1	48.2
0.3	47.8	49.8	53.0	58.3	60.6	58.4	62.4	61.9	68.5	56.3	53.2	48.7
0.4	48.4	50.3	53.7	59.2	61.5	59.4	63.3	62.6	70.1	57.2	54.0	49.4
0.5	48.9	50.7	54.4	60.0	62.4	60.5	63.8	63.4	71.3	58.1	54.8	50.0
0.6	49.5	51.1	55.2	60.9	63.4	62.5	64.5	64.3	72.2	59.1	55.5	50.5
0.7	50.2	51.9	56.1	61.8	64.4	63.8	65.3	65.1	73.3	61.1	56.4	51.3
0.8	50.9	52.9	57.0	62.8	65.9	65.3	67.0	66.2	74.2	64.5	57.5	51.9
0.9	51.9	54.0	57.8	64.1	67.8	66.8	68.6	68.1	75.4	68.7	58.6	52.8
Max	54.9	57.1	61.8	68.5	74.3	77.3	74.5	75.5	81.9	77.1	66.7	56.1
Avg	48.9	50.9	54.5	60.0	62.9	61.0	63.7	63.2	69.8	59.8	54.9	49.9

Notes: Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-14b. Alternative 3 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Tuolumne River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	43.2	47.6	49.7	51.3	52.6	50.0	51.4	54.8	53.2	51.8	51.9	49.9
0.1	45.9	50.3	52.4	54.0	56.9	51.2	52.9	58.6	60.4	53.5	52.9	51.4
0.2	47.3	51.0	53.2	55.2	57.8	51.8	53.9	59.8	62.8	53.7	53.4	51.8
0.3	48.0	51.5	54.0	56.3	58.7	52.5	57.8	60.4	69.2	53.9	53.7	52.2
0.4	48.7	52.0	54.7	57.2	59.3	53.8	60.1	61.0	71.4	54.2	53.9	52.5
0.5	49.3	52.6	55.4	57.8	59.8	54.8	62.6	64.5	73.1	54.9	54.3	52.8
0.6	49.8	53.3	56.2	58.5	60.5	56.0	70.4	69.3	74.4	55.3	54.6	53.1
0.7	50.3	54.2	57.4	59.3	61.3	57.1	71.9	71.0	76.0	55.8	55.1	53.3
0.8	51.2	55.5	58.8	59.9	62.6	59.1	74.0	72.7	77.1	56.8	56.0	53.7
0.9	52.2	57.4	60.3	61.2	63.8	63.4	75.8	74.4	78.6	58.9	57.0	54.6
Max	55.8	61.8	64.1	64.8	68.9	75.6	79.6	77.4	84.3	77.9	59.1	56.5
Avg	49.2	53.3	55.9	57.7	60.2	55.9	64.6	65.7	71.1	55.7	54.6	52.9

Notes: Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-14c. LSJR Alternative 3 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Merced River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.2	41.5	44.8	46.9	54.2	51.4	56.6	59.2	61.4	43.5	47.1	44.3
0.1	43.4	44.1	47.9	55.9	60.0	56.0	59.0	62.2	66.5	54.7	51.4	47.2
0.2	45.8	45.4	49.2	57.9	61.4	57.4	60.3	63.3	69.3	57.1	52.5	48.3
0.3	46.7	46.9	50.4	59.7	62.2	59.9	64.9	64.2	71.1	58.0	53.4	48.8
0.4	47.4	47.7	52.0	61.1	63.4	61.9	68.6	68.6	73.5	58.8	54.6	49.6
0.5	48.0	48.6	53.0	61.9	64.2	63.5	70.9	71.0	75.8	59.8	55.6	50.1
0.6	49.2	49.2	53.9	62.9	65.2	64.4	72.1	73.6	77.5	60.8	56.2	51.0
0.7	50.4	49.9	54.7	63.7	66.7	65.7	74.9	75.8	78.7	61.6	56.8	51.8
0.8	51.5	51.4	55.7	64.5	67.9	67.1	77.1	77.1	79.7	62.5	58.2	53.1
0.9	52.6	52.5	56.4	65.7	69.4	69.0	78.7	78.5	81.1	64.0	59.9	54.4
Max	53.9	56.7	58.6	70.6	74.6	78.2	84.9	81.7	87.9	80.4	63.3	58.7
Avg	48.2	48.5	52.5	61.4	64.5	62.8	69.6	70.5	74.6	59.3	55.4	50.5

Notes: Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-14d. LSJR Alternative 3 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the LSJR for Each Month of the 1980–2003 Modeling Period

40% Alternative	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.8	47.7	53.8	53.9	59.0	59.3	66.2	67.1	66.7	57.3	47.9	42.2
0.1	44.4	50.8	57.4	59.2	62.2	66.1	70.1	71.8	73.1	64.0	52.9	47.9
0.2	45.9	51.9	58.7	60.3	63.3	67.2	72.3	74.2	74.6	65.5	54.5	48.8
0.3	47.2	52.9	59.8	61.4	64.1	68.1	75.1	75.3	75.4	66.6	55.9	49.7
0.4	47.9	53.7	60.9	62.2	64.9	68.9	76.6	76.2	76.2	67.6	57.0	50.4
0.5	48.8	54.5	61.7	62.8	65.7	69.7	77.6	76.7	77.2	68.5	58.1	51.1
0.6	49.5	55.2	62.5	63.3	66.4	70.9	78.5	77.4	77.8	69.7	58.9	51.6
0.7	50.3	56.2	63.2	63.9	67.2	72.9	79.2	78.0	78.5	70.6	60.2	52.3
0.8	51.1	57.3	64.1	64.9	68.3	74.7	79.9	78.6	79.5	72.2	61.5	52.9
0.9	52.3	58.8	65.7	66.1	69.9	77.4	80.8	79.5	80.6	73.8	63.0	53.9
Max	55.8	63.2	70.3	72.8	74.5	82.0	83.2	83.3	84.5	84.3	66.0	57.6
Avg	48.6	54.6	61.5	62.7	65.8	70.7	76.5	76.3	76.9	68.7	57.9	50.9

Notes: Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Juvenile Rearing and Outmigration

Under LSJR Alternative 3, the frequency of water temperatures exceeding the USEPA-recommended criterion (61°F or 57°F, depending on location and month) in the Stanislaus River would increase by 10 percent in April, remain unchanged in May, and decrease by 10 percent in June. The median water temperatures increased by 1.0°F in April, decreased by 0.3°F in May, and decreased by 1.2°F in June. Overall, changes may not substantially affect long-term survival of rearing and outmigrating salmonids in the Stanislaus River. As discussed under AQUA-3, the seasonal volume of water available for release February–June is equal to or higher than that under baseline conditions in most years (Figure 7-4b). This suggests that sufficient water is frequently available to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. For example, this could be accomplished by shifting releases from February and March and/or May and June to April whenever adverse flows and water temperatures are predicted in April. Consequently, with successful implementation of adaptive flow and temperature management on the Stanislaus River, water temperature impacts on rearing and outmigrating juvenile salmon and steelhead under LSJR Alternative 3 would be less than significant.

In the Tuolumne and Merced Rivers, the frequency of modeled water temperatures exceeding the USEPA-recommended criterion for the spring rearing and outmigration period was reduced by 10–40 percent, and median water temperatures were reduced by 1.8–10.2°F (Tables 7-14b and c). This represents a substantial improvement in spring rearing and outmigration conditions relative to baseline. LSJR Alternative 3 also resulted in lower spring water temperatures in the LSJR. In the LSJR, the frequency of water temperatures being exceeded in April decreased 10 percent of the time relative to baseline. Therefore, there would be beneficial effects on spring rearing and outmigration conditions in the Tuolumne and Merced Rivers and the LSJR. Impacts on spring rearing and outmigration in these rivers would be less than significant.

Summer Rearing

Under LSJR Alternative 3, lower summer water temperatures would be expected in June, while water temperatures would remain largely unchanged in July and August. In June, the frequency of modeled water temperatures exceeding the USEPA-recommended criterion for summer rearing (61°F) decreased by 10 percent in the Stanislaus River , 40 percent in the Tuolumne River, and <10 percent on the Merced River (Tables 7-14a, b, and c). These changes correspond to reductions in median maximum daily temperatures of 1.2°F in the Stanislaus River, 10.2°F in the Tuolumne River, and 3.7°F in the Merced River. Little or no change occurred in the frequency of potentially stressful temperatures in July and August relative to baseline. Summer water temperatures in the LSJR would continue to be unsuitable for juvenile salmonids under LSJR Alternative 3. Exceedances beyond the USEPA recommended criterion for summer would be similar to baseline. Although water temperatures for rearing steelhead would be improved in June, especially in the Tuolumne River, the benefits would likely be limited because the extent of suitable rearing habitat would continue to be limited by late summer water temperatures. Overall, LSJR Alternative 3 would result in less-than-significant impacts on summer rearing conditions on the Stanislaus, Tuolumne, and Merced Rivers and the LSJR.

Adult Migration

Under LSJR Alternative 3, no substantial changes would be expected in the frequency of optimal, suboptimal, and lethal water temperatures for upstream migrating adults in September in the

Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-14a-d). Therefore, water temperature impacts on migrating adult salmon and steelhead would be less than significant.

Spawning and Incubation

Under LSJR Alternative 3, no substantial changes would occur in the frequency of optimal, suboptimal, and lethal water temperatures for Chinook salmon spawning and incubation life stages in October–December in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-14a-d). Therefore, water temperature impacts on spawning and incubation life stages would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

The expected temperature conditions under LSJR Alternative 4 are summarized in Tables 7-15a–d for each river and then discussed with respect to species life stages below.

Juvenile Rearing and Outmigration

Under LSJR Alternative 4, the frequency of water temperatures potentially causing thermal stress in juvenile salmon and steelhead during the spring rearing and outmigration period would be expected to decrease in each of the rivers. The number of days that modeled water temperatures exceeded the USEPA-recommended criterion (61°F or 57°F, depending on location and month) decreased by <10–20 percent in the Stanislaus River, 10–50 percent in the Tuolumne River, ≤10 percent on the Merced River, and ≤30 percent on the LSJR (Tables 7-15a-d). These differences correspond to reductions in median maximum daily temperatures of 0.3–2.4°F in the Stanislaus River, 2.7 –10.6°F on the Tuolumne River, 3.2–5.5°F in the Merced River, and 2.7–4.9°F in the LSJR, depending on the location and month. Therefore, LSJR Alternative 4 is expected to have beneficial effects on rearing and outmigration conditions in the Stanislaus, Tuolumne and Merced Rivers and the LSJR. Impacts would be less than significant.

Summer Rearing

Under LSJR Alternative 4 , lower summer water temperatures would be expected in June, while water temperatures would remain largely unchanged in July and August. In June, the frequency of modeled water temperatures exceeding the USEPA-recommended criterion for summer rearing (61°F) decreased by 20 percent in the Stanislaus River , 50 percent in the Tuolumne River, and 10 percent in the Merced (Tables 7-15a, b and c). These changes correspond to reductions in median maximum daily temperatures of 2.4°F in the Stanislaus River, 10.6°F in the Tuolumne River, and 4.3°F in the Merced River. Little or no change occurred in the frequency of potentially stressful temperatures in July and August relative to baseline. Summer water temperatures in the LSJR would continue to be unsuitable for juvenile salmonids under LSJR Alternative 4. Exceedances beyond the USEPA-recommended criterion for summer would be similar to baseline conditions. However, the median maximum daily water temperatures would decrease by 4.9°F in June, while water temperatures would remain largely unchanged in July and August. Although water temperatures for rearing steelhead would be improved in June, the benefits would likely be limited because the extent of suitable rearing habitat would continue to be limited by late summer water temperatures. Overall, LSJR Alternative 4 would have a less-than-significant impact on summer rearing conditions on the Stanislaus, Tuolumne, and Merced Rivers and the LSJR.

Table 7-15a. LSJR Alternative 4 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Stanislaus River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	42.6	44.7	48.6	50.9	53.9	52.8	52.9	53.8	54.1	51.2	48.9	42.5
0.1	45.6	48.1	50.5	54.9	58.0	54.3	58.7	57.7	60.5	54.6	50.9	47.0
0.2	46.9	49.0	51.7	56.2	59.2	56.1	61.1	60.8	65.3	55.4	52.1	48.2
0.3	47.8	49.7	52.3	57.3	59.9	57.5	62.3	62.3	68.7	56.3	53.2	48.8
0.4	48.4	50.2	53.2	58.0	60.6	58.3	63.3	63.0	70.3	57.2	54.0	49.4
0.5	48.9	50.6	53.7	58.7	61.3	59.3	64.0	63.8	71.5	58.0	54.8	50.0
0.6	49.5	51.2	54.5	59.6	62.1	60.8	64.8	64.6	72.4	59.2	55.5	50.6
0.7	50.2	51.9	55.1	60.3	62.9	62.2	65.6	65.4	73.5	61.4	56.4	51.3
0.8	50.9	52.8	55.7	61.0	64.1	63.5	67.1	66.6	74.2	64.4	57.6	52.0
0.9	51.8	53.8	56.5	62.2	65.7	65.1	69.1	69.4	75.5	68.8	58.3	52.8
Max	54.8	57.5	59.5	66.3	71.3	74.7	71.8	74.0	82.6	77.7	66.7	55.9
Avg	48.9	50.9	53.7	58.7	61.7	59.9	63.7	63.7	70.0	59.9	54.9	50.0

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-15b. Alternative 4 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Tuolumne River for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	43.1	47.6	49.6	51.1	52.7	49.9	51.3	54.8	52.1	51.8	52.0	49.9
0.1	45.8	50.3	52.4	53.8	56.8	51.1	52.8	58.7	59.4	53.4	52.8	51.4
0.2	47.3	50.9	53.1	54.8	57.7	51.7	54.0	59.8	61.4	53.7	53.2	51.8
0.3	48.0	51.3	53.7	55.6	58.5	52.4	57.9	60.5	69.2	53.9	53.5	52.1
0.4	48.7	51.9	54.4	56.3	59.1	53.7	60.4	61.1	71.6	54.4	53.8	52.4
0.5	49.3	52.5	55.0	56.9	59.5	54.4	62.3	65.4	73.3	55.1	54.2	52.7
0.6	49.8	53.1	55.6	57.5	60.0	55.4	71.1	69.9	74.5	55.4	54.6	53.0
0.7	50.3	53.9	56.3	57.9	60.7	56.3	72.7	71.6	76.0	55.9	55.0	53.2
0.8	51.2	55.0	57.1	58.5	61.4	58.1	75.3	73.7	77.1	56.9	55.9	53.7
0.9	52.2	56.4	58.3	59.2	62.6	60.8	77.6	75.8	78.6	58.8	56.8	54.4
Max	55.7	61.7	61.2	62.2	66.2	73.4	82.3	79.2	84.3	77.9	58.5	56.4
Avg	49.2	52.9	55.2	56.7	59.6	55.1	65.3	66.3	70.8	55.7	54.5	52.8

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-15c. LSJR Alternative 4 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the Merced River for Each Month of the 1980–2003 Modeling Period

Merced 60%	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.1	43.8	44.7	46.8	53.2	51.4	56.7	59.1	61.4	43.0	47.1	44.3
0.1	43.4	45.6	47.7	55.0	59.9	55.8	59.0	62.3	66.5	54.8	51.4	47.1
0.2	45.7	46.8	49.0	56.8	61.2	57.3	60.5	63.2	69.5	56.4	52.4	48.1
0.3	46.6	47.5	50.2	58.4	61.9	59.6	65.6	64.2	71.3	57.8	53.4	48.7
0.4	47.3	48.1	51.5	59.7	62.9	61.2	69.5	69.7	73.6	58.7	54.6	49.4
0.5	48.0	48.7	52.5	60.6	63.6	62.9	71.6	71.8	76.0	60.0	55.7	50.0
0.6	49.2	49.3	53.3	61.5	64.4	63.9	73.3	75.1	77.7	60.8	56.2	50.9
0.7	50.3	50.5	54.0	62.2	65.5	65.0	76.2	77.2	78.9	61.9	56.9	51.9
0.8	51.5	51.5	54.8	63.0	66.8	66.3	79.0	78.7	79.9	63.0	58.3	53.1
0.9	52.5	52.5	55.7	64.1	68.0	68.2	80.7	80.3	81.4	65.1	60.3	54.4
Max	53.8	56.5	58.1	68.6	73.4	77.0	85.4	83.6	87.9	80.6	63.7	58.6
Avg	48.1	49.0	52.0	60.1	63.8	62.2	70.5	71.5	74.8	59.5	55.5	50.5

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Table 7-15d. LSJR Alternative 4 Cumulative Distribution of Maximum Daily Water Temperatures (Percent of Time that Specified Water Temperatures were Exceeded) in the LSJR for Each Month of the 1980–2003 Modeling Period

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Min	40.8	47.7	53.7	53.5	58.2	59.7	65.6	66.8	66.3	57.3	47.9	42.2
0.1	44.4	50.7	57.2	58.3	61.7	65.5	70.0	71.8	73.1	64.0	52.9	47.9
0.2	45.9	51.9	58.5	59.5	62.7	66.5	72.0	74.2	74.6	65.5	54.5	48.8
0.3	47.1	52.8	59.5	60.4	63.6	67.3	74.7	75.4	75.4	66.6	55.9	49.7
0.4	47.9	53.6	60.5	61.0	64.3	68.1	76.4	76.2	76.2	67.6	57.0	50.4
0.5	48.8	54.4	61.3	61.7	65.0	68.9	77.4	76.8	77.2	68.5	58.1	51.1
0.6	49.5	55.1	62.1	62.2	65.6	69.8	78.2	77.5	77.8	69.7	58.9	51.6
0.7	50.3	56.1	62.8	62.9	66.6	71.2	79.0	78.0	78.6	70.6	60.2	52.3
0.8	51.1	57.3	63.8	63.7	67.6	73.1	79.8	78.7	79.5	72.2	61.5	52.9
0.9	52.3	58.7	65.2	65.1	69.1	75.8	80.7	79.6	80.6	73.8	63.0	53.9
Max	55.8	62.9	69.4	72.4	74.4	81.1	83.1	83.2	84.5	84.3	66.0	57.6
Avg	48.6	54.5	61.2	61.7	65.2	69.6	76.3	76.3	76.9	68.7	57.9	50.9

Notes:
Dark gray represents a temperature that exceeds a lethal USEPA criterion.
White represents a temperature that exceeds suboptimal temperatures.
Light gray represents a temperature that is within suboptimal temperatures.

Adult Migration

Under LSJR Alternative 4, no substantial changes would be expected in the frequency of optimal, suboptimal, and lethal water temperatures for upstream migrating adults in September in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-15a-d). Therefore, water temperature impacts on migrating adult salmon and steelhead would be less than significant.

Spawning and Incubation

Under LSJR Alternative 4, no substantial changes would occur in the frequency of optimal, suboptimal, and lethal water temperatures for Chinook salmon spawning and incubation life stages October–December in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables 7-15a-d). Therefore, water temperature impacts on spawning and incubation life stages would be less than significant.

AQUA-5: Changes in exposure to pollutants resulting from changes in flow (dilution/mobilization effects)

In general, surface water originating in the three major SJR tributary watersheds is good quality and has low salinity concentrations. As increased flow due to precipitation or reservoir operations mobilizes sediment, pollutant levels in the water column have the potential to increase if present in the sediment. Certain land uses, such as abandoned mining operations, in the tributary watersheds have leached different pollutants into the rivers. These pollutants include toxic trace metals (e.g., copper, zinc, and cadmium) (Boles et al. 1988). This has increased known pollutant concentrations in river sediment, which can result in increased fish mortality.

Increased flows would have the potential to increase mobilization and concentration of pollutants in surface waters in the tributaries and LSJR, potentially increasing exposure of aquatic organisms to toxic substances. However, while copper, zinc, and cadmium tolerance limits exist for juvenile Chinook salmon (Boles et al. 1988) direct effects on fish cannot be accurately or precisely quantified for the LSJR alternatives given the current understanding of the complex processes involved in mobilizing sediment-linked toxins. The volume and concentrations of pollutants that could be mobilized into rivers are generally unknown, and site-specific analyses would be needed to confirm real-time concentrations. However, because pollutants attached to sediment are entering the water column, the potential for increased toxins in the system can be linked to a change in suspended sediment and turbidity. An increased concentration of toxins as a result of increased flows would adversely impact indicator species. However, increased flows would also provide benefits to indicator species by diluting existing pollutants in the water column, and any other pollutants that may be mobilized from the sediment on the bottom of the riverbed and along the river channel.

Decreased flows could increase concentrations of pollutants and, thus, adversely impact fish and wildlife. Decreased flows could also result in increased temperatures, which generally increase the toxic effects of metals and reduce the survival time of Chinook salmon if lethal levels of metals are present. Warming water temperatures can increase pollutant dose because fish respiration and feeding rates must increase to support higher metabolic rates as a result of warmer water temperatures. Additionally, warming water temperatures can reduce the energy reserves that fish utilize to lessen the effects of pollutants (Brooks et al. 2012). Consequently, lower flows and higher temperatures may exacerbate the effects of pollutants (Heugens, et al. 2001).

This assessment is qualitative and based on published literature regarding dilution and mobilization effects that can be expected to result from the LSJR alternatives. The information is qualitatively discussed below and assumes that dilution from increased flow would result in long-term improvement in water quality conditions in the rivers. (For a description of expected changes to sediment and turbidity resulting from increased flows see AQUA-6.)

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

Lower flows in the month of April during juvenile rearing and outmigration (AQUA-3) and potential thermal stress to fish (AQUA 4) is expected as a result of LSJR Alternative 2 on the Stanislaus River. Low flows and high water temperatures could result in low dilution effects and increased vulnerability of fish to the effects of pollutants. Thus, it is expected there will be an increased risk of long-term effects on the health of juvenile salmonids and other fish species. This would be a significant impact.

Because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the effects of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.*

An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Rags., tit. 23, § 3777(b)(3)). As discussed under AQUA-4, ppotential measures that may be implemented to minimize water temperature impacts on salmonids and other fish species include: (1) development and implementation of a coldwater pool management program designed to maintain best available water temperatures for sensitive fish species and life stages, and (2) working cooperatively with local stakeholders to implement riparian restoration strategies designed to increase shading and improve water temperatures during critical periods (e.g., April–May). However, given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset potential temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Consequently, significant impacts may still occur under LSJR Alternative 2 with the implementation of these measures. Additional flow to reduce temperatures and potentially decrease pollutant concentrations may also reduce significant impacts. However, evaluating the effects of more flow to potentially reduce temperatures is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce the significant impacts identified above cannot be independently applied because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Impacts would remain significant and unavoidable.

Flows are not expected to greatly differ from baseline conditions on the Tuolumne River (see AQUA-3). Additionally, water temperatures are expected to remain within acceptable limits during the different life stages of salmonids and other fish species. Therefore, a decrease in dilution effects and an increase in the risk of exposure to pollutants are not expected to lead to long-term effects on the health of juvenile salmonids and other fish species. Although there may be lower spring flows on the Merced River in April (AQUA-3) and the LSJR, the overall volume of water February–June would remain similar to baseline and thus would be adaptively managed to avoid impacts on fish and wildlife. In addition, water temperatures are expected to remain within acceptable limits during the life stages on the Merced River and LSJR and, thus, are not expected to represent a stress to fish. Exposure to pollutants would have a less-than-significant impact on the Tuolumne and Merced Rivers and the LSJR.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Lower flows in the month of April during juvenile rearing and outmigration (AQUA-3) and increases in thermal stress to fish (AQUA-4) are expected as a result of LSJR Alternative 3 on the Stanislaus River. Low flows and high water temperatures could result in low dilution effects and increased vulnerability of fish to the effects of pollutants. However, the total amount of water that would be released in the February–June period under LSJR Alternative 3 is equal to or higher than the volume of water released under baseline conditions in most years. Consequently, although model results indicate frequent reductions in monthly flows in April, the overall availability of water appears to be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. This is because baseline conditions and conditions under LSJR Alternative 3 are approximately 40 percent of the average unimpaired flow. For example, optimizing rearing and outmigration conditions could be accomplished by shifting releases from February and March and/or May and June to April whenever adverse flows and water temperatures are predicted in April. Therefore, lower flows in April and increases in thermal stress to fish would not occur, and the resulting low dilution effects and increased vulnerability of fish to the effects of pollutants would not occur. Thus, changes in exposure to pollutants under LSJR Alternative 3 would be less than significant.

Flows are expected to generally increase on the Tuolumne and Merced Rivers and not substantially change on the LSJR from baseline conditions (see AQUA-3). Additionally, the frequency of water temperatures exceeding the USEPA-recommended criterion for spring rearing and outmigration period is expected to be reduced by 10–40 percent on the Tuolumne and Merced Rivers. Dilution would potentially increase and, therefore, not result in an increase in the risk of exposure or long-term effects on the health of juvenile salmonids and other fish species. This would be a less-than-significant impact.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

LSJR Alternative 4 is expected to have overall higher flows than those described above for LSJR Alternative 3. Therefore, the impacts under LSJR Alternative 4 would be similar to those described above for LSJR Alternative 3. Dilution would be expected to increase and, therefore, not result in an increase in the risk of exposure or long-term effects on the health of juvenile salmonids and other fish species. Impacts would be less than significant.

AQUA-6: Changes in exposure to suspended sediment and turbidity resulting from changes in flow (mobilization)

Higher flows generally have a higher capacity to mobilize and transport sediment in rivers, resulting in higher concentrations of suspended sediment and reduced water clarity (i.e., increased turbidity). Suspended sediments, such as clay, silt, organic matter, plankton and other microscopic organisms, cause turbidity in water that can interfere with photosynthetic primary productivity, water temperature, DO, and fish feeding habits. During high-flow events, high concentrations of suspended sediment can temporarily bury stream substrates that provide habitat for aquatic invertebrates and important food sources for many indicator species . Sediment that falls out of suspension may also reduce the quality of spawning substrates and has the potential to entomb or suffocate eggs and larvae in stream gravels. Other common effects of suspended sediment on fish include displacement from key habitats, physiological stress and respiratory impairment, damage to gills, reduced tolerance to disease and toxicants, and direct mortality at very high levels (Newcombe and Jensen 1996; Bash et al. 2001).

High turbidity levels generally reduce the efficiency of piscivorous (fish-eating) and planktivorous (plankton-eating) fish in finding and capturing their prey (Henley et al. 2000). Higher turbidity may favor the survival of young fish by protecting them from predators (De Robertis et al. 2003) but can also reduce the feeding rates of young fish that depend on sight to detect prey (Newcombe and Jensen 1996). Typically, when waters are turbid, predator success rate is less. Juvenile salmon losses to predators may be reduced by at least 45 percent in turbid-water stream reaches relative to clear-water reaches (Gregory and Levings 1998). Turbid water may also stimulate faster migration rates, which reduces the time young fish are exposed to freshwater mortality risks (USBR 2008). However, if waters become too turbid, suspended particles that are entrained through the gills of fish can cause physical injury.

Under baseline conditions, gravel transport is estimated to occur at flows between 5,000 and 8,000 cfs in the Stanislaus River(Kondolf et al. 2001), between 7,050 and 9,800 cfs in the upper reaches of the Tuolumne River (McBain and Trush 1999), and at flows greater than 4,800 cfs in the upper reaches of the Merced River (Stillwater Sciences 2001; Kondolf et al. 1996). Flows below these levels (above approximately 2,000–3,000 cfs) can mobilize finer sediment in the mid- to lower sand-bedded portions of these tributaries, potentially increasing suspended sediment and turbidity in the lower reaches of these tributaries and the LSJR. In the southern Delta low turbidity contributes to poor feeding conditions and potentially higher predation rates on delta smelt and other pelagic species. For delta smelt, it appears that turbidity enhances visual contrast and detection of prey. Feeding of other planktivorous species such as longfin smelt may also be similarly affected by turbidity (Nobriga et al. 2008; USBR 2011).

A major source of sediment and turbidity is overbank flows that exceed their channel capacities and cause bank erosion and channel migration. With the exception of the highest flood flows, the LSJR, three tributaries, and Bay-Delta all transport their respective flows within their channels (Table 6-2; USACE 1999). Also, higher flows may cause gravel transport (bed mobilization), bank erosion, and an initial temporary increase in suspended sediment and turbidity in the SJR through short-term bed and bank scour of previously immobile material. To evaluate potential impacts from changes in exposure to suspended sediment and turbidity, changes in flows are compared to channel capacities and inundation of the floodway along the LSJR, major SJR tributaries, and Bay-Delta, and this information is used to determine if flows under the LSJR alternatives would increase flooding (overbank flows) and erosion and sedimentation rates in the adjacent channels.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

Under LSJR Alternative 2, modeling of peak flows based on 1999–2008 hydrology indicates flows would remain below the current capacities of the existing channels and thresholds associated with gravel mobilization in the upper reaches of the major SJR tributaries (Table 7-16; Chapter 6, *Flooding, Sediment and Erosion*, FLO-1). Although peak flows may sometimes exceed levels associated with sediment mobilization in lower sand-bedded portions of the tributaries and SJR, changes in the frequency, duration, and magnitude of increased suspended sediment and turbidity levels are expected to be minor and within the range of historical levels experienced by native fishes and other aquatic species. Therefore, no long-term changes in sediment dynamics or sediment-related impacts on aquatic resources are expected to occur. Impacts would be less than significant**.**

Table 7-16. Peak Monthly Flow Estimates Reached and Percent of Channel Capacity for each Major SJR Tributary (cubic feet per second)

Water Year	LSJR Alternative 2/% Channel Capacity Stanislaus River	LSJR Alternative 2/% Channel Capacity Tuolumne River	LSJR Alternative 2/% Channel Capacity Merced River
1999	960/12	1780/12	900/15
2000	640/8	1360/9	720/12
2001	720/9	1220/8	400/7
2002	1040/13	1700/11	880/15
2003	600/8	820/5	480/8
2004	1760/22	2760/18	1540/26
2005	1760/22	2620/17	1600/27
2006	400/5	820/5	380/6
2007	620/8	1200/8	640/11
2008	900/11	1820/12	960/16

Notes:

Information is summarized from Tables 6-9, 6-10, and 6-11 in Chapter 6, *Flooding, Sediment, and Erosion*.

Channel Capacities are presented in Tables 6-3, 6-4, and 6-5 in Chapter 6, *Flooding, Sediment and Erosion*.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Similar to LSJR Alternative 2, peak flows under LSJR Alternative 3 are not expected to affect the frequency of overbank or bed mobilization flows in the Stanislaus, Tuolumne, and Merced Rivers (Table 7-17; Chapter 6, *Flooding, Sediment and Erosion* FLO-1). As described in Chapter 6 (FLO-1), peak flows would occasionally be sufficient to cause gravel transport in the upper gravel-bedded reaches and some instream bank erosion, but the frequency and magnitude of these events would not be sufficient to cause long-term changes in sediment transport rates. Higher rates of sediment transport are also expected to occur in the lower sand-bedded portions of the major SJR tributaries and the SJR, but the frequency, duration, and magnitude of increased suspended sediment and turbidity levels are expected to be minor and within the range of historical levels experienced by native fishes and other aquatic species. Furthermore, such movement has been documented to support aquatic habitat enhancement (McBain and Trush 1999; Kondolf et al. 2001). Therefore, no long-term changes in sediment dynamics or sediment-related impacts on aquatic resources are expected to occur. Impacts would be less than significant**.**

Table 7-17. Peak Monthly Flow Estimates and Percent of Channel Capacity for each Tributary (cubic feet per second)

Water Year	LSJR Alternative 3/% Channel Capacity of the Stanislaus River	LSJR Alternative 3/% Channel Capacity of the Tuolumne River	LSJR Alternative 3/% Channel Capacity of the Merced River
1999	1920/24	3560/24	1800/30
2000	1280/16	2720/18	1440/24
2001	1440/18	2440/16	800/13
2002	2080/26	3400/23	1760/29
2003	1200/15	1640/11	960/16
2004	3520/44	5520/37	3080/51
2005	3520/44	5240/35	3200/53
2006	800/10	1640/11	760/13
2007	1240/16	2400/16	1280/21
2008	1800/23	3640/24	1920/32

Notes:

Information is summarized from Tables 6-9, 6-10, and 6-11 in Chapter 6, *Flooding, Sediment and Erosion*.

Channel Capacities are presented in Tables 6-3, 6-4, and 6-5 in Chapter 6, *Flooding, Sediment and Erosion*.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Under LSJR Alternative 4, peak flows are expected to remain below the capacities of the existing channels and thresholds associated with gravel mobilization in the upper reaches of the major SJR tributaries (Table 7-18; Chapter 6, *Flooding, Sediment and Erosion*, FLO-1). Compared to Alternative 3, peak flows would exceed the thresholds for sand mobilization more frequently and occasionally exceed 60 percent of channel capacity, which has the potential to cause localized bank erosion in the Stanislaus and possibly the Merced Rivers. Higher flows may cause an initial increase in suspended sediment and turbidity through short-term bed and bank scour of previously immobile material. However, the effects would likely be periodic in nature and unlikely to produce levels high enough to significantly impact salmonids or other native fishes. Additionally, such movement supports aquatic habitat enhancement (McBain and Trush 1999; Kondolf et al. 2001). Furthermore, sediment carried into the southern Delta could be considered beneficial to delta smelt and other pelagic fish species in the southern Delta, since the Delta is known to be limited with respect to suspended sediment. Impacts would be less than significant.

Table 7-18. Peak Monthly Flow Estimates and Percent of Channel Capacity for each Tributary (cubic feet per second)

Water Year	LSJR Alternative 4 /% Channel Capacity Stanislaus River	LSJR Alternative 4/% Channel Capacity Tuolumne River	LSJR Alternative 4 /% Channel Capacity Merced River
1999	2880/ 6	5340/36	2700/45
2000	1920/24	4080/27	2160/36
2001	2160/27	3660/24	1200/20
2002	3120/39	5100/34	2640/44
2003	1800/23	2460/16	1440/24
2004	5280/66	8280/55	4620/77
2005	5280/66	7860/52	4800/80
2006	1200/15	2460/16	1140/19
2007	1860/23	3600/24	1920/32
2008	2700/34	5460/36	2880/48

Notes:

Information is summarized from Tables 6-9, 6-10, and 6-11 in Chapter 6, *Flooding, Sediment and Erosion*.

Channel Capacities are presented in Tables 6-3, 6-4, and 6-5 in Chapter 6, *Flooding, Sediment and Erosion*.

AQUA-7: Changes in redd dewatering and fish stranding losses resulting from flow fluctuations

Reservoir operations can result in unnatural fluctuations in river flows that can dewater or strand redds and juvenile Chinook salmon and steelhead. Redds are considered stranded when water levels drop below the tail spill (gravel pushed behind the redd during spawning) of the redd and are considered dewatered when the surface of the hyporheic zone (the region beneath and alongside a streambed where there is mixing of shallow groundwater with surface water) drops below the egg pockets (where female fish deposit eggs in a stream). The quality of the hyporheic habitat for embryonic and larval salmonids in redds varies depending on spawning site selection, construction, and maintenance of redds (Williams 2006). Spawning site selection depends on the presence of suitable water depths and velocities for adult spawning activities and redd construction. Suitable spawning sites are also characterized by bed topography that facilitates flow exchange through the gravel, as occurs in the transitional area between a pools and riffles (Shapovalov and Taft 1954) or where larger channel features induce upwelling or down welling (Geist et al. 2001). Following egg deposition and completion of redd construction, the survival of eggs and pre-emergent fry depends on the maintenance of suitable hyporheic flow, water temperatures, and DO levels. Eggs can tolerate temporary dewatering provided that the temperature remains suitable and the eggs remain moist (Becker et al. 1982; McMichael et al. 2005). Alevins are more sensitive to dewatering because of their dependence on hyporheic flow and relatively high concentrations of DO in the surrounding water.

Impacts related to redd dewatering and fish stranding are based on habitat suitability criteria for spawning depth preferences and egg pocket depths. Most Chinook salmon and steelhead/rainbow trout spawning occurs at water depths greater than about 0.50 feet[10] (USFWS 2010). Assuming that eggs are buried approximately 0.50 feet below the original streambed level (DeVries 1997), the analysis of dewatering or stranding impacts was based on a median reduction of 1 foot or more during the primary Chinook salmon and steelhead incubation season (October–March). However, since the flows in the major SJR tributaries are very similar to baseline conditions October–January, only February and March were evaluated. Flow rating curves presented in Table 7-19 below were utilized to calculate the depth of flow using the resulting monthly average flows (October–March) for each major SJR tributary under LSJR Alternatives 2, 3, and 4. These curves describe the relationships between river stage and flow at the gage locations in Table 7-19 and may not be representative of the relationships for existing spawning locations in these tributaries. Therefore, the results are used here only to evaluate the relative magnitude or potential for redd dewatering. The percent of time that depth was reduced by 1 foot or greater from the previous month was then determined for LSJR Alternatives 2, 3, and 4 and the baseline. An increase of 10 percent or more in the frequency of monthly flow reductions of 1 foot or more during the primary spawning and incubation months was considered a significant impact. The results are shown in Tables 7-20a, 20b, and 20c. A positive value indicates an increase in the frequency of flow reductions of 1 foot or more and a negative value indicates a decrease in the frequency of flow reductions of 1 foot or more.

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[15] Alternative habitat suitability criteria for spawning depth preferences include 0.6 feet (Raleigh et al. 1984), 0.65 feet (Raleigh et al. 1986), and 0.98 feet (Geist and Dauble 1998).

Table 7-19. Flow Rating Curves for the Major SJR Tributaries

Stanislaus at Goodwin		Tuolumne at La Grange		Merced at Crocker Huffman	
flow (cfs)	depth (feet)	flow (cfs)	depth (feet)	flow (cfs)	depth (feet)
250	2.4	250	2.0	250	2.0
500	3.0	500	2.6	500	2.5
750	3.5	750	3.1	750	2.9
1000	3.9	1000	3.5	1000	3.2
1250	4.2	1250	3.8	1250	3.5
1500	4.5	1500	4.1	1500	3.7
1750	4.7	1750	4.4	1750	3.9
2000	4.9	2000	4.6	2000	4.1
2250	5.1	2250	4.8	2250	4.2
2500	5.3	2500	5.0	2500	4.4
2750	5.5	2750	5.2	2750	4.5
3000	5.7	3000	5.4	3000	4.6
3250	5.9	3250	5.6	3250	4.8
3500	6.0	3500	5.8	3500	4.9
3750	6.2	3750	5.9	3750	5.0
4000	6.3	4000	6.1	4000	5.1
4250	6.4	4250	6.2	4250	5.2
4500	6.6	4500	6.4	4500	5.3
4750	6.7	4750	6.5	4750	5.4
5000	6.8	5000	6.6	5000	5.5

cfs = cubic feet per second

Table 7-20a. Percent of Time Greater than 1 foot Decrease in Depth from Previous Month for the Stanislaus River

	FEB	MAR
Baseline	6	7
LSJR Alternative 2		
% of time greater than 1 foot decrease	6	21
Difference between Baseline and LSJR Alternative 2	0	14
LSJR Alternative 3		
% of time greater than 1 foot decrease	5	22
Difference between Baseline and LSJR Alternative 3	-1	15
LSJR Alternative 4		
% of time greater than 1 foot decrease	4	18
Difference between Baseline and LSJR Alternative 4	-2	11

Table 7-20b. Percent of Time Greater than 1 foot Decrease in Depth from Previous Month for the Tuolumne River

	FEB	MAR
Baseline	5	4
LSJR Alternative 2		
% of time greater than 1 foot decrease	10	6
Difference between Baseline and LSJR Alternative 2	5	2
LSJR Alternative 3		
% of time greater than 1 foot decrease	7	4
Difference between Baseline and LSJR Alternative 3	2	0
LSJR Alternative 4		
% of time greater than 1 foot decrease	5	4
Difference between Baseline and LSJR Alternative 4	0	0

Note: negative numbers indicate a reduction in the occurrence of 1 foot depth exceedances.

Table 7-20c. Percent of Time Greater than 1 foot Decrease in Depth from Previous Month for the Merced River

	FEB	MAR
Baseline	4	15
LSJR Alternative 2		
% of time greater than 1 foot decrease	7	24
Difference between Baseline and LSJR Alternative 2	3	9
LSJR Alternative 3		
% of time greater than 1 foot decrease	9	15
Difference between Baseline and LSJR Alternative 3	5	0
LSJR Alternative 4		
% of time greater than 1 foot decrease	10	7
Difference between Baseline and LSJR Alternative 4	6	-8

Note: negative numbers indicate a reduction in the occurrence of 1 foot depth exceedances.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

The modeling results for LSJR Alternative 2 indicate that the potential for significant redd dewatering and fish stranding impacts would exist only on the Stanislaus River in March based on predicted changes in the frequency of flow reductions of 1 foot or more in each of the major SJR tributaries (Tables 7-20a, b, and c). Specifically, increases in the frequency of flow reductions of 1 foot or more by 14 percent in March could substantially increase the frequency of dewatering and stranding impacts on steelhead redds and Chinook salmon fry in the Stanislaus River.

An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Regs., tit. 23, § 3777(b)(3)). Evaluating the effects of more flow to potentially reduce red dewatering and fish stranding is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce the impacts identified above cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). However, as specified by the NMFS BO, USBR is required to create a Stanislaus Operations Group (SOG) to make recommendations to implement the flow schedule prescribed in the NMFS BO and make adjustments to water operations, as needed, to further protect steelhead in the Stanislaus River. The flow management strategy would include adaptive management of pulse flows to improve attraction flows for adults and outmigration flows for juveniles, as well as measures to minimize impacts of flow fluctuations on steelhead spawning, incubation, and juvenile rearing in the Stanislaus River. Because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the effects of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses*. Thus, while implementation of the NMFS BO and adaptive management of flows to protect steelhead from impacts of flow fluctuations would be in effect, the ability to effectively manage flows would be constrained by reductions in the total volume of water that would be available for release February–June in most years under LSJR Alternative 2 (see AQUA-3). Therefore, redd dewatering and stranding impacts on steelhead redds and Chinook salmon fry in the Stanislaus River under LSJR Alternative 2 would be significant and unavoidable.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

The modeling results for LSJR Alternative 3 indicate that the potential for significant redd dewatering and fish stranding impacts on the Stanislaus River in March(Table 7-20a). However, the overall volume of water between February–June would be similar to baseline conditions such that there would be sufficient water to adaptively manage flows to minimize potential redd dewatering and stranding impacts. All other rivers would either result in no change from the baseline with respect to redd dewatering or a reduction in the potential for redd dewatering (Tables 20b and c). Therefore, redd dewatering and stranding impacts on Chinook salmon and steelhead populations in the Stanislaus, Tuolumne, and Merced Rivers under LSJR Alternative 3 would be less than significant.

LSJR Alternative 4:60% Unimpaired Flow (Less than significant)

The modeling results for LSJR Alternative 4 indicate that the potential for redd dewatering and fish stranding impacts would be similar to that described above for LSJR Alternative 3 (Tables 7-20a, b, and c). However, the overall volume of water between February–June would be similar to baseline conditions such that there would be sufficient water to adaptively manage flows to minimize redd dewatering and stranding impacts. All other rivers would either result in no change from the baseline with respect to redd dewatering or a reduction in the potential for redd dewatering (Tables 20b and c). Therefore, redd dewatering and stranding impacts on Chinook salmon and steelhead populations in the Stanislaus, Tuolumne, and Merced Rivers under LSJR Alternative 4 would be less than significant.

AQUA-8: Changes in spawning habitat quality (spawning gravel) resulting from changes in peak flows

Variability in stream flow during the spawning season, combined with diverse channel topography, provides variation in depth and velocity that is an important mechanism for distributing spawning within different channel locations. This mechanism maximizes available spawning habitat and may reduce scour and superimposition (same redd sites being used by later spawning fish) mortality on incubating eggs. Low, nonfluctuating flow releases that do not incorporate variability may produce the undesirable consequence of limiting spawning to the center of the channel as opposed to margin habitat, which encourages salmon to construct their redds on top of pre-existing redds (redd superimposition), and increasing the vulnerability of egg pockets to scour during moderate or large floods (McBain and Trush 1999). Redd superimposition by fall-run Chinook salmon has been reported in the Tuolumne River and in the Stanislaus River (Mesick 2001).

Higher flows cause bed mobilization and a more secure gravel supply thus maintaining the quantity and quality of alluvial deposits that provide Chinook salmon spawning habitat (McBain and Trush 2000). However, high flows can also negatively affect redds by scouring the gravel away down to the depth of the eggs and washing the eggs out or by piling more gravel and fine sediment on top of the redds so alevins are unable to emerge or are suffocated (USBR and DWR 2003). Baseline gravel transport conditions are summarized above in AQUA-6 and Chapter 6, *Flooding, Sediment, and Erosion*. In the Stanislaus River, gravel transport in the upper reaches is estimated to begin in the range of 5,000 to 8,000 cfs (Kondolf et al. 2001). According to McBain and Trush (1999), gravel transport in the upper reaches of the Tuolumne River is estimated to begin at flows of 7,050 to 9,800 cfs. For the Merced River, Harrison et al. (2011) found that gravel movement primarily occurred at discharges between 4,255 and 5,015 cfs. It is assumed the above flow values for bed mobilization are representative of the whole spawning reach that is utilized by salmon and steelhead on each of the major SJR tributaries.

Currently, salmonids have limited spawning areas on the major SJR tributaries. These areas include: the 23-mile reach in the Stanislaus River between Goodwin Dam and the town of Riverbank, the 25-mile reach of the Tuolumne River between LaGrange Dam and the town of Waterford, and the 24-mile reach of the Merced River between the Crocker-Huffman Dam and the town of Cressy (USFWS 1995).

In order to determine potential impacts on spawning habitat quality, the primary salmon and steelhead spawning and incubation period (October–March), baseline conditions are compared against the simulated LSJR Alternatives 2, 3, and 4 with regard to exceeding the reported thresholds for bed mobilization for each of the major SJR tributaries. The following flows were used as thresholds that initiate bed mobilization: 5,000 cfs for the Stanislaus River, 7,050 cfs for the Tuolumne River, and 4,255 cfs for the Merced River. The assessment also takes into account mechanisms that drive changes in spawning habitat quality at flows lower than needed for bed mobilization.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

Flows that could result in bed mobilization as a result of peak flows are described in AQUA-6 for LSJR Alternative 2. The frequency of flows capable of causing bed movement resulting in changes in spawning habitat quality would not be different from baseline conditions. Consequently, this would be a less-than-significant impact on changes in spawning habitat in the major SJR tributaries.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Higher peak flows are expected under LSJR Alternative 3 as described in AQUA-6; however, they would not be expected to occur with the frequency or duration such that they would damage existing spawning habitat. When the peak flows occur, they would be expected to provide more variability in depth and velocity. This can be an important mechanism for distributing some spawning habitat within different channel locations and could maximize available spawning habitat. Consequently, LSJR Alternative would have less-than-significant impacts on changes in spawning habitat in the major SJR tributaries.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Higher peak flows are expected to occur under LSJR Alternative 4 as described in AQUA-6; however, they would not be expected to occur with the frequency or duration such that they would damage existing spawning habitat. This would be expected to provide variation in depth and velocity, which are important mechanisms for distributing spawning habitat. Therefore, it is expected salmonids would generally benefit from this variability. LSJR Alternative 4 is expected to have a less than significant impacts on changes in spawning habitat.

AQUA-9: Changes in food availability resulting from changes in flow, nutrient transport, and water quality (food web support)

Food web support includes nutrient availability and cycling of food production, and food availability. Physical and chemical processes occurring in an ecosystem provide the structure in which biological constituents can develop; thus, organisms that provide the food base for fish species are affected by the same environmental conditions that affect indicator species. Food web support is essential to maintain species diversity, abundance, and distribution within an aquatic community. Changes in other environmental conditions, such as riparian vegetation, flow, channel morphology, water quality, instream habitat components, pollution inputs, and floodplain and off-channel habitat access can impact nutrient cycling, food availability and food web dynamics (Spence et al. 1996). The primary processes that alter food web support include magnitude and frequency of bed mobilizing flows and floodplain inundating flows.

The impacts of the alternatives on primary and secondary production, nutrient input, and other environmental processes and conditions that could increase or decrease food availability for indicator species were qualitatively evaluated in the assessment of potential fisheries impacts related to food resources and food web support. In general, increased spring flows were assumed to create and improve aquatic and riparian habitat, increase aquatic production, and nutrient input from terrestrial sources. In addition, increased magnitude and frequency of bed mobilizing flows and floodplain connectivity were assumed to improve nutrient transport and cycling in the major SJR tributaries and LSJR (see Appendix C, *Technical Report on the Scientific Basis for Alternatives San Joaquin River Flow and Southern Delta Salinity Objectives*).

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

The primary processes that alter food web support, including the magnitude and frequency of bed mobilizing flows and floodplain inundating flows (see AQUA-6 and 8), are not expected to change substantially under LSJR Alternative 2. Furthermore, Figures 7-4a and 7-6a show relatively little evidence for increased floodplain inundation in the Stanislaus and Merced River. There is some potential for increased floodplain inundation in the Tuolumne River as depicted by Figure 7-5a. Since the frequency of peak flows that would inundate the floodplain would not substantially change under LSJR Alternative 2, impacts on food availability resulting from changes in flow, nutrient transport, and water quality (food web support) would be less than significant on the major SJR tributaries.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

The primary processes that alter food web support, including the magnitude and frequency of bed mobilizing flows and floodplain inundating flows (see AQUA-6 and 8), are not expected to change substantially under LSJR Alternative 3. Figures 7-4a and 7-6a show relatively little evidence for increased floodplain inundation in the Stanislaus and Merced River. There is some potential for increased floodplain inundation in the Tuolumne River as depicted by Figure 7-5a. Impacts on food availability resulting from changes in flow, nutrient transport, and water quality (food web support) would be less than significant on the major SJR tributaries.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

LSJR Alternative 4 has flows greater in all months on the major SJR tributaries and the LSJR (Figures 7-4a, 5a, 6a, and 7a. However, even with greater median flows, the primary processes that alter food web support, including the magnitude and frequency of bed mobilizing flows and floodplain inundating flows (see AQUA-6 and 8), are not expected to change substantially under LSJR Alternative 4. LSJR Alternative 4 has similar impacts as those described above for LSJR Alternative 3. Impacts on food availability resulting from changes in flow, nutrient transport, and water quality (food web support) would be less than significant on the major SJR tributaries.

AQUA-10: Changes in predation risk resulting from changes in flow and water temperature

Predation pressures on indicator species are considerable under baseline conditions (SJRGA 2009, 2010). Predation impact mechanisms include changes in ecosystem structure that increase prey vulnerability or increase predator feeding efficiency. Several physical impact mechanisms may contribute to increased predation, including alterations inflow regime, removal of riparian cover, changes in turbidity, and reduced habitat heterogeneity. Increased prey vulnerability is also associated with other environmental conditions, including water temperature conditions, water diversions, change in water surface level, increase pollutant concentration, and fishing (Spence et al. 1996). These mechanisms generally alter predator-prey relationships by disrupting or reducing cover, space, and refuge.

Predation pressures come from a variety of native and non-native species and are exacerbated by water management and structures located within the rivers in the plan area and physical conditions of the river (e.g., temperature). Fish, avian, and wildlife species that prey on steelhead and fall-run Chinook salmon in the plan area include striped bass, Sacramento pikeminnow, smallmouth bass, trout, largemouth bass, seagulls, mergansers, cormorants, river otters, herons, sea lions, and seals (USDOI 2008). Infrastructure or operational elements of the water conveyance system may lead to behavioral changes, metabolic disruption, or other biological and ecological outcomes that increase prey vulnerability to predators. Increased water temperatures or other environmental conditions may place increased metabolic demands on susceptible groups of fish and hinder their flight response or capability to take refuge from threats by predation (Spence et al. 1996). Specifically, warm water temperatures may impact the performance of young salmon or enhance habitat conditions favorable to predatory fishes, thereby increasing losses of young Chinook salmon to predators (Boles et al. 1988). Reductions in shaded riverine aquatic cover can expose fish to increased risk of capture by avian or terrestrial predators.

Predation-related impacts are evaluated qualitatively and identify the potential for the LSJR alternatives to create or modify environmental conditions that could increase or decrease the vulnerability of indicator fishes to predation. The assessment is based on potential changes in predator-prey interactions that could result from altered flow and temperature conditions. Lower flows are expected to result in warmer and slower (e.g., reduced flow velocity) habitat conditions favored by nonnative predators and decrease in habitat suitability for native species. Thus, results from AQUA-3 and AQUA-4 are incorporated in the evaluation, where appropriate.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

Lower flows and higher temperatures are expected on the Stanislaus River when compared to baseline for certain life stages, specifically juvenile rearing and outmigration and summer rearing (see AQUA-3 and AQUA-4). These lower flows are expected to result in warmer and slower (e.g., reduced flow velocity) habitat conditions favored by nonnative predators. Additionally, it is expected that a decrease in habitat suitability for native species may result. Lower flows afford prey with a smaller volume of water in which to disperse. Bowen and Bark (2010) identified that predation appears to be a function of river flow, and high predation rates result from lower flows when smolts and predators are concentrated into a smaller volume of water (see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta*

Salinity Objectives). Therefore, increases in thermal stress for rearing/emigrating salmonids on the Stanislaus River would alter predator-prey relationships by increasing prey vulnerability and predator feeding efficiency. A combination of reduced flows and thermal stress on the Stanislaus River is expected to impair predator avoidance ability, resulting in significant impacts. Because the State Water Board's plan amendment would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the effects of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.*

An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Regs., tit. 23, § 3777(b)(3)). Evaluating the effects of more flow to potentially reduce predation effects is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce the significant impacts identified above cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Potential measures that may be implemented to minimize predation impacts on salmonids and other fish species include: modifying in-river gravel pits, restoration of key fluvial geomorphic processes by creating floodplain and riffle habitat, gravel supplementation, and the reestablishment of riparian vegetation on floodplains and other areas, where feasible. Typically the expense of modifying in-river gravel pits is prohibitive and would need to be implemented on a relatively large scale to be effective. Other measures, such as gravel supplementation, may reduce exposure of juvenile salmonids to predators, but their effectiveness in reducing overall levels of predation mortality has not been demonstrated (Stanislaus River Fish Group 2003). Because of the timing and overall volume of reduction of flows in the Stanislaus River, it is unlikely that these types of restoration actions by other agencies would effectively mitigate impacts related to predation. As discussed in AQUA-4, there are some possible measures that could help to reduce temperature effects related to increased predation (e.g., riparian restoration); however, the effectiveness of these measures would depend on the downstream extent to which water temperatures can be controlled during the late spring when predation rates are likely to be highest. Given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Consequently, significant impacts related to increased predation may still occur on the Stanislaus River under LSJR alternative 2 with the implementation of these measures. Impacts would remain significant and unavoidable.

Flows and temperatures would remain relatively unchanged on the Tuolumne River and, therefore, an increase in predation risk is not anticipated. Lower monthly median flows are expected on the Merced River and the LSJR in April when compared to baseline. Thermal stress of fish is not expected on these two rivers because the overall volume of water released in the February–June period would be similar to baseline conditions and be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile rearing and outmigrating salmonids. Consequently, although model results indicate frequent reductions in median monthly flows in April, the overall availability of water appears to be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. For example, this could be accomplished by shifting releases from February and March and/or May and June to April whenever low flows and high water temperatures are predicted in April. Consequently, the lower flows in the Merced and LSJR would not necessarily be expected to result in increased prey vulnerability. Impacts on the Tuolumne, Merced, and LSJR would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Lower median monthly flows in the month of April during juvenile rearing and outmigration (see AQUA-3) and increases in thermal stress could alter predator-prey relationships by increasing prey vulnerability and predator feeding efficiency under LSJR Alternative 2 on the Stanislaus River. However, the total amount of water that would be released in the February–June period (see AQUA-3) under LSJR Alternative 3 on the Stanislaus River is equal to or higher than the volume of water released under baseline conditions in most years. Consequently, although model results indicate frequent reductions in median monthly flows in April, the overall availability of water appears to be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. For example, this could be accomplished by shifting releases from February and March and/or May and June to April whenever low flows and high water temperatures are predicted in April. Therefore, lower flows in April and increases in thermal stress to fish are not expected, and the resulting alteration to predator-prey relationships through increased prey vulnerability and predator feeding efficiency would not result on the Stanislaus River. Impacts would be less than significant. The change in flows and temperatures are not anticipated to result in thermal stress of fish on the Tuolumne or Merced Rivers or the LSJR (see AQUA-3 and 4). Consequently, an increased prey vulnerability on these rivers is not expected, and impacts would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Under LSJR Alternative 4, changes in flows are not expected, and temperatures are not anticipated to result in additional thermal stress to fish on the Stanislaus, Tuolumne or Merced Rivers or the LSJR (see AQUA-3 and 4). Consequently, an increased prey vulnerability on these rivers is not expected, and impacts would be less than significant.

AQUA-11: Changes in disease risk resulting from changes in flow, water temperature, and water quality

Disease impacts fish populations by directly increasing mortality (which generally requires several days) and by indirectly contributing to increased susceptibility to predation and decreasing the ability to perform essential functions, such as feeding, swimming, and defending territories (McCullough 1999). Chinook salmon are susceptible to a variety of diseases, many of which have specific temperature requirements. Certain freshwater diseases are known to be more prevalent in cold water. The mycobacterium *Cytophaga psychrophila* produces disease in salmonids at temperatures of 41–50°F, and infectious hematopoietic necrosis (IHN) is a viral disease that is most common at 46.4–50°F. BKD has been shown to have optimum temperatures for infection below 59°F (McCullough 1999).

While certain diseases are more prevalent in cold water, most of the more significant diseases afflicting LSJR Chinook salmon increase in virulence as temperature increases. Water temperatures greater than 56°F favor bacteria-causing columnaris and furunculosis, while temperatures greater than 65°F favor the protozoan-causing ichthyophthirosis (Boles et al. 1988). Vibrio is caused by the marine bacterium *Vibrio anguillarum* and produces a hemorrhagic septicemia that has optimum growth conditions in waters above 59°F (McCullough 1999).

As some freshwater diseases have optimum conditions for infecting fish in cold water and some in warmer water, there may be considered no preference in temperature regulation regarding disease. However, bacterial coldwater disease flourishes at temperatures up to 50°F but appears to be controlled at 55°F. Most warmwater diseases begin to become serious threats above 59°F. Therefore, with respect to freshwater diseases, temperatures in the range of 55°F to 59°F appear to be least problematic for salmonids in resisting both cold and warm water diseases (McCullough 1999).

Steelhead are assumed to be susceptible to the same diseases as Chinook salmon. Although very little information exists to quantify changes in infection levels and mortality rates for steelhead that are attributed to these diseases, steelhead are probably more susceptible to diseases in freshwater habitats than Chinook salmon. Because steelhead rear in riverine and estuarine habitats for 1–3 years, compared to the 3–7 month rearing period of fall-run Chinook salmon, the exposure to disease or disease carrying organisms in these habitats is increased. This is especially true during summer months when flows are lower and temperatures are higher for steelhead. For this impacts assessment, effects of disease on Chinook salmon are assumed to have similar effects on steelhead and to be generally representative of effects on aquatic resources.

Impacts of disease on Chinook salmon and steelhead are assessed by evaluating potential changes in exposure of juvenile salmonids to water temperatures and pollutants that could increase physiological stress and susceptibility to disease. For water temperature-related effects, the assessment focuses on the period March–October and compares LSJR Alternatives 2, 3, and 4 to baseline conditions to determine changes in the number of days that water temperatures would exceed 59°F near the confluence of each tributary with the LSJR and on the SJR at Vernalis (Tables 7-21a-d). An increase of a week (7 days) or more in the occurrence of daily water temperatures exceeding this threshold was used to determine the potential for increased disease risk (a 7-day increase corresponds roughly to a 20 percent increase in the frequency of these water temperatures in each month; see AQUA-4). The effects of pollutants are addressed qualitatively based on the general relationships between changes in flow and pollutant exposure (see AQUA-5).

Table 7-21a. Percent Exceedances of the 59°F Threshold for the Stanislaus River

Stanislaus – Confluence	March	April	May	June	July	August	September	October
Baseline	27	57	99	100	100	100	96	75
LSJR Alternative 2	26	91	100	100	100	100	98	74
LSJR Alternative 3	20	69	87	100	100	100	97	75
LSJR Alternative 4	9	50	83	100	100	100	97	76

Table 7-21b. Percent Exceedances of the 59°F Threshold for the Tuolumne River

Tuolumne – Confluence	March	April	May	June	July	August	September	October
Baseline	40	52	82	100	100	100	100	98
LSJR Alternative 2	39	64	88	100	100	100	100	90
LSJR Alternative 3	16	27	66	100	100	100	100	92
LSJR Alternative 4	0	3	60	100	100	100	100	90

Table 7-21c. Percent Exceedances of the 59°F Threshold for the Merced River

Merced – Confluence	March	April	May	June	July	August	September	October
Baseline	42	91	100	100	100	100	100	91
LSJR Alternative 2	53	93	100	100	100	100	100	92
LSJR Alternative 3	44	76	100	100	100	100	100	92
LSJR Alternative 4	27	70	100	100	100	100	100	91

Table 7-21d. Percent Exceedances of the 59°F Threshold for the LSJR

SJR – Vernalis	March	April	May	June	July	August	September	October
Baseline	50	100	100	100	100	100	100	99
LSJR Alternative 2	55	100	100	100	100	100	100	100
LSJR Alternative 3	32	100	100	100	100	100	100	99
LSJR Alternative 4	27	97	100	100	100	100	100	99

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

As shown in Tables 7-21a–d , predicted changes in the frequency of water temperatures above the 59°F threshold under LSJR Alternative 2 ranged from an 8 percent decrease in the Tuolumne River in October to a 34 percent increase in the Stanislaus River in April. The potential for a substantial increase in disease risk exists in the Stanislaus River only. In April, water temperatures exceeding 59°F at the confluence of the Stanislaus River are predicted to occur 91 percent of the time compared to 57 percent under baseline conditions (Table 7-21a). This is expected to substantially increase the incidence of disease and disease-related mortality of juveniles in the Stanislaus River relative to baseline. In addition, exposure to higher concentrations of pollutants associated with lower spring flows may increase the susceptibility of juvenile salmonids and other fishes to disease in the Stanislaus River (see AQUA-5). Therefore, lower flows, higher water temperatures, and higher concentrations of pollutants under LSJR Alternative 2 would result in a significant impact on salmonids and other native fishes in the Stanislaus River.

Because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the effects of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.*

An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Regs., tit. 23, § 3777(b)(3)). Evaluating the effects of more flow to potentially reduce disease risk is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce the significant impacts identified above cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Other feasible mitigation measures related to disease include improved hatchery management practices to reduce incidence of disease at the hatcheries and transmission of disease to the wild population. The program of implementation includes recommendations for such measures. However, those measures would not necessarily reduce impacts below the significant level. In addition, the State Water Board does not have authority over hatchery management activities and could not mandate that such activities take place. As discussed in AQUA-4, there are some possible measures that could help to reduce temperature effects on disease risk; however, the effectiveness of these measures would depend on the downstream extent to which water temperatures can be controlled during these critical periods. Given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Consequently, significant impacts may still occur under LSJR Alternative 2 with the implementation of these measures. Impacts would remain significant and unavoidable.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

As shown in Tables 21a–d, predicted changes in the frequency of water temperatures above the 59°F threshold under LSJR Alternative 3 ranged from a 25 percent decrease in the Tuolumne River to a 12 percent increase in the Stanislaus River in April. These changes are not expected to substantially increase the incidence of disease and may reduce the risk of disease in some locations and months relative to baseline conditions. In addition, increases in disease risk associated with reduced flows and higher concentrations of pollutants are not expected to substantially affect fish populations in the Stanislaus River (see AQUA-5). Therefore, the predicted changes in flow, water temperature, and water quality resulting from LSJR Alternative 3 are not expected to increase the incidence of disease in salmonids or other fishes in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR. Impacts would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

As shown in Tables 21a–d, predicted changes in the frequency of water temperatures above the 59°F threshold under LSJR Alternative 4 ranged from a 49 percent decrease in the Tuolumne River in April to a 1 percent increase in the Stanislaus River in October. Overall, the predicted changes in flow, water temperature, and water quality resulting from LSJR Alternative 4 are not expected to increase the incidence of disease in salmonids and other fishes in the Stanislaus, Tuolumne, and Merced Rivers and the LSJR and may reduce the risk of disease throughout the plan area during the spring rearing and outmigration period (see also AQUA-5). Impacts would be less than significant.

AQUA-12: Changes in fish transport resulting from changes in flow

Changes in flows on the tributaries and mainstem SJR can affect migration rates of outmigrating salmonids from the major SJR tributaries to the Bay-Delta during the primary spring outmigration period (February–June). The VAMP study results in particular indicate that increased inflows to estuaries and increased down-estuary net current velocities decrease juvenile salmon travel times through the system and increase survival (Hankin et al. 2010). The net current velocity of these transport flows depends on the amount of inflow coming into the estuary. Higher inflows are characterized by higher velocities, which result in faster travel times for juvenile salmonids and, consequently, less exposure to a variety of environmental stressors (e.g., predation, contaminants, poor feeding conditions, stressful water temperatures). Not only does increased SJR inflow to the Bay-Delta decrease residence time for fish in the Bay-Delta, but increased LSJR flow also generally improves water quality.

To assess impacts related to fish transport resulting from changes in flow, a qualitative assessment was performed based on published literature and the comparison of flows for LSJR Alternatives 2, 3, and 4 with baseline flows that was performed in AQUA-3.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Significant and unavoidable)

The reduction in flows on the Stanislaus River (see AQUA-3) would affect travel times of juveniles to the Bay-Delta during the outmigration period (specifically in April). The lower inflows could result in lower velocities and slower travel times (increased residence time) for juvenile salmonids and, consequently, increased exposure to a variety of environmental stressors (e.g., predation, contaminants, poor feeding conditions, stressful water temperatures). The expected impacts on fish transport resulting from changes in flow would be significant.

Because the LSJR alternatives would not directly result in any changes to the NMFS BO flow requirements on the Stanislaus River, actual reductions in flows below the NMFS BO flows would be unlikely. At the same time, the NMFS BO flow requirements may change in the future as a result of coordination between the State Water Board, NMFS, and others. Accordingly, a conservative assessment of potential impacts on the Stanislaus River that captures a range of flow-related impacts was performed. Flows under the NMFS BO fall within this range. In addition, a sensitivity analysis showing the effects of the LSJR alternatives on flows with the NMFS BO in effect is presented in Appendix L, *Sensitivity Analyses.*

An SED must identify feasible mitigation measures for each significant environmental impact identified in the SED. (Cal. Code Regs., tit. 23, § 3777(b)(3)). Evaluating the effects of more flow to potentially reduce predation effects is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce the significant impacts identified above cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Potential measures that may be implemented to minimize predation impacts on salmonids and other fish species are discussed in AQUA-10; however, because of the timing and overall volume of reduction of flows in the Stanislaus River, it is unlikely these types of restoration actions by other agencies would serve to mitigate the impacts of predation. Also, as discussed in AQUA-4, there are some possible measures that could help to reduce temperature effects; however, the effectiveness of these measures would depend on the downstream extent to which water temperatures can be controlled during these critical periods. Given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Consequently, significant impacts may still occur under LSJR Alternative 2 with the implementation of these measures. Impacts would remain significant and unavoidable.

As discussed above in AQUA-3, median monthly flows would be similar to baseline conditions for the Tuolumne River. Additionally, while median monthly flows may be less on the Merced and LSJR; the overall volume of water on these two rivers would be similar to baseline conditions and could be adaptively managed to maximize protection or aquatic beneficial uses. Impacts on the Tuolumne and Merced Rivers and LSJR would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

The reduction in flows on the Stanislaus (see AQUA-3) would affect travel times of juveniles to the Bay-Delta during the outmigration period (specifically in April) on that river. The lower inflows could be characterized by lower velocity, which would result in slower travel times for juvenile salmonids and, consequently, increase fish exposure to a variety of environmental stressors (e.g., predation, contaminants, poor feeding conditions, stressful water temperatures). However, the total amount of water that would be released in February–June period (see AQUA-3) under LSJR Alternative 3 is equal to or higher than the volume of water released under baseline conditions in most years. Consequently, although model results indicate frequent reductions in median monthly flows in April, the overall availability of water appears to be sufficient in most years to adaptively manage flows to optimize spring rearing and outmigration conditions for juvenile salmonids. For example, this could be accomplished by shifting releases from February and March and/or May and June to April whenever low flows and high water temperatures are predicted in April. Impacts under LSJR Alternative 3 would be less than significant.

As discussed above in AQUA-3, median monthly flows would be greater than baseline conditions for the Tuolumne and Merced River under LSJR Alternative 3 and would be similar on the LSJR. Impacts on the Tuolumne and Merced Rivers and LSJR would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

LSJR Alternative 4 has target flows that are greater than baseline for the SJR and the major SJR tributaries in all months during the outmigration period of February–June, with the highest increase occurring in June (see AQUA-3). Tagging studies conducted for VAMP have demonstrated that smolt survival through the Bay-Delta is positively related to SJR inflow (SJRTC 2008; Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*). The effects of these changes are expected to be beneficial in the short-term to Chinook salmon outmigration and distribution. LSJR Alternative 4 would expedite juvenile salmonid outmigration during the February–June time frame. Since the flows are substantially higher in all months during the outmigration period, the flow changes are expected to decrease average travel times to the Bay-Delta. Consequently, the changes in fish transport resulting from changes in flow on the Stanislaus, Tuolumne, and Merced Rivers and the LSJR would be a less-than-significant impact.

AQUA-13: Changes in southern Delta and estuarine habitat resulting from changes in SJR inflows and export effects

The distribution of fish in the southern Delta is determined by tidal flows, tidally averaged (nontidal) net flows, and directed swimming of the fish. The largest flows in the southern Delta are tidal flows, which far exceed other flows in most Delta channels. The tidal flows tend to move small, weak-swimming fish, such as fish larvae, upstream and downstream, dispersing them into neighboring channels without imparting any net directional movement (Kimmerer and Nobriga 2008). Nontidal flows determine the net direction of water movement (i.e., net flows) and of fish larvae and other weak swimmers suspended in the water (Kimmerer 2008; Kimmerer and Nobriga 2008; Monsen et al. 2007).

Changes in the direction of channel flows, due to diversion rates at the CVP and SWP pumping plants, strongly affect net flow patterns in the southern Delta. These changed patterns also influence how fish are distributed in the southern and interior Delta and how long the fish remain there (NMFS 2009a; Kimmerer and Nobriga 2008; Monsen et al. 2007). These flows lead to increased straying away from the main channel of the SJR and towards the southern Delta via reverse OMR flows (USDOI 2008; Kimmerer and Nobriga 2008; Mesick 2001). Reverse OMR flows occur because the major freshwater source, the Sacramento River, enters on the northern side of the Bay-Delta while the two major pumping facilities, the CVP and SWP, are located in the south. This results in a net water movement across the Delta in a north to south direction along a network of channels including OMR (see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*).

Water is drawn from the central Delta through lower OMR to the pumps in the southern Delta when combined pumping exceeds the incoming flow from the LSJR. This situation causes reverse flows in OMR. Reverse flows in the southern Delta make fish more vulnerable to entrainment at the pumps and delay migrations through or from the southern Delta. However, SJR inflow generally counteracts the effects of reverse OMR flows by providing higher inflows, which tend to result in movement of fish and larvae away from the southern Delta. In addition to the pumps in the southern Delta, there are hundreds of agricultural diversions throughout the southern Delta that entrain small fish. These diversions not only entrain fish, but also affect them indirectly by altering flow patterns, food supply, and habitat.

Movements of delta smelt, Chinook salmon, steelhead, and other species are behaviorally directed. Therefore, the types of changes in Delta channels and patterns of flow circulation described above likely increase the risk of juvenile salmon migrating to the southern Delta and in the zone of the pumps. These changes have also strongly affected fish distribution, migration behaviors, survival, and spawning success for in-Delta spawners, such as delta smelt and longfin smelt. Although many of these fish are capable of directed swimming, there is still the possibility that many outmigrating salmonids may follow net flows through the southern Delta in the direction of the pumps. Inflow from the SJR is beneficial in helping to move fish downstream and away from the influence of the pumps (ICF International 2012).

When exports are high, net flows are often negative and flow toward the pumps instead of toward the Pacific Ocean. By increasing SJR inflow, and thereby increasing Delta inflow, the pumps in the southern Delta are allowed to increase exports. Conversely, exports are reduced as freshwater inflow to the Delta is lowered. Currently, the export limit for February is based on the best available estimate of the Eight River Index for January. The Eight River Index refers to the sum of the unimpaired runoff as published in DWR's *Bulletin 120*. If the best available estimate of the Eight River Index for January is less than or equal to 1.0 million acre-feet (MAF), the export limit for February is 45 percent of Delta inflow. If the Eight River Index for January is greater than 1.5 MAF, the February export limit is 35 percent of Delta inflow. If the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be within the range of 35 to 45 percent.

This assessment of changes in southern Delta and estuarine habitat resulting from changes in SJR inflows and exports is quantitative and is largely based on the comparison of flows for LSJR Alternatives 2, 3, and 4 to baseline flows that was performed in AQUA-3. The comparison also uses information presented in Appendix F.1, *Hydrologic and Water Quality Modeling,* Section F.1.6 . The comparison evaluates flows on the SJR at Vernalis as a measure of the inflow into the estuary.

LSJR Alternative 1: No Project

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

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

Based on the modeling results and application of several rules and objectives currently governing Delta operations (see Appendix F.1, *Hydrologic and Water Quality Modeling*), LSJR Alternative 2 is not likely to substantially change export pumping or the direction or magnitude of flows in the southern Delta. Estimated differences in monthly pumping rates between modeled rates and baseline conditions averaged +57cfs in January, -266 cfs in February, -221 cfs in March, -133 cfs in April, -96 cfs in May, and +235 cfs in June (Table F.1-23H). These changes represent a combination of monthly increases and decreases in pumping rates that are not expected to have substantial long-term effects on export pumping or flow patterns in the southern Delta. On average, southern Delta pumping would change by -2 percent relative to combined CVP and SWP baseline pumping for February–June (generally between 5,000 and 10,000 cfs) (Table F.1-22B). The effect on Delta outflows and the position of X2 would be even smaller because of the relatively small contribution SJR flows provide to total outflow. Under LSJR Alternative 2, it is assumed that Delta operations would continue to be governed by current restrictions on export pumping rates, inflow/export ratios, and OMR flows to protect listed fish species from direct and indirect impacts of southern

Delta operations. For example, LSJR Alternative 2 generally results in reduced SJR flows in April and May, which could impact through-Delta survival of fall-run Chinook salmon and steelhead smolts originating from the Stanislaus, Tuolumne, and Merced Rivers. The model results indicate that export pumping is expected to be reduced or remain unchanged to comply with current operating rules and objectives, thus minimizing the potential for increased entrainment of juvenile salmonids and other fish species into the channels and pumps in the southern Delta. Impacts of changes in Delta operations associated with LSJR Alternative 2 would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

Under LSJR Alternative 3, estimated differences in monthly pumping rates between modeled pumping and baseline pumping averaged +33 cfs in January, -203 cfs in February, -52 cfs in March, -9 cfs in April, +252 cfs in May, and +803 cfs in June. In January–May, the estimated changes represent a combination of monthly increases and decreases in pumping rates that are not expected to have substantial long-term effects on export pumping or flow patterns in the southern Delta (Table F.1-24B). On average, southern Delta pumping would change by +4 percent relative to combined CVP and SWP baseline pumping for February–June (generally between 5,000 and 10,000 cfs) (Table F.1-22B). Under LSJR Alternative 3, it is assumed that Delta operations would continue to be governed by current restrictions on export pumping rates, inflow/export ratios, and OMR flows to protect listed fish species from direct and indirect impacts of southern Delta operations. For example, during the primary fall-run SJR Chinook salmon smolt emigration period (April–May), no changes would be expected in export pumping rates in many years, thus enhancing net flows and hydraulic conditions in the Delta. Although substantial increases in southern Delta pumping would be expected in June, no long-term changes in the inflow/outflow ratio are expected to occur because of higher SJR flows at Vernalis (Figure 7-7a). Consequently, LSJR Alternative 3 is not expected to have long-term effects on juvenile salmonids or other fish species. Impacts associated with changes in Delta operations as a result of LSJR Alternative 3 would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

Under LSJR Alternative 4, estimated differences in monthly pumping rates averaged +46 cfs in January, +99 cfs in February, +323 cfs in March, +233 cfs in April, +424 cfs in May, and +1,158 cfs in June (Table F.1-25B). Baseline pumping generally ranges between 5,000 and 10,000 cfs in these months. On average, southern Delta pumping would change by +10 percent relative to combined CVP and SWP baseline pumping for February-June (generally between 5,000 and 10,000 cfs) (Table F.1-22B). Under LSJR Alternative 4, it is assumed that Delta operations would continue to be governed by current restrictions on export pumping rates, inflow/export ratios, and OMR flows to protect listed fish species from direct and indirect impacts of southern Delta operations in these months. Although southern Delta pumping would increase relative to baseline levels, compliance with the current rules and objectives would be expected to maintain or enhance net flows and hydraulic conditions in the Delta relative to baseline conditions. Similar to LSJR Alternative 3, no changes would be expected in April–May pumping in many years, enhancing net flows and hydraulic conditions in the Delta during the primary SJR fall-run Chinook salmon smolt emigration period. Although substantial increases in southern Delta pumping would be expected in June, no long-term changes in the inflow/outflow ratio would occur because of higher SJR flows at Vernalis (Figure 7-7a). Consequently, LSJR Alternative 4 is not expected to have long-term effects on juvenile salmonids or other fish species. Impacts associated with changes in Delta operations as a result of LSJR Alternative 4 would be less than significant.

7.5 Cumulative Impacts

7.5.1 Definition

Cumulative impacts are defined in the State CEQA Guidelines (14 Cal. Code Regs., § 15355) as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." A cumulative impact occurs from "the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time" (14 Cal. Code Regs., § 15355(b)).

Consistent with the State CEQA Guidelines (14 Cal. Code Regs., § 15130(a)), the discussion of cumulative impacts in this section focuses on significant and potentially significant cumulative impacts specific to aquatic resources. The State CEQA Guidelines (14 Cal. Code Regs., § 15130(b)) state the following.

> The discussion of cumulative impacts shall reflect the severity of the impacts and their likelihood of occurrence, but the discussion need not provide as great detail as is provided for the effects attributable to the project alone. The discussion should be guided by the standards of practicality and reasonableness, and should focus on the cumulative impact to which the identified other projects contribute rather than the attributes of other projects which do not contribute to the cumulative impact.

7.5.2 Past, Present, and Reasonably Foreseeable Future Projects

Chapter 16, *Cumulative Impact Summary, Growth-Inducing Effects, and Irreversible Commitment of Resources*, includes a list of past, present, and reasonably foreseeable future projects considered for the cumulative analysis.

Present and reasonably foreseeable future projects are projects that are currently under construction, approved for construction, or in final stages of formal planning. These projects were identified by reviewing available information regarding planned projects and are summarized in Chapter 16. Past, present and reasonably foreseeable future projects related to aquatic resources or that could affect aquatic resources include all projects listed in Chapter 16.

7.5.3 Significance Criteria

Two significance criteria must be met for an environmental consequence to have a significant cumulative impact: (1) the effect must make a cumulatively considerable incremental contribution to an overall cumulative impact, and (2) the overall cumulative impact (considering past, present, and reasonably foreseeable future projects) must be significant. (Cal. Code Regs., tit. 14, §§ 15064, 15065, 15130.). The cumulative analysis uses the impact threshold topics discussed in the impact analysis (i.e., habitat, temperature, predation, transport flows, and disease).

7.5.4 Mitigation Measures for Significant Cumulative Impacts

As specified by Section 15130 of the State CEQA Guidelines (2012) the analysis of cumulative impacts will examine feasible options for mitigating or avoiding a project's contribution to any significant cumulative effects. With some projects, the only feasible mitigation for cumulative impacts may be the adoption of ordinances or regulations rather than the imposition of conditions on a project-by-project basis. Mitigation measures to reduce an alternatives contribution to significant cumulative effects are presented below where feasible and appropriate.

7.5.5 Cumulative Impact Analysis

Methodology

The methodology to analyze cumulative impacts associated with aquatic resources qualitatively describes the cumulative impacts expected from past, present, and reasonably foreseeable projects, and then determines whether the LSJR or SDWQ alternatives have a cumulatively considerable impact when included with the past, present, and reasonably foreseeable future projects impacts. Where appropriate, the cumulative analysis is combined for various alternatives.

Geographic Scope

This cumulative impacts analysis considers projects located within the plan area and the Upper SJR (upstream of the confluence of the SJR and the Merced River) that have been identified as potentially having an effect on aquatic resources. In addition, it considers the downstream area of the Bay-Delta.

Analysis

The fisheries in the geographic area have experienced cumulative adverse impacts related to changes in the distribution, abundance, and species composition of native fish assemblages. These impacts have been a result of primarily human-caused factors, including the introduction of nonnative fish species; highly altered flow regimes and substantial flow reductions; isolation of floodplains from the river channel by channelization and levee construction;substantial reductions in the frequency, magnitude, and duration of floodplain inundation; creation of false migration pathways by flow diversions; and poor water quality. The combined effects of past and present activities in the Bay-Delta and the SJR Basin have led to declines in a number of indicator species. Of the approximately 21 native fish species historically present in the LSJR, at least eight are now uncommon, rare, or extinct (Moyle 2002). Species in decline as a result of these ongoing activities include delta smelt, longfin smelt, green sturgeon, Sacramento splittail, Central Valley fall-run Chinook salmon, and Central Valley steelhead. Striped bass, an important warmwater game species, is also in decline.

Several cumulative impacts may arise as climate change is taken into account. Conditions in the LSJR would gradually worsen and in the future would have the potential to negatively impact salmonids. As climate change becomes more prominent and consumptive need for water grows, juveniles and smolts may become exposed to less-than-ideal habitat conditions as preferred or required habitat becomes limited. As water temperatures increase and food becomes limited, juveniles will be displaced from preferred habitat and forced to forage in deeper waters for food to sustain their increasing metabolisms. As juveniles are displaced downstream into less preferred and habitat, the opportunity to be preyed upon increases.

Average sea levels, as a result of climate change,are expected to rise about 1 foot by 2030, which would cause increased salinities in the Delta. Delta smelt and longfin smelt spawn in the fresher water portions of the Delta, and delta smelt remain in areas with low salinities thought their lifecycle. Increased salinity would likely be stressful to delta smelt and longfin smelt, particularly during their egg and larval stages. Conditions in the LSJR would continue to be undesirable for Chinook salmon and steelhead and would have the potential to gradually worsen as consumptive need for water grows and as climate change becomes more prominent.

Climate change is already affecting Central Valley Chinook salmon. Summer water temperatures in the major SJR tributaries upstream from the major reservoirs are currently stressful for coldwater species, such as rainbow trout, and also stressful for hardhead and Kern brook lamprey. By 2030, average summer air temperatures are expected to rise as much as 8°F, and water temperatures in the major SJR tributaries and their reservoirs are expected to measurably increase. Significant increases in water temperatures could significantly impact rainbow trout and land-locked Kokanee that reside in and above the reservoirs. Surface water temperatures are also expected to rise in the reservoirs, but most of the species in the reservoirs are warmwater species that would likely not be affected by the expected water temperature increases or potential associated decreases in DO concentrations.

Inflow from the major SJR tributaries is expected to increase during winter months and decrease during spring and early summer months because of reduced snowpack associated with global climate change. The changes in seasonal inflows are likely to affect Central Valley fall-run Chinook salmon, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, Central Valley steelhead, green sturgeon, Sacramento splittail, longfin smelt, and delta smelt. Spawning migrations and other lifecycle processes of these species are adapted to high spring flows in the major SJR tributaries and into the Delta. Reductions in these flows would likely have significant impacts on several life stages. In addition, a greater frequency of very high winter flow could destroy salmon and steelhead redds in the tributaries and flush resident species from the Delta, causing high mortality rates (USBR 2011).

Given the current condition of many aquatic species in the major SJR tributaries, LSJR, and the Bay-Delta, the cumulative impacts of past, present, and reasonably foreseeable future projects have been cumulatively considerable and significant with respect to aquatic resources.

LSJR Alternative 2 is expected to have significant impacts on wetted habitat area, temperature, and other environmental stressors that affect indicator species. Specifically, this alternative is expected to result in lower monthly median flows on the Stanislaus River and some lower monthly median flows on the LSJR, which would contribute to reductions in habitat necessary for indicator species and increases in temperature ranges that are not appropriate for indicator species. These impacts, combined with other cumulatively considerable impacts, are considered significant. Therefore, the incremental impacts on the Stanislaus River would be cumulatively considerable, and when considered with past, present and reasonably foreseeable future projects, impacts would be cumulative and significant. As discussed above in AQUA-3, AQUA-4, AQUA-10, and AQUA- 12, additional flow in the Stanislaus River could reduce the significant impacts, and thus the overall cumulative significant impact.

However, evaluating the effects of more flow to potentially reduce temperature effects, predation effects, and habitat effects, is part of other alternatives (i.e., LSJR Alternatives 3 and 4) and is separately considered in this document. Therefore, requiring additional flow as part of LSJR Alternative 2 to reduce cumulative significant impacts cannot be independently applied as a mitigation measure because requiring additional flow would be inconsistent with the terms of LSJR Alternative 2 (i.e., requiring 20 percent of unimpaired flow on the Stanislaus River). Also described in AQUA-3, AQUA-4, AQUA-10, and AQUA-12 are a number of measures that could reduce the cumulatively significant impacts, such as: development and implementation of a coldwater pool management program designed to maintain best available water temperatures for sensitive fish species and life stages; working cooperatively with local stakeholders to implement riparian restoration strategies designed to increase shading and improve water temperatures during critical periods (e.g., April–May); modifying in-river gravel pits; restoring key fluvial geomorphic processes by creating floodplain and riffle habitat; supplementing gravel; and reestablishing riparian vegetation on floodplains and other areas, where feasible. However, the effectiveness of these measures to reduce temperature effects would depend on the downstream extent to which water temperatures can be controlled during these critical periods. Given the limited extent of shading that can be achieved and the dominant influence of meteorological conditions on large valley streams, such measures may not fully offset temperature impacts associated with reduced flows, especially in the lowermost tributary reaches. Furthermore, because of the timing and overall volume of reduction of flows in the Stanislaus River, it is unlikely these types of restoration actions by other agencies would serve to mitigate the significant cumulative impacts.

On the Merced and Tuolumne Rivers, LSJR Alternative 2 is expected to result in generally higher monthly median flows and an overall increase in the volume of water in the rivers February–June. These flows are expected to improve environmental conditions for indicator species by lowering temperatures, improving passage, and reducing predation. Therefore, the incremental contribution of LSJR Alternative 2 on these rivers would not be cumulatively considerable, and cumulative impacts would be less than significant.

LSJR Alternatives 3 or 4 are expected to have less-than-significant impacts on indicator species. The higher monthly median flows on the major SJR tributaries and the LSJR and the overall increase in the volume of flow on the rivers February–June are expected to improve conditions for native fish species (see Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*). Therefore, LSJR Alternatives 3 and 4 are not expected to result in conditions that may be less favorable to indicator species and would not result in a cumulatively considerable contribution to the conditions established by past, present, and reasonably foreseeable future projects. The incremental contribution of LSJR Alternatives 3 and 4 would not be cumulatively considerable, and cumulative impacts would be less than significant.

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