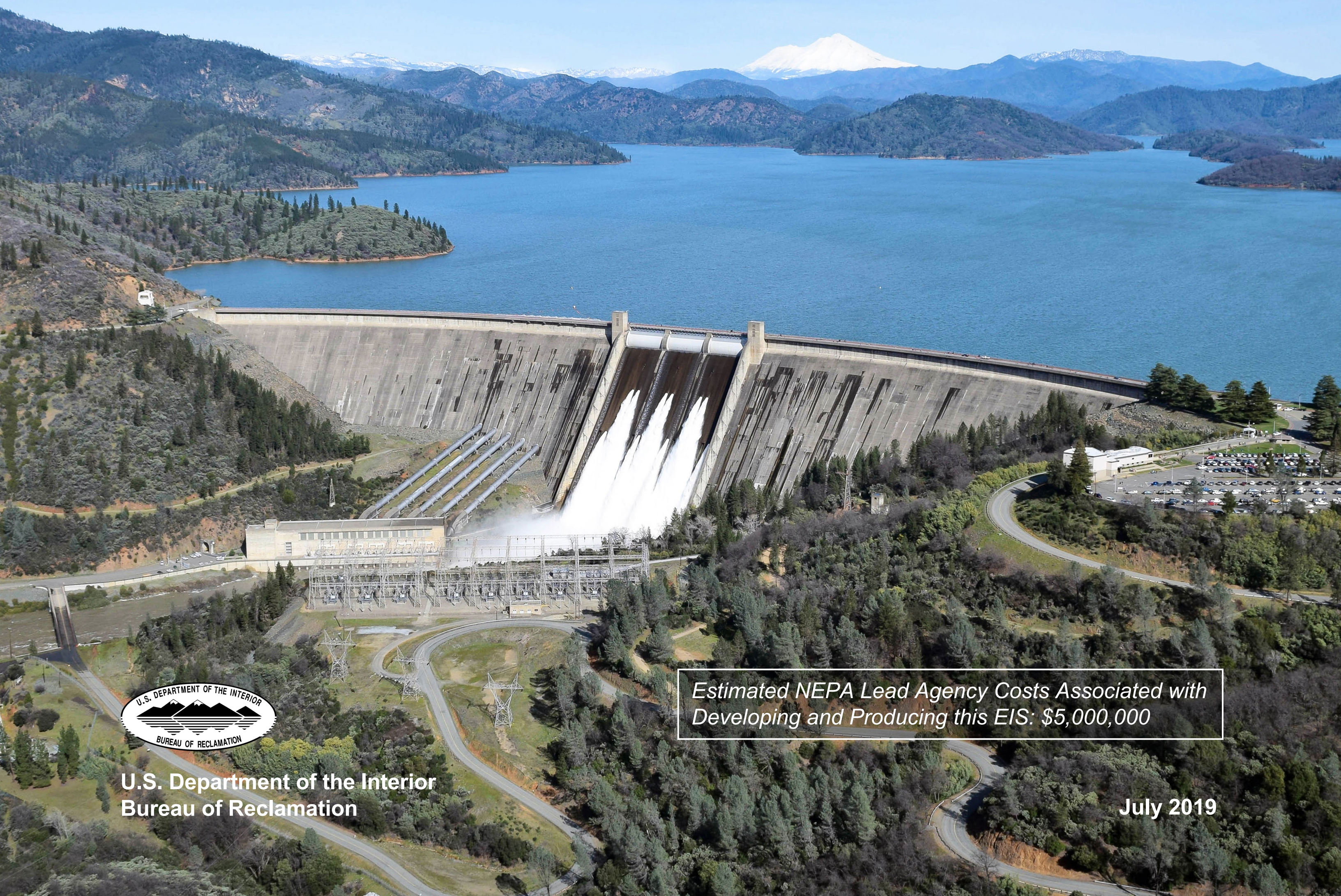
RECLAMATION

Managing Water in the West

Draft Environmental Impact Statement

Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

Central Valley Project, California
Mid-Pacific Region



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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

U.S. Department of the Interior
Bureau of Reclamation

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Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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List of Abbreviations / Acronyms

°F	degrees Fahrenheit
µmhos/cm	micromhos per centimeter
AF	acre-feet
AFY	acre-feet per year
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Bay-Delta WQCP	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BMP	best management practice
BOs	biological opinions
CAAQS	California Ambient Air Quality Standards
CCF	Clifton Court Forebay
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEQ	Council on Environmental Quality
cfs	cubic feet per second
CO	carbon monoxide
CO_2e	carbon dioxide equivalent
COA	Coordinated Operations Agreement
cu yd	cubic yard
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CVPIA	Central Valley Improvement Act
CWEST	California Water Economics Spreadsheet Tool
D-1485	Water Rights Decision 1485
D-1641	Water Rights Decision 1641
dBA	A-weighted decibels
DCC	Delta Cross Channel
Delta	Sacramento–San Joaquin Delta
DMC	Delta-Mendota Canal

DOI	U.S. Department of the Interior
DWR	California Department of Water Resources
E/I	export/inflow
EC	electrical conductivity
EDSM	Enhanced Delta Smelt Monitoring Program
EFH	essential fish habitat
EIS	environmental impact statement
ESA	Endangered Species Act
EWMP	efficient water management practice
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
FMWT	Fall Midwater Trawl
ft	foot
GCID	Glenn-Colusa Irrigation District
GHG	greenhouse gas
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
IEP	Interagency Ecological Program
IMPLAN	Impact Analysis for Planning
ITA	Indian Trust Asset
JPE	juvenile production estimate
JPOD	Joint Point of Diversion
km	kilometer
KLCI	Knights Landing Catch Index
Lower American River FMS	Lower American River Flow Management Standard
Lower Klamath ROD	Record of Decision for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
LTO	long-term operation
M&I	municipal and industrial
MAF	million acre-feet
MAST	Management Analysis and Synthesis Team
mg/L	milligram per liter
mi	mile
Mm	millimeter

MOA	Memorandum of Agreement
MRR	minimum river release
NAAQS	National Ambient Air Quality Standards
NBA	North Bay Aqueduct
NEPA	National Environmental Policy Act
NGO	nongovernmental organization
NMFS	National Marine Fisheries Service
NO_X	nitrogen oxide
NTU	Nephelometric Turbidity Unit
OBI	Old River at Bacon Island
OES	(California) Office of Emergency Services
OMR	Old and Middle River
$PM_{2.5}$	particulate matter of 2.5 microns diameter and smaller
PM_{10}	particulate matter of 10 microns diameter and smaller
ppt	parts per thousand
Psu	Practical Salinity Unit
RBDD	Red Bluff Diversion Dam
Reclamation	Bureau of Reclamation
ROC on LTO	Reinitiation of Consultation on the Coordinated Long-Term Operation
ROG	reactive organic gas
RPA	Reasonable and Prudent Alternative
SCI	Sacramento Catch Index
Settlement Act	San Joaquin River Restoration Settlement Act
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SO_2	sulfur dioxide
sq mi	square mile
SRP	stepped release plan
SWAP	Statewide Agricultural Production
SWG	Smelt Working Group
SWP	State Water Project

SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TCD	temperature control device
TFCF	Tracy Fish Collection Facility
Trinity River ROD	U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report
USACE	U.S. Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WOMT	Water Operations Management Team
WQCP	water quality control plan
YOY	young of the year

Chapter 1 Summary

1.1 Purpose of this Environmental Impact Statement

On August 2, 2016, the United States Department of the Interior, Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation (ROC on LTO) of the Central Valley Project (CVP) and State Water Project (SWP), referred to as the “Project.” The United States Fish and Wildlife Service (USFWS) accepted the reinitiation request on August 3, 2016, and the National Marine Fisheries Service (NMFS) accepted the reinitiation request on August 17, 2016. Reclamation completed a biological assessment to support consultation under Section 7 of the Endangered Species Act (ESA) of 1973, as amended, that documents the potential effects of the proposed action on federally listed endangered and threatened species that have the potential to occur in the study area and critical habitat for these species. The biological assessment also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH).

Reclamation prepared this environmental impact statement (EIS) to analyze potential modifications to the continued long-term operation of the CVP, for its authorized purposes, in a coordinated manner with the SWP, for its authorized purposes. This EIS evaluates alternatives to maximize water supply deliveries and optimize marketable power generation consistent with applicable laws, contractual obligations, and agreements and to augment operational flexibility by addressing the status of listed species.

1.2 Project Background

Reclamation’s mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reclamation is the largest wholesale water supplier in the United States, and the nation’s second largest producer of hydroelectric power. Its facilities also provide substantial flood control, recreation, and fish and wildlife benefits. In Northern California, Reclamation operates the CVP in coordination with DWR’s operation of the SWP. The mission of DWR is to manage the water resources of California, in cooperation with other agencies, to benefit the state’s people and to protect, restore, and enhance the natural and human environment.

The CVP consists of 20 dams and reservoirs that together can store nearly 12 million acre-feet (MAF) of water. Reclamation holds over 270 contracts and agreements for water supplies that depend upon CVP operations. Through operation of the CVP, Reclamation delivers water in 29 of California’s 58 counties in the following approximate amounts: 5 MAF of water for farms; 600 thousand acre-feet (TAF) of water for municipal and industrial (M&I) uses (enough water to supply about 2.5 million people for a year); and an average of 355 TAF of Level 2 CVP water for wildlife refuges (plus additional Level 2 and Incremental Level 4 supplies delivered from various sources). Reclamation operates the CVP under water rights granted by the state of California, including those intended to protect agricultural and fish and wildlife beneficial uses in the Sacramento–San Joaquin Delta (Delta). On average, the CVP generates approximately 4.5 million megawatt hours of electricity annually.

The SWP's main facilities are Oroville Dam, the Harvey O. Banks Pumping Plant (Banks Pumping Plant), and San Luis Reservoir. These facilities are operated and connected by a network of canals, aqueducts, and other facilities of the SWP to deliver on average 2.6 MAF of contracted water supplies annually. DWR holds contracts with 29 public agencies in the Feather River Area, North Bay Area, South Bay Area, San Joaquin Valley, Central Coast, and Southern California for water supplies from the SWP. Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP contractors. Through the SWP, DWR provides flood control below Oroville Dam and water for agricultural, M&I, recreational, and environmental purposes. DWR conserves water in Lake Oroville and makes releases to meet regulatory obligations and agreements tied to the operations of the SWP. Releases also serve three contractors in the Feather River area and two contractors from the North Bay Area. DWR pumps water at the Banks Pumping Plant in the Delta for delivery to the remaining 24 public water agencies in the SWP service areas south of the Delta.

The coordinated long-term operation of the CVP and SWP is currently subject to biological opinions (BOs) from USFWS (USFWS 2008) and NMFS (NMFS 2009) issued pursuant to Section 7 of the ESA. Each of these BOs included a Reasonable and Prudent Alternative (RPA) to avoid the likelihood of jeopardizing the continued existence of listed species or the destruction or adverse modification of critical habitat that were the subject of consultation.

This EIS evaluates potential long-term direct, indirect, and cumulative impacts on the environment that could result from implementation of modifications to the continued long-term operation of the CVP and SWP. This EIS is a mixed project-specific and programmatic document that analyzes some actions at a programmatic level and some actions at a project-specific level. Actions that involve construction are analyzed at a more general (programmatic) level because the action is not defined in detail at this time. Subsequent National Environmental Policy Act (NEPA) analyses may be performed as needed for programmatic actions to analyze site-specific environmental impacts.

1.3 Major Conclusions

1.3.1 Alternatives

The CVP and SWP convey water from major water sources to meet agricultural, M&I, and fish and wildlife demands in California. State and Federal regulatory actions, federal trust responsibilities, and other agreements have significantly constrained the ability of the projects to convey water south of the Delta, with the intent of protecting water quality within the Delta and preventing jeopardy of and adverse modification to critical habitat of threatened and endangered species. This EIS evaluates alternatives to maximize water supply deliveries and optimize marketable power generation consistent with applicable laws, contractual obligations, and agreements and to augment operational flexibility by addressing the status of listed species. The following alternatives are evaluated in the EIS.

- No Action Alternative: Reclamation and DWR would continue with current operation of the CVP and SWP, including the 2008 and 2009 RPA actions.
- Alternative 1: Alternative 1 includes a combination of flow-related actions, habitat restoration, and intervention (such as adult rescue or juvenile trap and haul) measures to increase water deliveries and protect fish and wildlife.
- Alternative 2: Reclamation would operate in accordance with the State Water Resources Control Board (SWRCB) Water Rights Decision 1641 (D-1641) and other water right and permit requirements but would not release additional flows for fish and wildlife purposes.

- Alternative 3: Alternative 3 would incorporate the same flow and operations as described in Alternative 2 but also would incorporate habitat restoration and fish intervention measures.
- Alternative 4: Alternative 4 would manage reservoir storage for the primary objective of preserving the coldwater pool. In addition to managing water temperatures, Alternative 4 would release additional instream flows in the Sacramento River and its tributaries to benefit fish but would balance this operation with the need to preserve the coldwater pool.

The habitat restoration and fish intervention actions in Alternatives 1 and 3 are analyzed at a program level, and the remaining flow actions are analyzed at a project level (Chapter 3 includes more details about which actions are evaluated at a project and program level.).

1.3.2 Analysis Overview

This EIS evaluates potential environmental positive and negative effects of the action alternatives. While the EIS examines, in later chapters, a broad suite of resources that could potentially be affected by the actions, the resources most anticipated to have impacts are summarized here.

Actions evaluated at a project level in the EIS are primarily related to operation of the CVP and SWP and result in changes to water flows and deliveries to contractors. Key impacts of the action alternatives include:

- Water Quality: The changes in river flows for Alternatives 1 through 4 would have minor effects on water quality for the Trinity, Sacramento, Feather, American, and San Joaquin Rivers and their tributaries. Changes in flow in each of these rivers are not of sufficient magnitude to affect the concentration of constituents of concern and affect overall water quality. In Clear Creek and the Stanislaus River, the action alternatives would cause flow reductions in some water year types that could result in water quality degradation. Alternatives 1 and 4 would change flows on the Stanislaus River to meet the multiple purposes of the reservoir. Alternatives 2 and 3 would have fewer flow requirements in the Stanislaus River, and while overall changes in flow are not expected to fluctuate greatly, there could be changes to the concentration of water quality constituents of concern. In the Bay-Delta region, electrical conductivity (EC) and chloride concentrations at certain western and southern locations under the action alternatives would be higher than those that would occur under the No Action Alternative, primarily in the months of September through December and primarily in wet and above normal water year types. The amount by which EC and chloride would be higher depends on location, with western Delta having the greatest differences compared to the No Action Alternative. The CVP and SWP would continue to be operated in real-time to meet the *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (Bay-Delta WQCP) EC and chloride objectives for protection of Delta beneficial uses. Thus, additional impairments to the Delta's beneficial uses, related to EC and chloride, would not be expected under the action alternatives compared to the No Action Alternative.
- Surface Water Supply: On the Sacramento, Feather, and American Rivers, CVP and SWP contract deliveries under Alternatives 1 through 3 would have either minor changes (less than 5%) or increased deliveries compared to the No Action Alternative, with the largest increases identified for CVP agricultural water supply ranging from approximately 9 to 10%. Alternative 4 would decrease (less than 5%) CVP and SWP deliveries. In the San Joaquin River hydrologic region, there would be no measurable change in CVP deliveries to the Exchange Contractors, refuge deliveries, and CVP and SWP M&I deliveries. Alternatives 1 through 3 would increase CVP agricultural deliveries compared

to the No Action Alternative by an average of 23%-39%%. Alternative 4 would decrease CVP agricultural deliveries (less than 5%). All CVP and SWP contractors in the San Francisco, Central Coast, Tulare Lake, South Lahontan, and South Coast hydrologic regions would see increased deliveries under Alternatives 1 through 3, with the largest increases seen for Alternatives 2 and 3. Alternative 4 would decrease CVP and SWP supplies to these regions, particularly during dry and critical years.

- Groundwater: For Alternatives 1 through 4, the small increase in Sacramento Valley SWP and CVP deliveries would not likely affect groundwater pumping or groundwater levels. Alternatives 1 through 3 result in a smaller volume of groundwater pumped from the San Joaquin Valley than the No Action Alternative due to increased surface water deliveries, ranging from 3.4% less under Alternative 1 to 6.9% less under Alternative 2. Groundwater levels in this region would be expected to increase compared to the No Action Alternative, with the amount of change dependent upon the amount and timing of additional surface water deliveries and the type of hydrologic year. In the CVP and SWP service areas outside the San Joaquin Valley, groundwater pumping would likely remain unchanged or decrease and groundwater levels would tend to remain stable or rise. The overall increase in groundwater levels across all geographies and all action alternatives would result in more areas and increased frequency of groundwater discharging from the subsurface to the surface water system and would likely not result in land subsidence. Alternative 4 would decrease CVP and SWP deliveries in the San Joaquin Valley, which would increase groundwater pumping by about 0.7% compared to the No Action Alternative. Groundwater levels in the San Joaquin Valley would decrease compared to the No Action Alternative. In the CVP and SWP service areas outside the San Joaquin Valley, Alternative 4 would result in increased groundwater pumping and declining groundwater levels compared to the No Action Alternative.
- Air Quality: The changes to operations could affect the amount of hydroelectric generation at the CVP and SWP facilities. All action alternatives would increase both power generation and energy use for the CVP and SWP. Under the No Action Alternative, the CVP and SWP together produce more power than they use. The action alternatives would increase both power generation and energy use compared to the No Action Alternative, but the increase in energy use would be greater than the increase in power generation, so that the CVP and SWP together would use more power than they produce. Because more power is used than is produced, the CVP and SWP would purchase power from the regional electric system (the grid) to meet demand for power. To the extent that the additional purchased power would be generated by fossil-fueled powerplants, emissions from these plants would increase.
- Aquatic Resources: The changes in Trinity River flows for Alternatives 1 through 4 would result in lower water temperatures from December through May but higher water temperatures in September and November under some alternatives. While maximum September water temperatures under the action alternatives would exceed recommended criteria for spawning and egg incubation, little salmonid spawning occurs in the Trinity River in September and adverse effects are not expected. Under Alternative 3, modeled maximum November water temperatures would increase substantially and exceed the recommended criterion, likely resulting in adverse effects on Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, and Coho Salmon spawning success. Flows in Clear Creek would be similar between the No Action Alternative and Alternative 1, but Alternatives 2 and 3 would have lower flows and reduced habitat quality and quantity for salmonids, and Pacific lamprey in all months. Water temperatures in Clear Creek under Alternatives 2 and 3 would be higher during

key life stages (July through October) for Spring-Run Chinook Salmon and steelhead. Changes in Sacramento River flows would improve water temperatures for salmonids under Alternative 1 and 4, whereas Alternatives 2 and 3 would have the opposite effect. Lower flows in some fall months of wet and above normal years would reduce habitat quality under Alternatives 1 and 4. Spawning and rearing habitat restoration under Alternatives 1 and 3 would improve conditions for salmonids and steelhead. Changes in Feather and American River flows and temperatures for all of the action alternatives would have minor effects on fish. Changes in operation on the Stanislaus River under Alternative 1 and 4 would be modest, whereas Alternatives 2 and 3 would have substantially reduced flows. These changes would result in reductions in suitable habitat for juvenile salmonids, with a lower level of reduction under Alternative 1 and 4 when compared to Alternatives 2 and 3. Restoration under Alternatives 1 and 3 would increase food production and provide protection from predators. Changes in San Joaquin River flows under all action alternatives would be minimal. In the Bay-Delta, changes to water project operation have the potential to increase the risk of entrainment, but would increase flow in the Sacramento River mainstem, which would increase survival and reduce routing into the interior Delta where survival is often lower regardless of flows. Changes in water operations under Alternatives 1 through 3 could potentially increase Delta Smelt entrainment risk, reduce food availability, and reduce habitat extent. Summer-fall habitat operations under Alternative 1 may increase habitat extent, and food subsidy studies and habitat restoration may provide benefits under Alternatives 1 and 3. Reintroduction of captive-bred Delta Smelt under Alternatives 1 and 3 could potentially increase population abundance. Changes in water operations under Alternatives 1 through 3 potentially could negatively affect Longfin Smelt abundance and increase south Delta entrainment risk, whereas Alternative 4 could have the opposite effect.

- Terrestrial Resources: Changes to CVP and SWP operation under Alternatives 1 through 4 would change water levels in reservoirs and along rivers. The flow changes are relatively small during each year type and would not result in substantive changes to riparian habitat. Implementation of the action alternatives could result in changes to flow management and these changes are small relative to normal month-to-month and year-to-year variability in the system. Operation of the CVP and SWP under Alternative 4 would change river flows and reservoir levels compared to the No Action Alternative, which would not change existing flow conditions. However, evaluation of changes in peak flow indicates that increases will maintain higher flows generally in the February through June period, where it is common for seasonal discharge to increase naturally. Alternatives 1 through 4 could potentially affect bank swallow habitat along the banks of rivers and reservoirs through erosion of existing habitat; these changes could decrease nesting habitat for bank swallows.
- Regional Economics: Alternatives 1 through 3 would increase water supply deliveries in comparison to No Action Alternative to North of Delta and South of Delta M&I contractors, reducing the costs paid by customers to develop alternate water supply projects. These reductions in cost would result in an increase in disposable income (compared to the No Action Alternative) and could result in more spending in the regional economy, particularly in the Southern California region. Alternative 4 would decrease M&I deliveries in these areas, which would increase water costs (to develop alternate water supplies) and reduce disposable income spending in the regional economy. Alternatives 1 through 3 would increase water supply deliveries to North of Delta and South of Delta agricultural contractors in all year types, reducing reliance on groundwater supplies and lowering operation costs. Agricultural revenues would increase for growers and the farming support sector. Alternative 4 would decrease water supply deliveries to these agricultural users, which would increase reliance on groundwater supplies and increase operation costs. The increase in salmon population along the

southern Oregon and northern California coast under Alternatives 1 and 4 could potentially increase the revenues of the commercial and recreational (ocean sports) ocean salmon fishery industry. Under Alternatives 2 and 3, the decrease in salmon population could potentially decrease commercial and recreational ocean salmon harvest, having a potential detrimental impact on fishermen and other ocean fisheries support industries.

Actions evaluated at a program level in the EIS are primarily related to habitat restoration and fish intervention measures and could result in typical, short-term impacts from construction activities. Alternatives 1, 3, and 4 include program-level actions. Key impacts of the action alternatives include:

- Water Quality: Alternatives 1 and 3 include new tidal habitat areas, which have the potential to become new sources of methylmercury to the Delta, posing somewhat greater health risks to fish, wildlife, or humans. The amount of tidal habitat proposed for Alternative 1 is the same as that which would occur under the No Action Alternative. Alternative 3 proposes more than twice as much tidal habitat restoration as under the No Action Alternative; therefore, there could be greater potential for generation and bioaccumulation of methylmercury that could pose somewhat greater health risks to fish, wildlife, or humans. Alternative 4 includes construction of new water use efficiency measures, but these are typically not on waterways and potential water quality effects would be reduced with best management practices.
- Groundwater: Short-term construction dewatering may be required in certain areas; however, groundwater resources would likely return to a preconstruction state following construction activities.
- Cultural Resources: Construction and restoration activities under Alternatives 1, 3, and 4 would result in ground disturbance that could affect archaeological historic properties and could cause alteration, damage, or demolition of built environment historic properties, relative to the No Action Alternative. The likelihood of effects on cultural resources is greater under Alternative 3 than Alternative 1 due to the greater quantity of habitat restoration proposed. Alternative 4 would have a smaller potential effect than Alternatives 1 and 3 because the construction actions would not be on waterways and would typically be on disturbed areas.
- Air Quality and Greenhouse Gas Emissions: Program-level actions that include construction or repair of facilities or the transport of fish or materials have the potential to increase emissions of air pollutants and greenhouse gases. Potential construction impacts associated with the action alternatives relative to the No Action Alternatives would not be expected to lead to exceedances of air quality standards if mitigation measures are implemented but would have the potential to increase greenhouse gas (GHG) emissions. Mitigation measures presented in Chapter 5, *Environmental Consequences,* would lessen the potential temporary increases in GHG emissions.
- Aquatic Resources: Rearing habitat restoration under Alternatives 1 and 3 would potentially benefit rearing and emigrating juvenile salmonids and early lifestage sturgeon by increasing food production and affording greater protection from predators, high-velocity flow, and other potential stressors. Unscreened or poorly screened diversions entrain emigrating juvenile salmonids in the Sacramento River and the Sacramento-San Joaquin Delta. Screening these diversions under Alternatives 1 and 3 improves migration habitat for emigrating salmonids during summer and fall, when the diversions operate, potentially benefiting early migrating Winter-Run and late migrating Spring-Run Chinook Salmon. Tidal habitat restoration has the potential to benefit juvenile salmonids and Green Sturgeon. Removal of predator hot spots may increase the survival of migrating juvenile salmonids.

- Terrestrial Resources: Alternatives 1 and 3 would restore tidal wetlands, diked wetlands, and muted marsh habitat in the Bay-Delta region. Habitat restoration activities and restoration of tidal inundation could have deleterious short-term effects on existing tidal, nontidal, and managed marsh habitats and associated special-status species; however, in the longer term and with the implementation of remedial measures, the extent of habitat is expected to expand. Alternatives 1 and 3 are expected to have a wholly beneficial effect on special-status plant species. Alternatives 1 and 3 include creation of spawning habitat and side channels along rivers, channel margin restoration, floodplain restoration, and other aquatic habitat restoration on the banks of waterbodies that could result in loss of habitat for giant garter snake and western pond turtle. The effects of tidal marsh, aquatic habitat, and floodplain restoration and construction activities on special-status species in the Bay-Delta will be magnified under Alternative 3, as it proposes 25,000 acres of habitat restoration in the Delta (as described in Table 3.6-1), in comparison to the No Action Alternative and Alternative 1. Under Alternative 4, permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches and canals are replaced with pipes to reduce water loss. In addition, the conversion of rice to dryland farming would be a permanent loss of habitat for giant garter snake. Under Alternative 4, removal of occupied valley elderberry shrubs along agricultural channels and ditches could kill or injure valley elderberry longhorn beetles. Similarly, reduced groundwater permeability from conversion of ditches and canals to pipes could kill elderberry shrubs, which could injure or kill any valley elderberry beetles in occupied habitat.
- Regional Economics: Construction activities associated with Alternatives 1, 3, and 4 relative to the No Action Alternative would temporarily increase construction-related employment and spending in Shasta, Sacramento, San Joaquin, and Contra Costa Counties. These alternatives also would include habitat restoration projects that could remove agricultural lands or grazing lands out of production and reduce agricultural revenues. However, most habitat restoration projects are within floodplains, and therefore impacts from these projects to land use would be minimal.
- Noise: Habitat restoration, fish intervention, and construction activities under Alternatives 1, 3, and 4 would involve temporary use of construction equipment and increase truck traffic, which may result in increased ambient noise levels at sensitive receptor locations relative to the No Action Alternative. Habitat restoration actions under Alternative 3 would be greater than those under Alternative 1, as the construction of 25,000 acres of habitat would be expected to involve an increased use of construction equipment over a larger area for a longer period of time. Increased levels of long-term maintenance for spawning and rearing habitat restoration and winter-run conservation hatchery production under Alternatives 1 and 3 could expose sensitive receptors to intermittent, increased noise levels compared to the No Action Alternative.
- Hazards and Hazardous Materials: Tidal and floodplain habitat restoration components under Alternatives 1 and 3 could potentially provide suitable mosquito breeding habitat, which would potentially increase the public's risk of exposure to mosquito-borne diseases, and could attract waterfowl and other birds to restored areas within 5 miles (mi) of a public-use airport increasing the potential for bird-aircraft strikes relative to the No Action Alternative. Habitat restoration in the Delta under Alternative 3 could result in a greater potential for methylmercury generation in the restored areas and bioaccumulation in fish and shellfish, which could increase the potential for human exposure to mercury through fish consumption relative to the No Action Alternative. Construction and operation and maintenance activities could result in hazards and effects related to hazardous

materials. Mitigation measures would avoid or minimize the potential effects of mosquito breeding habitat, bird-aircraft strikes, and the use, disposal, and transport of hazardous materials.

1.4 Areas of Controversy

This summary outlines key areas of controversy as provided in 40 C.F.R. § 1502.12, which provides that the EIS shall identify issues of controversy, "including issues raised by agencies and the public." Public controversy is not the same as scientific controversy under NEPA, but many of the disagreements regarding choices to be made between alternatives stems from disputes about the science, including strongly held views raised by non-scientists. In addition, because some of the science is inconclusive and may need further study, this section also addresses those topics and summarizes the existing information related to them.

1.4.1 Delta Smelt and Longfin Smelt

1.4.1.1 *The importance of Delta outflow and related variables in driving smelt population dynamics*

1.4.1.1.1 Importance of Delta outflow for Delta Smelt (spring/summer/fall)

As a result of the USFWS (2008) BO for Delta Smelt, much focus has been placed on the importance of fall outflow for Delta Smelt. Whereas physical drivers such as the area of the low salinity zone habitat that Delta Smelt tend to occupy are well correlated with Delta outflow or X2, long-term analyses of the relationship to population dynamics have tended not to show correlations with fall outflow (e.g., Thomson et al. 2010; Mac Nally et al. 2010; Miller et al. 2012). Detailed investigations have provided some evidence for the importance of fall X2 from specific wet years (Brown et al. 2014), but work is ongoing to conduct further studies to reduce the uncertainty (Hobbs et al. 2019; Schultz et al. 2019. Spring outflow has also emerged as an area of renewed interest; previous studies did not suggest a link to Delta Smelt population dynamics (e.g., Kimmerer et al. 2009), whereas more recent preliminary analyses have provided some support for a potential positive effect of outflow (IEP MAST 2015). In addition, there is also interest in the potential effects of summer Delta outflow for Delta Smelt (Schultz et al. 2019). Focused studies associated with spring/summer outflow actions such as those proposed in the Delta Smelt Resiliency Strategy (California Natural Resources Agency 2017) have the potential to reduce the uncertainty in the effects of Delta outflow in these months (Sommer et al. 2018; SWC/SLMDA 2018).

1.4.1.1.2 Delta outflow as a driver of Longfin Smelt population dynamics

Various studies have shown positive correlations between Longfin Smelt and winter/spring Delta outflow (or negative correlations with X2) (e.g., Kimmerer et al. 2009; Mac Nally et al. 2010; Thomson et al. 2010; Nobriga and Rosenfield 2016). One recent study, however, suggested suspended sediment concentration to be more statistically supported than Delta outflow as a predictor of Longfin Smelt trends in catch per unit effort (Latour 2016), whereas another study suggested general hydrological conditions was a better predictor of Longfin Smelt population dynamics than Delta outflow (Maunder et al. 2015). Latour's (2016) study noted that the relationship with suspended sediment concentration could reflect catchability of Longfin Smelt by the sampling gear; studies are underway to reduce this area of scientific uncertainty (Feyrer et al. 2019 in prep). The specific mechanism for the potential effects of Delta outflow on Longfin Smelt is unknown, as the extent of correlation with habitat extent does not appear sufficient to explain the patterns in relative abundance (Kimmerer et al. 2013). Recent studies show that Longfin Smelt are spawning and rearing in tributaries throughout San Francisco Bay during wetter periods, suggesting mechanisms underlying abundance in wetter years is related to habitat conditions seaward of Suisun Bay and Delta (Grimaldo et al. 2018; Hobbs et al. 2018). Investigations into other mechanisms such as changes in retention and entrainment at SWP and CVP are also ongoing (Gross et al. 2019 in prep).

1.4.1.2 *Population-level importance of entrainment on Delta Smelt*

There is scientific uncertainty as to the population-level importance of south Delta entrainment losses to Delta Smelt. Some studies have suggested potential population-level effects of entrainment losses (Thomson et al. 2010), whereas others have not (Mac Nally et al. 2010; Miller et al. 2012). Maunder and Deriso (2011) interpreted their own modeling results as "some support for a negative relationship" of entrainment losses, whereas Rose et al. (2013) suggested that their own results were in agreement with Maunder and Deriso's (2011) results, and provided more than "some" support for a population-level effect; subsequent investigation by Kimmerer and Rose (2018) supported Rose et al.'s (2013) view. Further investigation to reduce the uncertainty in the population-level importance of entrainment is being undertaken through the Collaborative Adaptive Management Team studies (Gross et al. 2018; Korman et al. 2018, Smith et al. 2018).

1.4.1.3 *Distribution of Longfin Smelt and spawning locations*

Of potential importance to Longfin Smelt is the species' distribution as it pertains to potential effects of water operations, e.g., from entrainment and Delta outflow effects. Whereas previous studies suggested most spawning was concentrated in freshwater of the north Delta, uncertainty in the distribution was recently reduced by some elucidation of the importance of higher salinity waters (Grimaldo et al. 2017). This study, coupled with further studies to clarify distribution of spawning areas in the broader Bay-Delta as well as along the California coast (Grimaldo et al. 2018; Hobbs et al. 2018; Grimaldo et al 2019 in prep), aim to clarify the overall distribution of Longfin Smelt in order to reduce uncertainty related to potential effects of Central Valley water operations on the species.

1.4.1.3.1 <u>Potential benefits of tidal habitat restoration</u>

Large-scale tidal habitat restoration in the Bay-Delta is required under the USFWS (2008) BO to mitigate for lost estuarine productivity—including food web materials for Delta Smelt—as a result of south Delta export operations. There is uncertainty in the extent to which the restoration would benefit Delta Smelt. Some studies have suggested limited export of food web materials from restored areas to adjacent habitat (Lehman et al. 2010; Kimmerer et al. 2018). The potential benefits to Delta Smelt from tidal marsh restoration therefore may be limited to localized effects (Hartman et al. 2017, p.95), with greater food benefits potentially occurring with increasing area of tidal wetland (Hammock et al. 2019). Monitoring will aim to reduce the uncertainty in the effects of the restoration on Delta Smelt (e.g., Herbold 2016).

1.4.1.3.2 <u>Factors influencing food availability</u>

A number of studies have suggested that food availability is an important influence on Delta Smelt population dynamics (e.g., Maunder and Deriso 2011; Miller et al. 2012; Kimmerer and Rose 2013). Some authors have suggested that changes in phytoplankton and therefore zooplankton have arisen because of changes in nutrient composition (see summary by IEP MAST 2015, p.71-72). The change in nutrient composition may reflect increased wastewater loading (Parker et al. 2012), but the extent to which nutrient composition affects spring phytoplankton blooms and therefore Delta Smelt zooplankton prey has a large amount of uncertainty (see summary by IEP MAST 2015, p.71). Future studies are being planned to assess the effects of upgrades of the Sacramento Regional Wastewater Treatment Plant that are anticipated to change the nutrient composition (Richey et al. 2018).

1.4.2 Salmonids

1.4.2.1 *Hydrodynamic Effects on Juvenile Salmonids in the Tidal Delta*

River flows can influence juvenile salmonids in a variety of ways that are relatively well understood. For example, river flows can:

- affect the amount and quality of suitable rearing habitat within the active channel;
- inundate seasonal habitats (e.g. floodplains) that can be extremely productive for rapid growth of juvenile salmonids (Sommer et al. 2001; Jeffres et al. 2008);
- increase river velocities that can reduce the time and energy required for downstream migration; and,
- reduce water clarity to improve predation avoidance (Gregory and Levings 1998).

Generally, there is considerable support in the scientific literature for the importance of river flows to the health of salmonid populations (Nislow and Armstrong 2012). However, in the tidal Delta, flows are naturally bi-directional (i.e. alternating repeatedly between ebb, slack and flood cycles). As a result, the hydrodynamic consequences of river inflows and South Delta exports in the tidal Delta are very different from the effects we expect to observe in rivers. In addition to being tidal, the gradient in Delta channels is low and channels are u-shaped (i.e. with minimal shallow margins). Delta channels are also deeper, wider and more numerous (with many bifurcating routes). As such, the hydrodynamic effects of water project operations that can be easily observed in rivers is much less clear in the tidal Delta.

When South Delta exports exceed San Joaquin River inflows, hydrodynamic conditions commonly referred to as “reverse flows” occur in parts of the Delta (Arthur et al. 1996; Andrews et al. 2016). “Reverse flows” refer to net (tidally-averaged) flows going away from rather than toward San Francisco Bay. However, despite the implication of the term ‘reverse flow”, in many channels where net flow is negative, flow direction and instantaneous velocities change very minimally. Rather, waters continue to flow very near equally in both directions with tidal action. Net flows over weeks or months can clearly affect transport patterns and residence time of Delta waters (Glibert et al. 2014) and passive, neutrally buoyant particles (Kimmerer and Nobriga 2008). However, “reverse flows” have been hypothesized to cause juvenile salmonids to become disoriented, to have their migration slowed, and/or to be subjected to hydrodynamic attraction toward the South Delta where habitat conditions are poor and where risk of entrainment to diversion facilities is greatest (Newman and Brandes 2010; NMFS 2009). The 2009 NMFS Biological Opinion hypothesized higher San Joaquin River inflows and/or lower South Delta exports would reduce “reverse flows” and provide net flow conditions more favorable to juvenile salmonids. However, investigations completed more recently report juvenile salmonids are unlikely to perceive or be influenced by tidally-averaged “net” flows, but instead would potentially be affected by instantaneous changes in channel velocity or flow direction (Anderson et al. 2012, Monismith et al. 2014, SST 2017).

The NMFS South West Fishery Science Center (SWFSC) has been developing a salmon life cycle model since 2012. The NMFS SWFSC model was planned to include a mechanistic accounting of hydrodynamic effects on the behavior of juvenile salmonids in the Delta. Though the model has not been finalized, and no detailed model documentation of the Delta component has been produced to-date, findings provided in regular workshops indicate lack of support for the net flow hypothesis. For example, the mechanistic Delta model has been reported to assume juvenile salmonids possess a sense of direction that is independent of tidally-averaged net flows. Instead, the model reportedly assumes movements by juvenile salmon can be influenced by instantaneous velocities or flow direction.

Consistent with the updated conceptual model suggested by Anderson et al. (2012), Monismith et al. (2014), and SST (2017), this EIS includes an analysis of how proposed water project operations would influence instantaneous velocities and flow direction in the Delta. Though these data provide an appropriate mechanistic basis for assessing hydrodynamic effects, there is uncertainty about: 1) what magnitude of velocity (or flow direction) change is needed to influence migration behavior of juvenile salmonids; and 2) what is the behavioral response of juvenile salmonids to such hydrodynamic changes. Effects along the mainstem San Joaquin River of the Central Delta (where prior coded wire tag based studies like Newman and Brandes (2010), Newman (2003) have hypothesized impacts) appear very unlikely because velocity and flow direction changes in this region are quite subtle. In contrast, further south in the Old and Middle River corridor, export effects on flow direction and channel velocity can be substantial. While more study and observations are needed, available tagging studies suggest relatively few Sacramento basin juvenile salmonids pass through the Old and Middle River corridor (Zeug and Cavallo 2014) and thus population level effects in the Old and Middle River corridor are smaller than previously hypothesized. Tagging studies on San Joaquin basin juvenile salmonids indicate few fish reach the Old and Middle River corridor when the Head of Old River Barrier is in place. With no Head of Old River Barrier, more tagged fish approach the South Delta export facilities, but survival to Delta exit does not appear to be influenced by export rates (Buchanan et al. 2018, SST 2017). Generally, survival of tagged juvenile salmonids through the tidal Delta is very poor (particularly for San Joaquin basin origin fish). This poor background survival undoubtedly makes it more difficult for possible effects of hydrodynamic changes to be observed. However, the fact that survival has remained extremely low despite positive tidally-averaged net flows (Buchanan et al. 2018, SJRG 2011, SJRG 2013) clearly contradicts expectations articulated in the 2009 NMFS Biological Opinion. A better understanding of export-induced velocity changes on juvenile salmonids requires a better acoustic tag receiver array in the Central and South Delta and experiments involving contrasting export rates from the CVP and SWP facilities.

1.4.2.1.1 Navigational Cues for Juvenile Salmonids in the Tidal Delta

According to Monismith et al. (2014), "[juvenile salmon] respond to environmental cues and clues in ways that were designed by natural selection to succeed in the Delta as it was prior to human alteration." Juvenile salmonids undoubtedly reared in the many blind-ending dendritic tidal channels which typified the historic Delta (Whipple et al. 2012), and yet these fish were apparently capable of navigating out to the bay despite having no freshwater inputs from upstream (and therefore with zero net flow). Given their longstanding evolutionary need to navigate through large, complex estuarine and marine environments on their way to and from the ocean, it seems evolution likely equipped Chinook salmon (and steelhead) with an ability to orient in these environments. Navigation strategies specific to the Delta are unknown, the scientific literature shows juvenile salmonids in other non-riverine environments (lakes, oceans and estuaries) orient using sun/polarized light and by sensitivity to the Earth's magnetic field (Quinn 1980, Quinn and Brannon 1982; Ueda et al 1998; Parkyn et al. 2003; Putman et al. 2014; Burke et al . 2013). These mechanisms of navigation are unlikely to be used in isolation, but rather in conjunction with olfaction, taste or other senses capable of discriminating navigation clues from water quality characteristics (Monismith et al. 2014). Though tidally-averaged net flows are unlikely to disrupt juvenile salmonid navigation in the tidal Delta, olfactory or chemical cues of Sacramento River waters being drawn into the South Delta provides an alternative mechanism of navigational disruption. More specifically, if juvenile salmonids from the Sacramento basin are orienting to migrate with ebb tides based in part upon the olfactory or chemical cues unique to Sacramento River water, then the unnatural transport of Sacramento River water into the South Delta may cause fish to move in that direction when they otherwise would not. The acoustic tagging receiver array which has been operating in the Central and South Delta is too sparse to detect this behavior if it exists. Another difficulty for assessing this hypothesis is that due to low San Joaquin River inflows and export operations, there is almost always a relatively large amount of Sacramento River water moving into the South Delta. If Sacramento basin juvenile salmonids are chemically tracking Sacramento origin waters to find their way to bay waters, then it seems likely that any concentration of Sacramento River water moving to the South Delta has the potential to cause migratory disruption. Thus, potential confusion resulting from this hypothesized mechanism would occur at all exports levels sufficient to produce negative Old and Middle River flows. Available acoustic tagging observations (e.g. Perry et al. 2018, Buchanan et al. 2018, SST 2017) have not indicated OMR flows affect survival, but a sparse receiver network in the Central Delta and few observations with positive OMR flows are currently available. Studying this hypothesis would require an expanded acoustic tag receiver network in the Central Delta, acoustically tagged Chinook salmon entering from the North Delta during periods with positive and negative OMR flows, not just varying levels of negative OMR.

While available science suggests hydrodynamic effects of exports are different and less consequential than previously hypothesized (see Hydrodynamic Effects on Juvenile Salmonids in the Tidal Delta) uncertainty remains about the importance and possible effect of chemical cues originating from natal streams in guiding juvenile salmonid migration through the tidal Delta.

1.5 Scope of Analysis for Resource Areas

The alternatives evaluated in this EIS include a range of operational changes and nonflow habitat and facility improvements for long-term operation of the CVP and SWP. Reclamation presented preliminary alternative actions at three public scoping meetings held in January of 2018. Major areas of public comments included Reclamation complying with regulations; coldwater pool for fish; needs for listed species; nonflow measures to restore fisheries; water for agricultural uses instead of fish; effects of delivery changes on groundwater levels; Central Valley Improvement Act (CVPIA) Restoration Fund and costs to CVP power customers; and cultural and tribal trust resources. Reclamation has framed this EIS to address the issues identified through public scoping.

1.6 Selection of Preferred Alternative

The purpose of this EIS is to help inform the public and decision-makers at Reclamation by examining a range of reasonable alternatives and the potential effects on the environment. This EIS provides information on the direct, indirect, and cumulative impacts of potential modifications to the long-term operation of the CVP and SWP. Based on the Draft EIS, Reclamation has selected Alternative 1 as the preferred alternative because in its judgment it would best fulfill Reclamation's statutory mission and responsibilities. Alternative 1 is also the proposed action in the Biological Assessment that Reclamation submitted to USFWS and NMFS regarding long-term operation.

1.7 Issues to be Resolved

While Reclamation has identified a preferred alternative in this Draft EIS, actual selection of a preferred alternative will not be until the Record of Decision. The decision on the alternative to implement will consider public comments and the full analysis in the Final EIS.

Chapter 2 Purpose and Need

2.1 Background

Water operations have changed substantially since the CVP and SWP were constructed. Operations were initially limited by physical capacity and available water. Reclamation and DWR's operation of the CVP and SWP changed significantly in 1978 with the issuance of the Water Quality Control Plan (WQCP) under the SWRCB Water Rights Decision 1485 (D-1485). D-1485 imposed on the water rights for the CVP and SWP new terms and conditions that required Reclamation and DWR to meet certain standards for water quality protection for agricultural, M&I, and fish and wildlife purposes; incorporated a variety of Delta flow actions; and set salinity standards in the Delta while allowing the diversion of flows into the Delta during the winter/spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the CVP and SWP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure operations of the CVP and SWP were coordinated, the *Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project* (hereinafter referred to as the COA) was negotiated and approved by Congress in 1986, establishing terms and conditions by which Reclamation and DWR would coordinate operation of the CVP and SWP, respectively. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions; however, the revisions of the COA in 2018 addressed export restrictions. Revisions to the COA are further described in Section 3.2.1.

In 1992, the CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement as having an equal priority with power generation. The CVPIA included a number of other provisions that represented additional congressional direction for operation of the CVP and overlaid a more complex statutory framework. These overlapping and sometimes competing requirements create challenges in how to address and balance the obligations Reclamation has in operating the CVP and how to coordinate with the SWP.

In 1995, the SWRCB issued an update to the Bay-Delta WQCP. In 1999 (revised in 2000), the SWRCB issued D-1641 to implement those elements of the 1995 Bay-Delta WQCP that were to be implemented through water rights. The 1995 Bay-Delta WQCP and D-1641 included a new export to total Delta inflow export/inflow (E/I) ratio of 35% from February through June. The 35% E/I ratio from February to June was a significant change from D-1485. The 1995 WQCP and D-1641 also imposed spring X2 requirements and pumping limitations based on San Joaquin River flow, which in combination with the E/I ratio, reduced the availability of "unstored" flow for the CVP and SWP. (X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs.) February to June became an unreliable season for conveying water across the Delta. The effect of D-1641 was a shift in the export season, in part, to the summer. The CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter.

In addition, D-1641 imposed a flow requirement for the San Joaquin Basin at Vernalis that included both base flows and a large spring pulse flow. However, it did not address how the requirement would be shared between the three major San Joaquin tributaries. In lieu of the SWRCB assigning responsibility, a number of interested parties entered into the San Joaquin River Agreement, which included flow commitments from all three tributaries, funding commitments, transfers, and voluntary demand reductions. The agreement was initially set to expire in 2009 but was extended to 2012, when it expired and was not replaced. On December 12, 2018, through State Water Board Resolution No. 2018-0059, the State Water Board adopted the Bay-Delta Plan amendments establishing the lower San Joaquin River flow objectives and revised southern Delta salinity objectives. However, the SWRCB has not yet assigned responsibility to any water right holders to meet these new and revised objectives.

In 2000, the U.S Department of the Interior Secretary and the Hoopa Valley Tribe Chairman signed the *U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report* (Trinity River ROD). This defined a minimum flow regime ranging from 369,000 acre-feet (AF) in critical dry years to 816,000 AF in wet years in the Trinity River. The Trinity River ROD decreased the amount of water Reclamation could bring from the Trinity River to the Sacramento River, reducing water supplies for Delta outflow and salinity and reducing the Shasta Reservoir coldwater pool flexibility. Per CVPIA § 3406(b)(23), this effort was intended to meet Federal trust responsibilities to protect the fishery resources of the Hoopa Valley Tribe, and to meet the fishery restoration goals of the Act of October 24, 1984, Pub. L. 98-541. However, it complicated Reclamation's ability to meet requirements imposed for the protection of Sacramento River listed fish.

These requirements and projects have constrained the operation of the CVP and SWP, and the RPAs in the 2008 USFWS and 2009 NMFS BOs added additional restrictions (as described above). At the same time, California native fishes have declined and are likely to continue to decline because of stressors such as long-term meteorological variability, sea level rise, extreme weather events, predation, and ecosystem changes caused by nonnative species. Reclamation requested reinitiation of consultation based on new information based on multiple years of drought, monitoring of listed fish populations, and new information available as a result of ongoing scientific processes.

2.2 Purpose and Need

Continued operation of the CVP is needed to provide river regulation and navigation; flood control; water supply for irrigation and domestic uses; fish and wildlife mitigation, protection, and restoration; fish and wildlife enhancement; and power generation. Continued operation of the SWP is needed to provide flood control and water supply for agricultural, M&I, recreational, and environmental purposes. The need for the action is to use updated scientific information to better meet statutory responsibilities of the CVP and SWP.

The purpose of the action considered in this EIS is to continue the operation of the CVP in coordination with the SWP, for their authorized purposes, in a manner that enables Reclamation and DWR to maximize water deliveries and optimize marketable power generation consistent with applicable laws, contractual obligations, and agreements, and to augment operational flexibility by addressing the status of listed species.

2.3 Study Area Location and Description

The study area includes areas that could be affected directly or indirectly by the action alternatives. The study area encompasses the following reservoirs, rivers, and land between the levees adjacent to rivers and areas that receive water from the CVP and SWP:

- Trinity Reservoir and the Trinity River downstream of Lewiston Reservoir;
- Sacramento River from Shasta Lake downstream to and including the Delta;
- Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River;
- Feather River from the Federal Energy Regulatory Commission (FERC) boundary downstream to its confluence with the Sacramento River;
- American River from Folsom Reservoir downstream to its confluence with the Sacramento River;
- Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River;
- San Joaquin River from Friant Dam downstream to and including the Delta;
- San Francisco Bay and Suisun Marsh;
- Nearshore Pacific Ocean on the coast from Point Conception to Cape Falcon in Oregon; and
- Areas that receive water from the CVP or SWP.

Figure 2.3-1, Study Area Map, shows these areas.

Figure 2.3-1. Study Area Map

Chapter 3 Alternatives

3.1 Alternative Formulation Process

The alternatives development process involved input and review from water contractors, resource agencies, nongovernmental organizations (NGOs), stakeholders, and the interested public. Resource agencies and water contractors were involved at a detailed level, including participation in meetings to identify the proposed action and range of potential alternatives. The process began in 2016 with the reinitiation of Section 7 consultation (Section 7 of the ESA).

The alternatives development process included public scoping conducted in January 2018. Reclamation published a Notice of Intent on December 29, 2017 (61789 FR Vol. 82, No. 249). Reclamation scheduled two public meetings and added a third after receiving a formal request that a meeting be held in Chico, California.

- Sacramento, California, Tuesday, January 23rd
- Los Banos, California, Wednesday, January 24th
- Chico, California, Thursday, January 25th

Approximately 200 people attended the three meetings, including members of the public, landowners, elected officials, and representatives from public agencies. The Scoping Report is available on Reclamation's project website: https://www.usbr.gov/mp/bdo/lto.html. Public scoping allowed Reclamation to solicit ideas for achieving the purpose and need, understand the scope of environmental issues that should be evaluated, and learn of potential impacts.

After the public scoping process, Reclamation collected initial components that could help achieve the purpose and need of the project. A component is a project or plan that could contribute to meeting the purpose and need but may not be able to fully accomplish it independently. Reclamation added to the list of components suggested at scoping by identifying components from scientific research, asking resource agencies and water contractors, and building on the technical understanding of the project team.

After identifying a list of initial components, Reclamation screened the components to identify the ones that could meet the purpose and need and help form a range of reasonable alternatives for analysis in the EIS. The components remaining after screening were combined into alternatives, described in the following sections. The alternative formulation process is presented in detail in Appendix D, *Alternatives Formation,* including alternatives considered but eliminated. Several alternatives considered but eliminated relate to implementation of the Central Valley Project Improvement Act (CVPIA). Those alternatives included actions such as making the CVP yield dedicated under CVPIA section 3406(b)(2) available for irrigation, municipal, and industrial use; reducing deliveries of section 3406(b)(2) water dedicated for fish and wildlife to improve water delivery flexibilities for human health and safety; reducing the frequency and intensity of pulse flows under CVPIA section 3406(b)(8); and considering instream flow needs determinations for all Central Valley Project controlled streams and rivers pursuant to CVPIA section 3406(b)(1)(B). Appendix D includes more detail about the alternatives development process.

3.2 Components Common to All Alternatives

The following sections describe information applicable to the No Action Alternative and the action alternatives.

3.2.1 Coordinated Operation Agreement

Reclamation and DWR would operate their respective facilities in accordance with the COA. The COA defines the project facilities and their water supplies, sets forth procedures for coordinating operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. The COA further identifies how unstored flow is shared, sets up a framework for exchange of water and services between the projects, and provides for periodic review of the agreement.

In 2018, Reclamation and DWR amended four key elements of the COA to address changes since the COA was signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year (AFY); and (4) periodic review. The COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80% responsibility of the United States and 20% responsibility of the state of California in wet year types to 60% responsibility of the United States and 40% responsibility of the state of California in critical year types. In a dry or critical year following two dry or critical years, the United States and state of California will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin uses. When exports are constrained and the Delta is in balanced conditions, Reclamation may pump up to 65% of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40. The COA defines balanced conditions as periods when it is agreed that releases from upstream reservoirs plus unregulated flow approximately equal the water supply needed to meet Sacramento Valley inbasin uses, plus exports. The COA defines excess conditions as periods when it is agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley inbasin uses, plus exports.

3.2.2 CVP Water Contracts

Reclamation operates the CVP to meet its obligations to deliver water to senior water right holders who received water prior to construction of the CVP, wildlife refuge areas identified in the CVPIA, and water service contractors. Reclamation is not proposing to execute any new contracts or amend any existing contracts under the action alternatives. The action alternatives assess operation of the CVP and SWP to deliver water under the terms of all existing contracts up to full contract amounts, including full Level 4 refuge contract amounts.

3.2.3 SWP Water Contracts

The SWP has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system. The foundational allocation of water to each contractor is based on its respective Table A entitlement (the maximum amount of water delivered annually by the SWP to the contractor). Typically, for a variety of reasons, annual water deliveries to individual agencies are less than the contractor’s maximum Table A amount.

DWR operates the SWP in accordance with contracts with senior water right holders in the Feather River Service Area (approximately 983 TAF). Further, under State Water Contracts, DWR allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with over 3 MAF for San Joaquin Valley and Southern California water users.

3.2.4 Allocation and Forecasts

Reclamation allocates CVP water on an annual basis in accordance with contracts. Reclamation bases north-of-Delta allocations primarily on available water supply within the north-of-Delta system along with expected controlling regulations throughout the year. For south-of-Delta allocations, Reclamation relies on upstream water supply, previously stored water south-of-Delta (in San Luis Reservoir), and conveyance capability through the Delta. Flows on the San Joaquin River often limit conveyance, as these flows are a driver of the flow direction within the Delta and, through their influence on the Old and Middle River (OMR) net reverse flow, can affect entrainment levels at the state and federal pumps.

The water allocation process for the CVP begins in the fall when Reclamation makes preliminary assessments of the next year's water supply possibilities, incorporating fall storage conditions combined with a range of forecasted hydrologic conditions. Reclamation refines these preliminary assessments as the water year progresses.

The initial allocation for SWP deliveries is made by December 1 of each year, with a conservative assumption of future precipitation to avoid over-allocating water before the hydrologic conditions are well-defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured and known information and conservative forecasts of future hydrology. Monthly briefings are held with the DWR director to determine formal approvals of delivery commitments announced by DWR.

3.2.5 Agricultural Barriers

DWR initiated the South Delta Temporary Barrier Project in 1991. Currently, DWR has permits extending the project through 2022. This project seasonally installs three barriers to maintain water levels for agricultural diversions in parts of the South Delta.

3.2.6 Suisun Marsh Preservation Agreement

The Suisun Marsh Preservation Agreement (SMPA) between DWR, Reclamation, California Department of Fish and Wildlife (CDFW), and Suisun Resource Conservation District contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641, sets a timeline for implementing the plan of protection, and delineates monitoring and mitigation requirements.

3.2.7 CVPIA

Reclamation would operate in accordance with its obligations under the CVPIA. This includes exercising discretion to take actions under CVPIA 3406 (b)(2).

The Secretary of Interior may make water available for other purposes if the Secretary determines that the 800,000 AF identified in 3406(b)(2) is not needed to fulfill the purposes of Section 3406.

3.3 No Action Alternative

Under the No Action Alternative, Reclamation would continue with current CVP operation in coordination with DWR's SWP operation. The No Action Alternative includes implementation of the

2008 USFWS BO and 2009 NMFS BO and would continue current management direction related to implementation of these BOs. Some of the RPA actions in the 2008 and 2009 BOs have not been fully defined at this time; therefore, they would require future engineering and environmental evaluation prior to implementation. For the purposes of the reinitiation process, because they are not included in the No Action Alternative. These RPA actions from the 2008 and 2009 BOs are not included in the No Action Alternative:

- 2009 NMFS BO RPA Action I.1.2: Channel Maintenance Flows through Whiskeytown Glory Hole operations.
- 2009 NMFS BO RPA Action I.2.5: Winter-Run Passage and Re-Introduction Program at Shasta Dam.
- 2009 NMFS BO RPA Action II.5: Fish Passage at Nimbus and Folsom Dams.
- 2009 NMFS BO RPA Action III.2.4: Fish Passage at New Melones, Tulloch, and Goodwin Dams.
- 2009 NMFS BO RPA Action I: Fish Passage Program.

The operations are described below by system. Appendix C, *Facility Descriptions and Operations* includes descriptions of CVP and SWP facilities and current operations in more detail.

3.3.1 Upper Sacramento River (Shasta and Sacramento Divisions)

Figure 3.3-1, Upper Sacramento River Facilities, shows major storage and conveyance facilities and water bodies in the upper Sacramento River system. Water rights, contracts, and agreements specific to the upper Sacramento River include SWRCB Water Rights Decisions 990, 90-05, 91-01, and 1641; settlement contracts; the exchange contract; and water service contracts. Flood control operations are based on regulating criteria developed by U.S. Army Corps of Engineers (USACE) pursuant to provisions of the Flood Control Act of 1944. Flood control may reserve up to 1.3 MAF of storage behind Shasta Dam, leaving 3.2 MAF for storage management.

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01, modifying Reclamation's water rights for the Sacramento River. The orders stated Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56 degrees Fahrenheit (°F) as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to Winter-Run Chinook Salmon. Under the orders, the water temperature compliance point may be modified to an upstream location when the objective cannot be met at Red Bluff Pumping Plant. In addition, Water Rights Order 90-05 modified the minimum flow requirements initially established in the 1960 Memorandum of Agreement (MOA) for the Sacramento River below Keswick Dam. The orders also recommended construction of a Shasta temperature control device (TCD) to improve the management of the limited coldwater resources, and monitoring and coordination.

Figure 3.3-1. Upper Sacramento River Facilities

To operate the Shasta TCD, a defined amount of reservoir elevation above each set of gates is required to ensure safe operation. This requirement is reflected in Table 3.3-1, Shasta TCD Gates with Elevation and Storage as 35 feet (ft) of submergence above the top of the gates.

Table 3.3-1. Shasta TCD Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 ft of Submergence of the TCD Gates (ft)	Shasta Storage (MAF)
Upper Gates	1,035	approx. 3.66
Middle Gates	935	approx. 1.64
Pressure Relief Gates	840	approx. 0.59
Side Gates	720[1]	approx. 0.08

[1] Low-level intake bottom
TCD = temperature control device
ft = feet
MAF = million acre-feet

3.3.1.1 *Seasonal Operations*

Reclamation operates in the winter for flood control, including both the channel capacity within the Sacramento River and the Shasta Reservoir flood conservation space. On a given date, Reclamation is not to exceed the top of the conservation pool storage level set by the USACE Water Control Manual. Releases for flood control would vary depending on current storage, forecasted inflow, and flow in the mainstem Sacramento River at Bend Bridge. Reclamation operates Shasta Dam releases to keep flows at Bend Bridge below 100,000 cubic feet per second (cfs), and therefore reservoir elevations may temporarily exceed the top of conservation pool storage to protect downstream populated areas. During the winter period, there can be substantial flow fluctuations from Keswick Dam due to the flood control operations. When not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flow requirements both down the Sacramento River and in the Delta. These minimum flows are held until irrigation demands require increased releases.

During the winter to spring period there are accretions (flows from unregulated creeks) into the Sacramento River below Shasta Dam. These local accretions help to meet both instream demands and outflow requirements, minimizing the need for additional releases from Shasta and Folsom Reservoirs.

In the spring, releases are fairly steady (unless Shasta Reservoir is in flood control operations) until flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements. Releases for Delta Outflow requirements are balanced between Shasta Reservoir and Folsom Reservoir. Both reservoirs are relied upon to meet temperature control requirements, and both need to substantially fill to fully meet these requirements. Therefore, releases must be carefully balanced to allow each reservoir to fill without negatively affecting the other. An overarching goal for Reclamation when operating the CVP is to fill the reservoirs as much as possible by the end of the flood control season (end of May) while meeting all other authorized project purposes.

Currently, the seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are used to draw from the upper portions of the lake to conserve deeper, colder water resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Reservoir water elevation decreases and coldwater resources are used. In late summer and fall, the TCD side gates are opened if necessary, to use the remaining coldwater resources.

During summer, operational considerations include flows required for Delta outflows, instream demands, and temperature control. In-river temperatures below Shasta Dam can be controlled via two methods. The first method is changing release volume or shifting releases between Trinity and Sacramento Reservoirs. The second method is selective withdrawal through the TCD. Determination of which method to use is made on a daily basis as operators balance releases from multiple reservoirs to meet downstream needs.

Fall operations are dominated by temperature control and provision of fish spawning habitat. By late fall, the remaining coldwater pool in Shasta Reservoir is usually limited. This can be a delicate balancing act in that if the early fall flows are too high, then the fish may make their redds higher up on the edge of the river and become subject to possible dewatering when the flows are reduced later in the fall. Sacramento River releases cannot be too low early in the fall, as there are still substantial instream diversion demands on the mainstem of the Sacramento River between Keswick Dam and Wilkins Slough, and depending on conditions, SWRCB Delta requirements may require upstream reservoir releases. This necessitates maintaining higher releases to support the instream demands until they fall off later in the season. At that time, Reclamation’s objective is to drop Keswick Dam releases to a lower level to conserve storage.

3.3.2 Trinity River Division

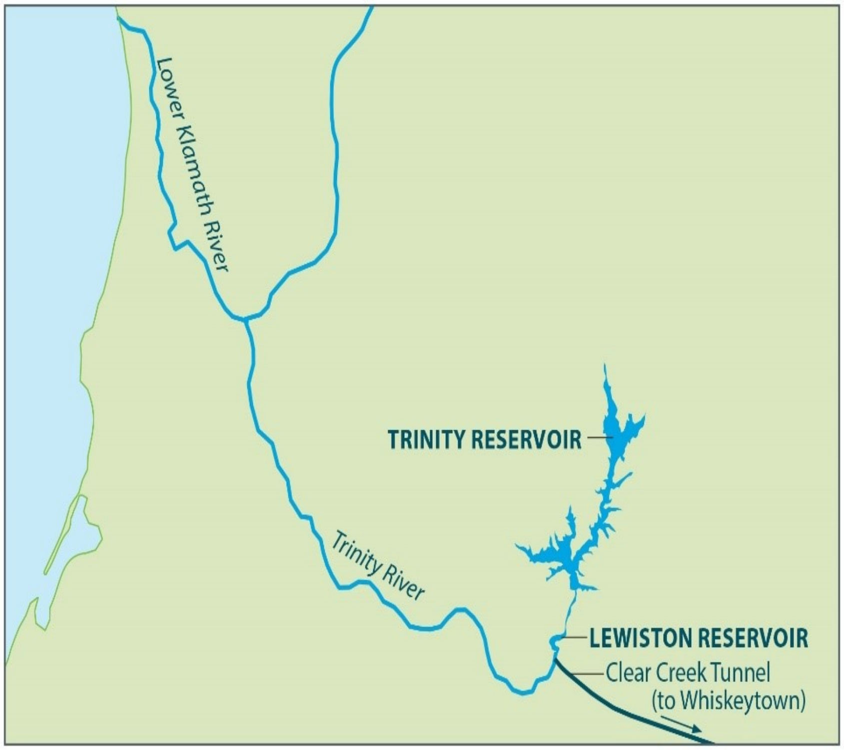


Figure 3.3-2, Trinity River Division Facilities, shows the Trinity River Division facilities. Reclamation operates the Trinity River Division both to export water to the Sacramento River system and to ensure necessary flow releases into the Trinity-Klamath Basin, such as through implementation of the 2000 *U.S. Department of the Interior Record of Decision Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report* (Trinity River ROD). Transbasin exports transfer water from the Trinity River to the Sacramento River system through Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek tunnel.

Figure 3.3-2. Trinity River Division Facilities

3.3.2.1 *Seasonal Operations*

Diversion of Trinity Basin water to the Sacramento Basin (transbasin diversion) provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River. Transbasin diversions are managed to support water supply and temperature objectives within the Sacramento River system and are regulated by the 2000 Trinity River ROD and Trinity Reservoir supply. The Trinity River ROD strictly limits Reclamation’s transbasin diversions to 55% of annual inflow on a 10-year average basis to meet legal and trust mandates for the restoration and protection of the Trinity River fishery; these factors restrict the amount of water authorized for exportation to the Central Valley. Reducing transbasin diversions was intended to support objectives of the Trinity River ROD, including habitat conditions for fall spawning of Coho and Chinook Salmon down the Trinity River. This limitation on transbasin diversions substantially affects Reclamation’s temperature operations on the Sacramento River and Reclamation’s ability to satisfy senior water right holder and/or Sacramento River Settlement Contractor commitments within the CVP system.

The amounts and timing of Trinity River Basin exports into the Sacramento River Basin are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity River water supply. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10–15% of water years when Shasta Reservoir storage is very low. These years do not have a specific threshold, but modified operations may be considered when storage in Shasta Reservoir is less than 2 MAF at the end of September and forecasted to continue falling. Reclamation addresses end-of-water-year carryover on a case-by-case basis in dry and critically dry water year types described in the water operations governance process below.

3.3.2.2 *Trinity River Record of Decision*

The 2000 Trinity River ROD prescribed increased flows to be released from Lewiston Dam to the Trinity River. Specifically, the ROD entails: (1) variable annual instream flows for the Trinity River from the Trinity River Division based on forecasted hydrology for the Trinity River Basin; (2) mechanical habitat rehabilitation projects along with sediment management and watershed restoration efforts; and (3) an adaptive management program. The Trinity River ROD flow release schedules vary among water-year classes and were designed to address the environmental flow requirements of anadromous fish. The Trinity River ROD established an Adaptive Environmental Assessment and Management Program to recommend possible adjustments to the annual flow schedule within the designed flow volumes provided for in the ROD or other measures to ensure the restoration and maintenance of the Trinity River anadromous fishery continues based on the best available scientific information and analysis. The five water year classes and associated annual water volumes for release to the Trinity River are critically dry (369 TAF), dry (453 TAF), normal (636 TAF), wet (701 TAF), and extremely wet (815 TAF).

3.3.2.3 *Long-Term Plan to Protect Adult Salmon in the Lower Klamath River*

Reclamation released the *Record of Decision for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River* in 2017 (Lower Klamath ROD), which identified an adaptive management approach for Reclamation to determine if and when to release augmentation flows from mid-August to late September from Lewiston Dam and to prevent an episodic disease outbreak in the lower Klamath River. These flows include a preventative base flow component of an augmented release of up to 40 TAF from Lewiston Dam over approximately 30 days, beginning on or about August 23, with the intent of meeting and/or maintaining an estimated target of up to 2,800 cfs in the lower Klamath River; a preventative pulse flow component of up to 10 TAF release over 4 days to achieve an estimated peak of 5,000 cfs in the lower Klamath River; and an emergency flow component of release up to 34 TAF from Lewiston Dam over no more than 8 days, beginning on or about September 20, to meet an estimated target of 5,000 cfs in the lower Klamath River.

3.3.2.4 *Whiskeytown Reservoir Operations*

Reclamation operates Whiskeytown Reservoir to (1) regulate inflows for power generation and recreation, (2) support upper Sacramento River temperature objectives, and (3) provide for releases to Clear Creek. Whiskeytown Lake is annually drawn down by approximately 35 TAF during November through April to regulate flows for winter and spring flood management. Heavy rainfall events occasionally result in spillway discharges to Clear Creek. Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, the Sacramento River, and Clear Creek. Figure 3.3-3, Storage and Conveyance Facilities on Clear Creek, shows storage and conveyance facilities on Clear Creek and at Whiskeytown Reservoir.

3.3.2.5 *Clear Creek Flows*

Reclamation operates Clear Creek flows in accordance with the 2000 agreement between Reclamation, USFWS, and CDFW and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation manages Whiskeytown Dam releases to meet a daily average water temperature of (1) 60°F at the Igo gage from June 1 through September 15 and (2) 56°F at the Igo gage from September 15 to October 31.

Figure 3.3-3. Storage and Conveyance Facilities on Clear Creek

3.3.3 Feather River

Figure 3.3-4, Feather River Facilities, shows major operational facilities on the Feather River. DWR maintains a minimum flow of 600 cfs within the Feather River Low Flow Channel as required by the August 1983 CDFW Agreement, *Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife* (1983 CDFW Agreement) (except during flood events when minimum flows are governed by the USACE Water Control Manual and under certain other conditions as described in the 1984 FERC order).

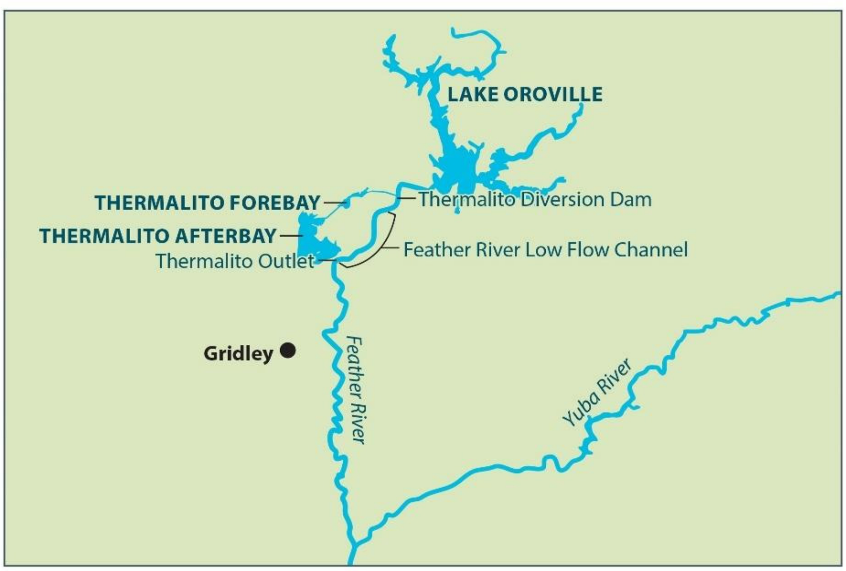
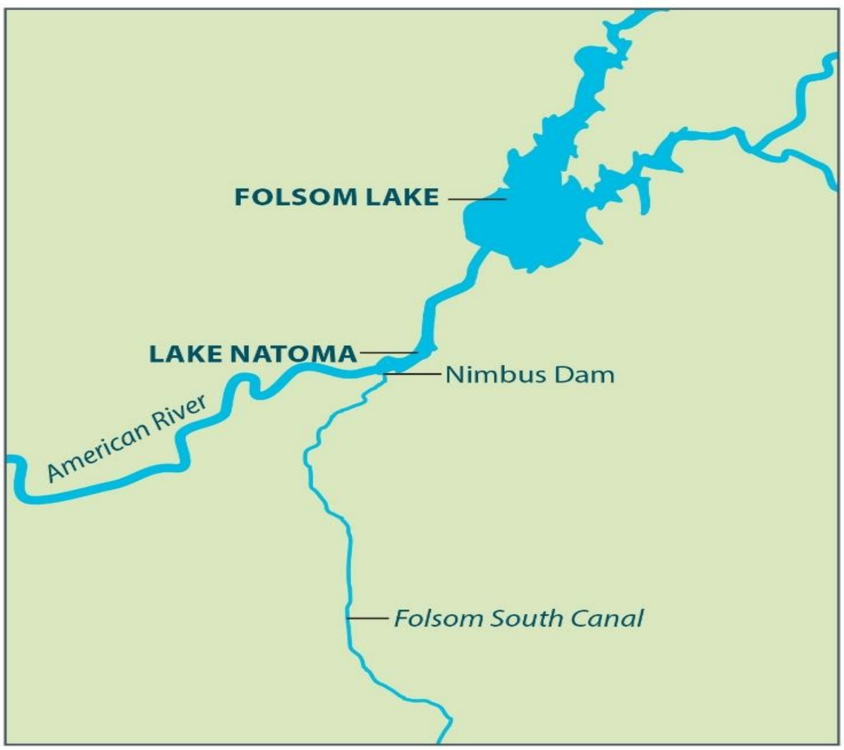


Figure 3.3-4. Feather River Facilities

Downstream of the Thermalito Afterbay outlet, in the high flow channel, per the license and the 1983 CDFW Agreement, minimum releases for flows in the Feather River are 1,000 cfs from April through September and 1,700 cfs from October through March, when the April to July unimpaired runoff in the Feather River is greater than 55% of normal. When the April to July unimpaired runoff is less than 55% of normal, the minimum flow requirements are 1,000 cfs from March to September and 1,200 cfs from October to February. The 1983 CDFW Agreement states that if the April 1 runoff forecast in a given year indicates that the reservoir level would be drawn down to 733 ft, water releases for fish may be reduced, but not by more than 25%.

In addition, according to the 1983 CDFW Agreement, during the period of October 15 to November 30, if the average highest 1-hour flow of combined releases exceeds 2,500 cfs, then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31 (with the exception of flood management, accidents, or maintenance.) In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

3.3.4 American River



Releases to the lower American River are governed by multiple factors. Minimum releases are set based on the *Lower American River Flow Management Standard* (Lower American River FMS) Minimum River Release (MRR). Releases above the MRR can be required for many reasons: instream temperature control, releases to help meet delta outflow or salinity requirements, flood control releases, and export needs. Figure 3.3-5, American River Division Facilities, shows facilities on the lower American River.

Figure 3.3-5. American River Division Facilities

3.3.4.1 *SWRCB Water Rights Decision 893*

The minimum allowable flows in the lower American River are defined by SWRCB Water Rights Decision 893 (D-893), which states, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during substantial portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream (Bay-Delta WQCP (SWRCB 1995) requirements and CVP water supply objectives. Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions.

3.3.4.2 *2006 Flow Management Standard*

In July 2006, Reclamation, the Sacramento Area Water Forum, and other stakeholders completed a draft technical report, Lower American River FMS, establishing a flow and temperature regime intended to improve conditions for fish in the lower American River (Reclamation et al. 2006). Minimum flow requirements during October, November, and December are primarily intended to address Fall-Run Chinook Salmon spawning, and flow requirements during January and February address Fall-Run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation and juvenile rearing and downstream movement of Fall-Run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult Fall-Run Chinook Salmon immigration.

3.3.5 Bay-Delta

The CVP and SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta and to regions south-of-Delta. Delta conditions are controlled by D-1641 (SWRCB 2000), which sets forth the water right requirements to meet the objectives in the Bay-Delta WQCP (SWRCB 1995). CVP and SWP operations are implemented in accordance with SWRCB water rights and water quality decisions, including D-1641, and federal requirements under the 2008 USFWS BO and the 2009 NMFS BO. Under the No Action Alternative, Reclamation and DWR would continue to operate the CVP and SWP to meet the RPA requirements in the 2008 USFWS BO RPA Actions 1 through 3 and the 2009 NMFS BO RPA Action IV.2.3. Under the No Action Alternative, current management direction would continue, and Reclamation would continue the RPAs that are currently being implemented. If an RPA is currently not being implemented, then it would not occur under the No Action Alternative.

3.3.5.1 *Seasonal Operations*

Winter and spring pumping operations generally maximize exports of excess, unregulated, and unstored water to help meet project demands later in the season and for Delta water quality. To minimize and avoid adverse effects on listed species, actions have been taken or imposed in the past to protect fish migration and minimize fish entrainment at C.W. “Bill” Jones Pumping Plant (Jones Pumping Plant) and Banks Pumping Plant. These restrictions limit the CVP’s and SWP’s ability to export excess water in the winter and spring and place a higher reliance on exporting previously stored water in the summer and fall.

Summer is generally a period of higher export potential. During the summer, the CVP and SWP typically operate to convey previously stored water across the Delta for exporting at the CVP and SWP pumps or other Delta facilities. Operational compliance concerns during the summer are typically focused on maintaining salinity and meeting outflow objectives while maximizing exports with the available water supply.

Fall Delta operations typically begin as demands decrease, accretions increase within the system, and reservoir releases are decreasing to start conserving water. Exports are typically maximized to export available water in the system and may decrease if the fall remains dry. As precipitation begins to fall within the Sacramento and San Joaquin Basins, the reservoirs focus on building storage and managing for flood control.

To meet health and safety needs, critical refuge supplies, and obligations to senior water rights holders, the combined CVP and SWP export rates at Jones and Banks Pumping Plants would not be required to drop below a daily average of 1,500 cfs.

3.3.5.2 *Delta Cross Channel*

The Delta Cross Channel (DCC) is a controlled diversion channel between the Sacramento River and Snodgrass Slough. When DCC gates are open, water is diverted from the Sacramento River through a short excavated channel into Snodgrass Slough and then flows through natural channels for about 50 mi to the vicinity of Banks and Jones Pumping Plants.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the central and southern Delta, and (3) reduce salinity intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000–25,000 cfs (on a sustained basis), the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

3.3.5.3 *Delta Water Diversions*

Delta water diversions include:

- SWP North Bay Aqueduct (NBA)-Barker Slough Intake – The intake diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency and the Napa County Flood Control & Water Conservation District (NBA water contractors).
- Clifton Court Forebay – The Clifton Court Forebay (CCF) is a 31 TAF reservoir that provides storage to allow off-peak pumping of water exported through Banks Pumping Plant, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the California Aqueduct. Aquatic weeds dominate CCF from late spring through fall. Algal blooms have occurred within CCF causing taste and odor issues in drinking sourcewaters. In past years, DWR has applied herbicides to control aquatic weeds and algal blooms. Mechanical methods are implemented to manually remove aquatic weeds. In recent years (2016-2018), DWR received approval to apply Aquathol K aquatic herbicide from June 29 to August 31, but this application has not been permitted in the long term and is no included in the No Action Alternative.
- SWP John E. Skinner Delta Fish Protective Facility – The facility diverts fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot-long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers while the main flow of water continues through the louvers and toward the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.
- SWP Banks Pumping Plant – The plant provides the initial lift of water 244 ft into the California Aqueduct by means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity. Although the installed capacity of the plant is 10,670 cfs, the maximum conveyance capacity of the California Aqueduct limits the pumping rate to 10,300 cfs.

Permits issued by USACE regulate the rate of diversion of water into CCF for pumping at the plant. This diversion rate is normally restricted to 6,680 cfs as a 3-day average inflow to CCF and 6,993 cfs as a 1-day average inflow to CCF. The CCF diversions may be greater than these rates between December 15 and March 15, when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis, when those flows are equal to or greater than 1,000 cfs.

- CVP Jones Pumping Plant – The plant has a physical capacity of approximately 5,200 cfs. Because of limited capacity in the Delta-Mendota Canal (DMC), the plant is operated at a rate of approximately 4,600 cfs or below, unless Reclamation accesses the Delta-Mendota Canal/California Aqueduct Intertie to operate at the full physical capacity.
- The Tracy Fish Collection Facility (TFCF) is located in the southwest portion of the Delta at the head of the intake channel for the Jones Pumping Plant. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (less than 200 millimeters [mm]) that would have difficulty fighting the strong pumping plant-induced flows, as the intake is essentially open to the Delta and impacted by tidal action.
- Contra Costa Water District Operations – Contra Costa Water District (CCWD) diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District's pre-1914 water right. The Rock Slough Intake, Contra Costa Canal, and shortcut pipeline are owned by Reclamation and are operated and maintained by CCWD under contract with Reclamation. Federal legislation providing the authority for Reclamation to transfer title of the facilities was passed by Congress and signed by the president in March 2019. CCWD and Reclamation are beginning the title transfer process, which includes conducting the required environmental and property record review to execute the transfer. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD. Operations at CCWD's intakes and Los Vaqueros Reservoir are governed by biological opinions from NMFS (NMFS 1993, 2007, 2010, 2017) and USFWS (USFWS 1993a, 1993b, 2000; 2007, 2010, 2017a), an MOU with CDFW (CDFG 1994), and an incidental take permit from CDFW (CDFG 2009b), which are separate from the biological opinions for the coordinated long-term operation of the CVP and SWP. CCWD operations in the No Action Alternative are consistent with these separate biological opinions and permits.

3.3.5.4 *Water Transfers*

The No Action Alternative includes water transfers through CVP and SWP facilities. Water transfers occur through various methods, including groundwater substitution, release from storage, and cropland idling and include individual and multiyear transfers. Water transfers would occur from July through September in volumes up to those described in Table 3.3-2, Water Transfers in the No Action Alternative.

Table 3.3-2. Water Transfers in the No Action Alternative

Water Year Type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following critical)	Up to 600
Dry (following dry)	Up to 600
All other years	Up to 360

3.3.6 Stanislaus River

The Stanislaus River watershed has annual obligations (including water rights, water contracts, and instream flow and quality requirements) that exceed the average annual runoff in a given year due to a number of factors, including SWRCB Water Rights Decisions 1641, 1422, and 1616; 1987 CDFW and Reclamation agreement; CVPIA objectives; 2009 NMFS BO; 1988 agreement and stipulation with Oakdale Irrigation District and South San Joaquin Irrigation District; riparian water right diverters; and CVP water delivery contracts.

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the ESA and the CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with D-1422 and D-1616, through protest settlement agreements with Tuolumne and Calaveras Counties, and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general. Reclamation is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply. Under the No Action Alternative, New Melones Reservoir releases would be controlled by Appendix 2E of the 2009 NMFS BO, which specifies releases for endangered fish.

Reclamation's New Melones Reservoir water rights require that water be bypassed through or released from New Melones Reservoir to maintain applicable dissolved oxygen standards to protect the salmon fishery in the Stanislaus River. The Central Valley Regional Water Quality Control Board's 2004 *San Joaquin Basin 5C Plan* designates the lower Stanislaus River with coldwater and spawning beneficial uses, which have a general water quality objective of no less than 7 milligrams per liter dissolved oxygen. This objective is applied through Reclamation's water rights to the Stanislaus River near Ripon.

3.3.7 San Joaquin River

Friant Dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements, provides restoration flow releases under Title X of Public Law 111-11, and provides conservation storage and diversion into Madera and Friant-Kern Canals for water supply. Figure 3.3-6, San Joaquin River Facilities, shows the major facilities on the San Joaquin River system.

The San Joaquin River Restoration Program (SJRRP) implements the San Joaquin River Restoration Settlement Act (Settlement Act) in Title X of Public Law 111-11. USFWS and NMFS issued BOs in 2012 that included project-level consultation for SJRRP flow releases up to 1,660 cfs, but require reconsultation for flows higher than that amount. recapture of those flows in the lower San Joaquin River and the Delta, and all physical restoration and water management actions listed in the Settlement Act. Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs located on the tributary systems to satisfy contract deliveries and instream flow requirements and operational agreements such as D-1641.

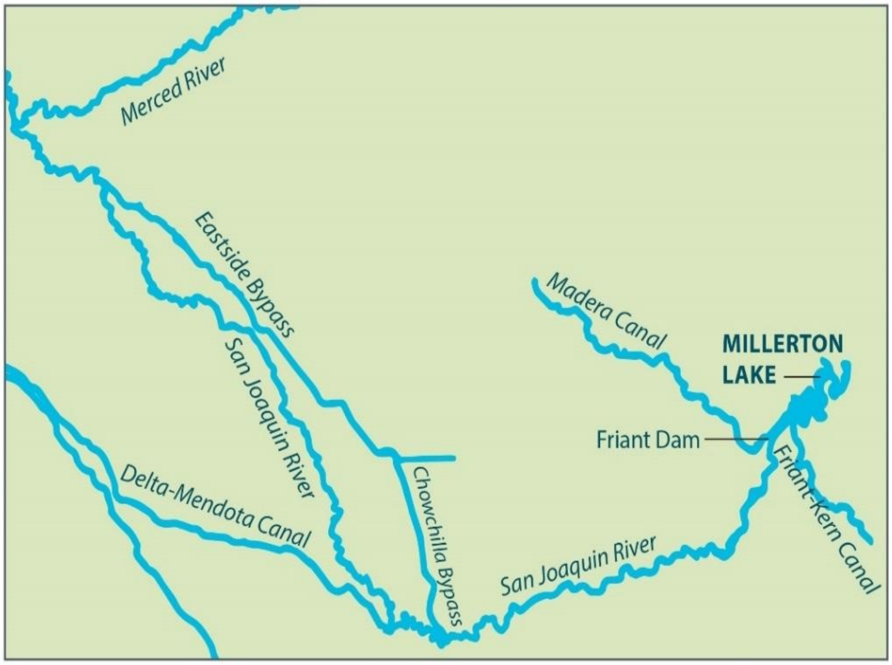


Figure 3.3-6. San Joaquin River Facilities

3.4 Alternative 1

Alternative 1 includes a combination of flow-related actions, habitat restoration, and intervention measures. Table 3.4-1, Components of Alternative 1, shows each of the components of Alternative 1, including both operational changes and nonflow habitat and facility improvements. The table shows whether each action is covered at a project or program level of analysis in this EIS. Alternative 1 components within each basin are described in more detail in the sections following the table. If not mentioned in the table, the No Action Alternative operations remain (Appendix D includes a comparison table with all components).

Table 3.4-1. Components of Alternative 1

Title	Project-Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Spring Pulse Flows	Project	–
Shasta Cold Water Pool Management	Project	–
Fall and Winter Refill and Redd Maintenance	Project	–
Rice Decomposition Smoothing	Project	–
Spring Management of Spawning Locations	Program	–
Coldwater Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough, Shasta TCD Improvements)	Program	X
Spawning and Rearing Habitat Restoration	Program	X
Small Screen Program	Program	X
Winter-Run Conservation Hatchery Production	Program	X
Adult Rescue	Program	–
Juvenile Trap and Haul	Program	X
Trinity		
Whiskeytown Reservoir Operations/Clear Creek Flows	Project	–
Feather River		
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project	–
American River		
2017 Flow Management Standard Releases and Planning Minimum	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Drought Temperature Facility Improvements	Program	X
Stanislaus		
Stanislaus Stepped Release Plan	Project	–
Alteration of Stanislaus DO Requirement	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Temperature Management Study	Program	–
San Joaquin		
Lower San Joaquin River Habitat	Program	X
Bay-Delta		
Delta Cross Channel Operations	Project	–
Water Transfers	Project	–
Clifton Court Aquatic Weed and Algal Bloom Management	Project	–
OMR Management	Project	–
Tracy Fish Collection Facility CO2 Injector and Release Sites	Project	–
Operations		
Delta Smelt Summer-Fall Habitat	Project	–
San Joaquin Basin Steelhead Telemetry Study	Project	–

Title	Project-Level Analysis or Program-Level Analysis	Construction Effects
Sacramento Deepwater Ship Channel Food Study	Program	–
North Delta Food Subsidies/Colusa Basin Drain Study	Program	–
Suisun Marsh Roaring River Distribution System Food Subsidies Study	Program	–
Habitat Restoration		
Predator Hot Spot Removal	Program	–
Facility Improvements		
Delta Cross Channel Gate Improvements	Program	X
Tracy Fish Facility Improvements	Program	X
Skinner Fish Facility Improvements	Program	X
Small Screen Program	Program	X
Fish Intervention		
Reintroduction efforts from Fish Conservation and Culture Laboratory	Project	–
Delta Fish Species Conservation Hatchery	Program	X

OMR = Old and Middle River; TCD = temperature control device

3.4.1 Upper Sacramento River (Shasta and Sacramento Divisions)

3.4.1.1 *Seasonal Operations*

Reclamation would continue to operate by season with the same primary purposes during each season as described for the No Action Alternative. For spring base flows under wetter hydrology, during the March through May time period, downstream demands are minimal and are generally met through unstored accretions to the system. Under these conditions, Reclamation aims to reduce Keswick flows during the fall-winter period. Operations under these conditions help build storage in those types of years. Other changes to specific operations are described below.

In addition to the requirements under D-1641, ramping rates for Keswick Dam between July 1 – March 31 would be reduced between sunset and sunrise:

- Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.
- Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.
- Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.

Ramping rates do not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

3.4.1.2 *Spring Pulse Flows*

Under Alternative 1, Reclamation would release spring pulse flows to help Spring-Run Chinook Salmon juvenile out-migration when the projected total May 1 Shasta Reservoir storage indicates a likelihood of sufficient coldwater to support summer coldwater pool management. Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. If Shasta Reservoir total storage on May 1 is projected to be sufficient for coldwater pool management, Reclamation could make a spring pulse release of up to 150 TAF in coordination with the upper Sacramento River scheduling team. Reclamation would make a determination of whether water could be released without affecting temperature management; Reclamation thinks that this volume is about 4 MAF, which is used as a surrogate for planning and analysis. Reclamation would not make pulse flow releases during times that Shasta Reservoir is releasing flood flows or if the release would interfere with the ability to meet other anticipated demands on the reservoir. Figure 3.4-1, Lake Shasta Spring Pulse Flow Operations, summarizes this operational regime. This figure shows timing of pulse flows potentially in March, April, or May, but the pulse flow total volume during the March through May period is up to 150 TAF total.

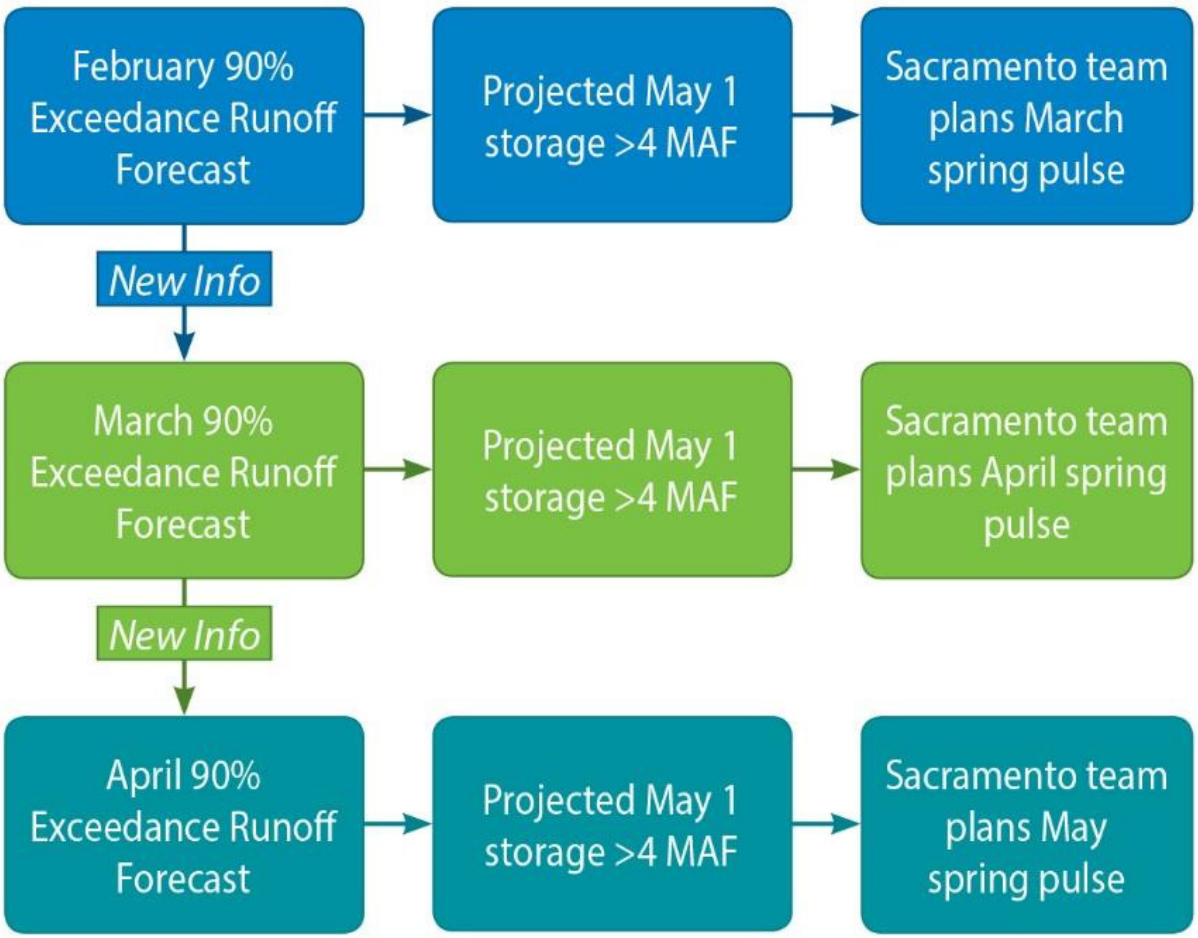


Figure 3.4-1. Lake Shasta Spring Pulse Flow Operations

3.4.1.3 *Coldwater Pool Management*

The closer Shasta Reservoir is to full by the end of May, the greater the likelihood of being able to meet the Winter-Run Chinook Salmon temperature control criteria throughout the entire temperature control season. If Shasta Reservoir storage is high enough to use the Shasta TCD upper shutters by the end of

May, Reclamation can maximize the coldwater pool potential. Figure 3.4-2, Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Coldwater Pool in Shasta Reservoir, provides an approximate rule of thumb for the relationship between temperature compliance, total storage in Shasta Reservoir, and coldwater pool in Shasta Reservoir.

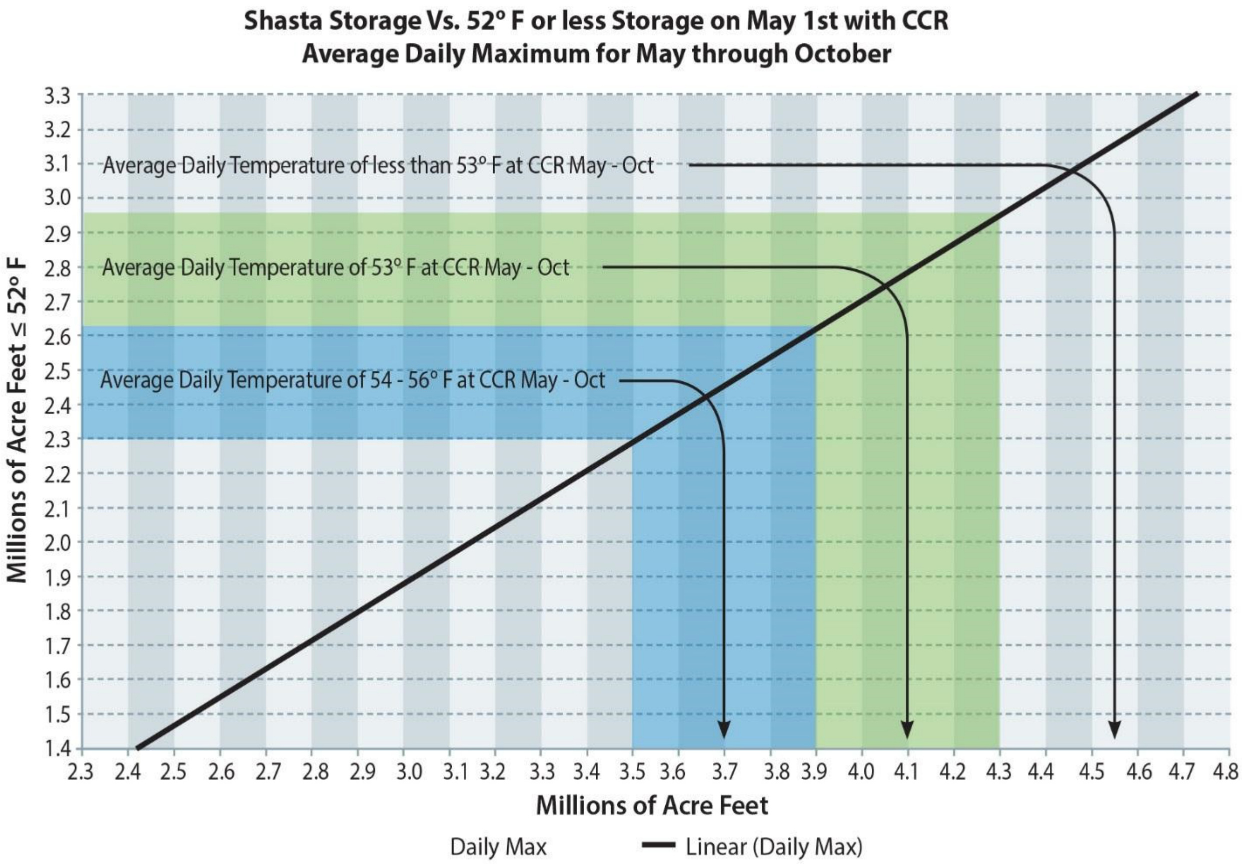


Figure 3.4-2. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Coldwater Pool in Shasta Reservoir

3.4.1.3.1 Summer Coldwater Pool Management

Under Alternative 1, Reclamation would operate the Shasta TCD to continue providing temperature management in accordance with CVPIA Section 3406(b)(6) while minimizing impacts on power generation. Coldwater pool is defined as the volume of water in Shasta Reservoir that is less than 52°F, which Reclamation would determine based on monthly (or more frequently) reservoir temperature profiles. The Sacramento River above Clear Creek gage is a surrogate for the downstream extent of most Winter-Run Chinook Salmon redds. Temperature management would start after May 15 or when the monitoring working group determines, based on real-time information, that Winter-Run Chinook Salmon have spawned, whichever is later. Temperature management would end October 31 or when the monitoring working group determines, based on real-time monitoring, that 95% of Winter-Run Chinook Salmon eggs have hatched and alevin have emerged, whichever is earlier.

Reclamation would address coldwater management using a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and coldwater pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. The tiered strategy recognizes that coldwater is a scarce resource that can be managed to achieve desired water temperatures for fisheries objectives. Figure 3.4-3, Decision Tree for Shasta Reservoir Temperature Management, provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

Reclamation would provide a draft temperature management plan to the Sacramento River Temperature Task Group (SRTTG) in April for its review and comment, consistent with WRO 90-5. The draft temperature management plan would describe which of the four tiers Reclamation forecasts for that year's summer temperature management season, along with a temperature modeling scenario and the operations forecast. The scenario would include projected reservoir releases, assumed meteorological conditions, and anticipated water temperatures and target locations for the planned water temperature targets (including allowable tolerances). Reclamation expects that tolerances would be based on conditions and modeling for that year.

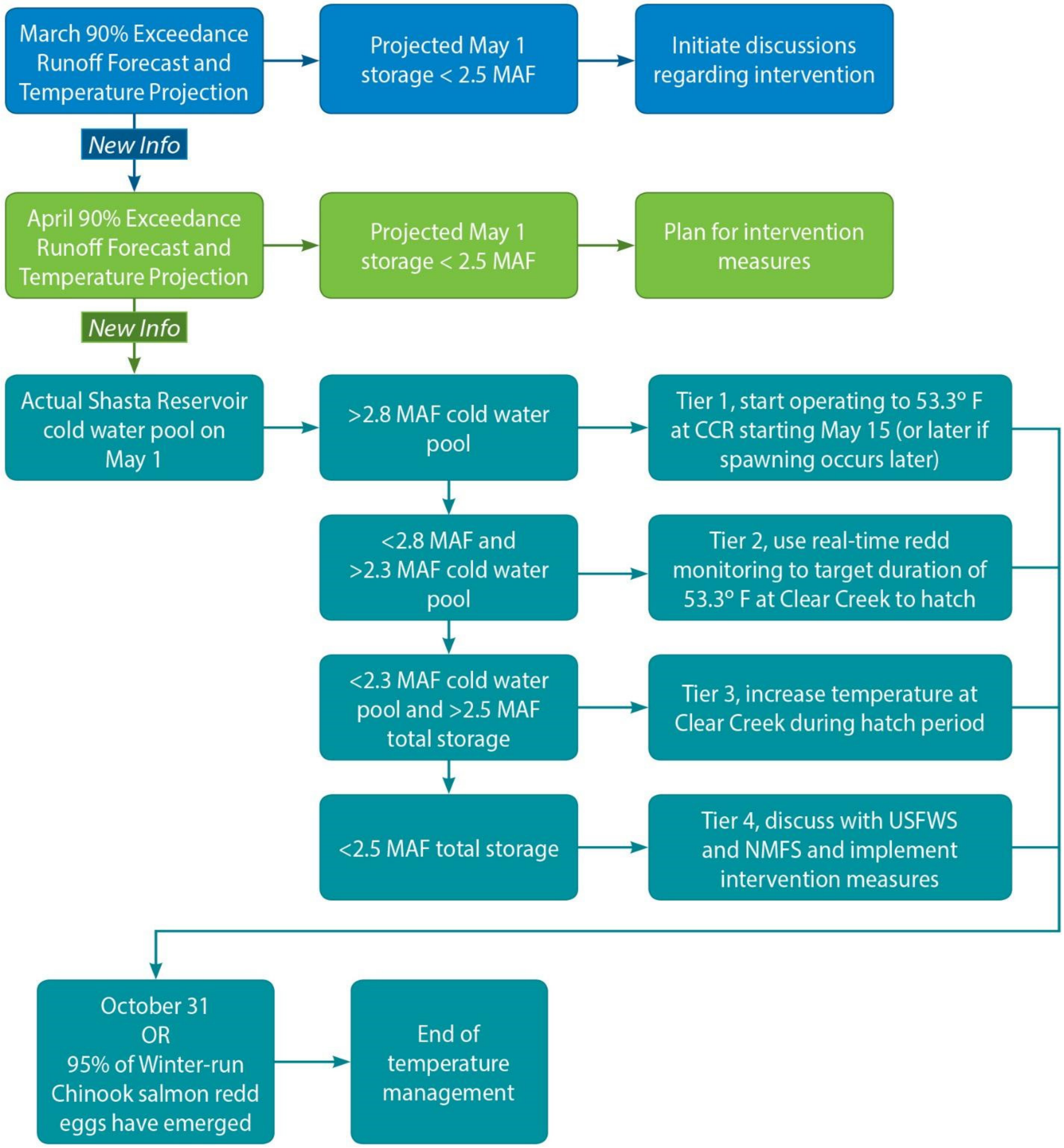


Figure 3.4-3. Decision Tree for Shasta Reservoir Temperature Management

3.4.1.3.2 Commitment to Coldwater Management Tiers

Once the initial tier is selected by May 15th, Reclamation would not cause a shift into a warmer tier during real-time implementation of the Shasta Coldwater Management Plan except in the event of responding to emergency and/or unforeseen conditions. Reclamation would reevaluate the temperature management plan (and associated tier) at least monthly and would notify NMFS within 2 business days of determining a potential change to the plan is necessary. Reclamation may be able to adjust operations to overcome unexpected events without changing to a lower tier. Should Reclamation be unable to remain within the same or cooler tier identified by the Shasta Cold Water Pool Management Plan, Reclamation would coordinate with NMFS on the need to charter an independent panel, at the end of the temperature management season, consistent with “Chartering of Independent Panels) under the “Governance” section of Alternative 1. The purpose of the independent review would be to evaluate the conditions experienced during the years under review, the success of the implementation of the tiered strategy, the effect of the implementation on the species, and, if needed, to develop recommendations to improve its implementation.

3.4.1.3.3 Upper Sacramento Performance Metrics

Reclamation would apply performance metrics for assessing coldwater management under the different tiers. The objective is to ensure that the performance falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of Alternative 1. If Alternative 1 performance falls outside the performance metrics in any single year, Reclamation would work with NMFS to determine if an independent panel is necessary. If necessary, the independent panel process would move forward as described in the “Governance” section of Alternative 1.

3.4.1.4 *Fall and Winter Refill and Redd Maintenance*

Under Alternative 1, Reclamation would rebuild storage and coldwater pool for the subsequent year. Maintaining releases to keep late spawning Winter-Run Chinook Salmon redds underwater may drawdown storage necessary for temperature management in a subsequent year. Reclamation would minimize effects with a risk analysis of the remaining Winter-Run Chinook Salmon redds, the probability of sufficient coldwater in a subsequent year, and a conservative distribution and timing of subsequent Winter-Run Chinook Salmon redds. If the combined productivity of the remaining redds plus a conservative scenario for the following year is less than the productivity of maintaining releases, Reclamation would reduce releases to rebuild storage. The conservative scenario for the following year would include a 75% (dry) hydrology; 75% (warm) climate; a median distribution for the timing of redds; and the ability to remain within Tier 3 or higher (colder) tiers. The forecast for flows in the fall would include any approved water transfers that may occur during this period.

Demands by the wildlife refuges, upstream CVP contractors, and the Sacramento River Settlement Contractors in October result in Keswick Dam releases that are generally not maintained throughout the winter due to needs to store water for beneficial uses the following year. These releases result in some early fall Chinook redds being dewatered at winter base flows. If, based on the above analysis, Reclamation determines releases need to be reduced to rebuild storage, targets for winter base flows (December 1 through the end of February) from Keswick Dam would be set in October based on Shasta Reservoir end-of-September storage. These targets would be set based on end-of-September storage and the current hydrology after accounting for Winter-run Chinook Salmon redd stranding. Base flows would be set based on historical performance to accomplish improved refill capabilities for Shasta Reservoir to build coldwater pool for the following year. Table 3.4-2, Keswick Dam Example Release Schedule for End-of-September Storage, shows examples of possible Keswick Dam releases based on Shasta Reservoir storage condition; these would be refined through future modeling efforts as part of the seasonal operations planning.

Table 3.4-2. Keswick Dam Example Release Schedule for End-of-September Storage

Keswick Release	Shasta End-of-September Storage
3,250 cfs	≤ 2.2 MAF
4,000 cfs	≤ 2.8 MAF
4,500 cfs	≤ 3.2 MAF
5,000 cfs	> 3.2 MAF

cfs = cubic feet per second

High storage years are not necessarily correlated with a following wetter fall and winter. As a result, Reclamation would manage the real time releases based on conditions observed. In scenarios where higher storage exists at the end of September but the fall hydrology is dry (generally defined as below 90% exceedance of historical hydrology), Reclamation would coordinate with appropriate agencies, including NMFS and CDFW at a minimum, to reduce flows below those described in the table, if possible.

3.4.1.5 *Additional Operations Components*

In addition to the changes to Shasta Reservoir coldwater pool operations, Alternative 1 includes multiple components to increase water deliveries and protect listed fish:

- Rice Decomposition Smoothing – Following the emergence of Winter-Run Chinook Salmon and prior to the majority of Fall-Run Chinook Salmon spawning, upstream Sacramento Valley CVP contractors and Sacramento River Settlement Contractors would work to synchronize their diversions to lower peak rice decomposition demand.
- Spring Management of Spawning Locations – Reclamation would establish experiments to refine the state of the science and determine if keeping water colder earlier induces earlier spawning or if keeping April to May Sacramento River temperatures warmer induces later spawning.
- Coldwater Management Tools – Reclamation would explore additional opportunities to extend the coldwater pool. Options include:
  - *Temperature Modeling Platform*: Reclamation would continue work to develop a new temperature model for the Upper Sacramento River (Shasta and Keswick Reservoirs) through a collaborative process that includes the NMFS Science Center.
  - *Battle Creek Restoration* – Reclamation would accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. Completion of this project would reintroduce a new population of Winter-Run Chinook Salmon, which could provide temperature compliance flexibility.
  - Lower Intakes near Wilkins Slough – This action would provide grants to water users within this area to install new diversions and screens that would operate at lower flows, which would allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (NCWA 2014).
  - Shasta TCD Improvements – Reclamation would study the feasibility of infrastructure improvements to enhance TCD performance, including reducing the leakage of warm water into the structure.

3.4.1.6 *Habitat Restoration Components*

Alternative 1 includes the following habitat restoration components:

- Spawning Habitat – Reclamation would create additional spawning habitat by adding approximately 15,000 to 40,000 tons of gravel annually into the Sacramento River to 2030, using the following sites: Keswick Dam Gravel Injection Site, Market Street Injection Site, Redding Riffle, Turtle Bay, Tobiasson Island, Shea Levee sites, and Kapusta.
- Rearing Habitat – Reclamation, in coordination with Sacramento River Settlement Contractors, would create 40 to 60 acres of side channel and floodplain habitat at multiple sites in the Sacramento River by 2030.
- Small Screen Program – Reclamation and DWR would continue to work within existing authorities (e.g., Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP and SWP streams and the Bay-Delta.

3.4.1.7 *Intervention Components*

Alternative 1 includes the following intervention components:

- Winter-Run Chinook Salmon Conservation Hatchery Production – In a Tier 4 coldwater pool management year, Reclamation would work with USFWS to increase production of Winter-Run Chinook Salmon.
- Adult Rescue – Reclamation would trap and haul adult salmonids and sturgeon from Yolo and Sutter Bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults and move them up the Sacramento River to spawning grounds.
- Trap and Haul – If Reclamation projects a Tier 4 year (less than 2.5 MAF of storage at the beginning of May), Reclamation would implement a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and steelhead in the Sacramento River watershed. Tier 4 years are anticipated to be drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream migration and survival.
- Director Meetings – In the event of two successive years with total egg-to-fry survival less than 15% in each year, Reclamation would convene a meeting of the Regional Directors of DWR, NMFS, USFWS, and CDFW to identify and implement actions to address the potential for a third year of low survival.

3.4.2 Trinity River Division

Seasonal operations in Trinity Reservoir would continue to be integrated with Shasta Reservoir operations, as described in the No Action Alternative. Additionally, Reclamation would continue to implement the Trinity River ROD and lower Klamath River augmentation flows (from the 2017 Lower Klamath ROD) that are described in the No Action Alternative. Whiskeytown Reservoir operations would be similar to those described for the No Action Alternative, with minor changes to accommodate Clear Creek flow measures described below. While Lewiston Dam releases to the Trinity River would in accordance with the ROD of 2000, modifications of operations of the CVP could cause minor changes in the operations on the Trinity River. Spring Creek Debris Dam operations and the Clear Creek Restoration Program would continue as described in the No Action Alternative.

3.4.2.1 *Clear Creek Flows*

Reclamation would release Clear Creek flows in accordance with the 2000 agreement between Reclamation, USFWS, and CDFW and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation would release a minimum base flow in Clear Creek of 200 cfs from October through May and 150 cfs from June through September in all water year types except critical water year types. In critical years, Clear Creek base flows may be reduced below 150 cfs based on available water from Trinity Reservoir. Additional flow may be required for temperature management during the fall.

In addition, Reclamation would create pulse flows for both channel maintenance and spring attraction flows. For spring attraction flows, Reclamation would release 10 TAF (measured at the release), with daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), in all water year types except for critical water year types to be shaped by the Clear Creek Implementation Team in coordination with Reclamation's Central Valley Operations Office. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown Dam, with a daily release up to the safe release capacity, in all water year types except dry and critical (based on the Sacramento Valley index) to be shaped by the Clear Creek Implementation Team in coordination with Reclamation Central Valley Operations Office.

The outlet from Whiskeytown Reservoir to Clear Creek is equipped with outlets at two different elevations. Releases can be made from either or both outlets to manage downstream temperature releases. Reclamation would manage Whiskeytown releases to meet a daily average water temperature of 60°F at the Igo gage from June 1 through September 15 and 56°F or less at the Igo gage from September 15 to October 31. Reclamation may not be able to meet these temperatures in critical or dry water year types. In those years, Reclamation would operate as close to these temperatures as possible.

Reclamation, CDFW, and SWRCB have a memorandum of understanding (MOU) regarding operations of the Spring Creek Reservoir to manage runoff from Iron Mountain Mine for the protection of water quality in the Sacramento River. Concentrations of toxic metals in acidic drainage from Iron Mountain Mine have decreased steadily because of remedial actions, so the agencies are negotiating a new MOU for inclusion in the No Action Alternative. Reclamation expects for the interim operations (currently in place) to continue into the future.

3.4.3 Feather River

DWR would operate Oroville Dam consistent with the NMFS, USFWS, and CDFW environmental requirements applicable for the current FERC license for the Oroville Complex (FERC Project #2100-134), as under the No Action Alternative. If FERC issues a new license, DWR would operate to the terms in that license.

3.4.4 American River Division

Reclamation would operate Folsom Reservoir to meet water rights, contracts, and agreements that are specific to the American River Division and to those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation would adopt the minimum flow schedule and approach proposed by the Sacramento Area Water Forum in 2017 in the 2017 *Flow Management Standard Releases and Planning Minimum* (2017 FMS).

Under Alternative 1, Reclamation would work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (that is, the planning minimum). The implementation of a planning minimum would allow Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities.

3.4.4.1 *Seasonal Operations*

In winter and spring, Reclamation would not reduce flows more than 500 cfs per day or more than 100 cfs per hour, except if necessary, for flood control operations. Reclamation would minimize releases above 4,000 cfs during sensitive life stages (eggs, incubation, rearing) of salmonids and steelhead to the extent feasible. As part of the 2017 FMS, Reclamation would implement redd dewatering protective adjustments to limit potential redd dewatering due to reductions in the minimum release during the January through May period.

During non-flood control operations within the fall and winter months, Reclamation would operate to build storage by making minimum releases and capturing inflows, although drier conditions may require releases for Delta requirements. To the extent possible, releases would be held relatively consistent to minimize potential redd dewatering.

Spring releases would be controlled by flood control requirements or, in drier hydrology, Delta requirements and water supply. Reclamation would operate Folsom Dam in a manner designed to maximize capture of the spring runoff to fill as close to full as possible. To the extent practicable, Reclamation would accommodate requests for spring pulse flows by reshaping previously planned releases; however, these requests would not be accommodated in times when they may compromise temperature operations later in the year.

Reclamation would continue making summer releases for instream temperature control, Delta outflow, and exports, typically above the planning minimum flows. By late October, it is typical for Folsom Reservoir to have depleted the coldwater pool. The primary way to provide additional instream cooling is to release water from the lower outlet works.

Reclamation would ramp down releases in the American River below Nimbus Dam as shown in Table 3.4-3.

Table 3.4-3: American River Ramping Rates

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

Ramping rates would not apply during flood control or if needed for facility operational concerns. The working groups may also determine a need for a variance.

3.4.4.2 *Temperature Management*

Reclamation would prepare a draft temperature management plan by May 15 for the summer through fall temperature management season using the best available (as determined by Reclamation) decision support tools. The draft plan would be shared with the American River Group before finalization and may be updated monthly based on system conditions.

3.4.4.3 *Water Operations Component*

In addition to the changes to Folsom Reservoir operations, Alternative 1 includes a component to increase water deliveries and protect listed fish:

- Drought Temperature Management – In severe or worse droughts, Reclamation would evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility.

3.4.4.4 *Habitat Restoration Components*

Alternative 1 includes the following habitat restoration components:

- Spawning and Rearing Habitat – Pursuant to CVPIA 3406(b)(13), Reclamation would implement the Cordova Creek Phase II and Carmichael Creek Restoration projects and increase woody material in the American River. Reclamation would also conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar—North, El Manto, Sacramento Bar—South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction.
- Reclamation would continue maintenance activities at Nimbus Basin, Upper Sailor Bar, Lower Sailor Bar, Upper Sunrise, Lower Sunrise, and River Bend restoration sites.

3.4.4.5 *Intervention Components*

Alternative 1 would include improvements to Nimbus Fish Hatchery to improve management. Reclamation would complete a Hatchery Genetics Management Plan for Steelhead and a Hatchery Management Plan for Fall-run Chinook Salmon as part of Nimbus Fish Hatchery management. Reclamation would work with CDFW and NMFS to establish clear goals, appropriate time horizons, and reasonable cost estimates for this effort.

3.4.5 Bay-Delta

As described in the No Action Alternative, the CVP and SWP divert water in the Delta through the Jones and Banks Pumping Plants for delivery to the Central Valley, San Francisco Bay Area, and Southern California. Operations of these facilities would continue in Alternative 1 with the changes described below.

3.4.5.1 *Delta Cross Channel*

Under Alternative 1, Reclamation would operate the DCC gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641. From October 1 to November 30, if the Knights Landing Catch Index or Sacramento Catch Index are greater than three fish per day Reclamation would operate based on Table 3.4-3, Delta Cross Channel October 1–November 30 Action, and Table 3.4-4, Water Quality Concern Level Targets, to determine whether to close the DCC gates and for what duration. From December 1 to January 31, the DCC gates would be closed. If drought conditions were observed (i.e., fall inflow conditions were less than 90% of historic flows), Reclamation and DWR would consider opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR would coordinate with USFWS, NMFS, and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. Reclamation and DWR would conduct a risk assessment that would consider the Knights Landing Rotary Screw Trap monitoring, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation would also consider the cumulative entrainment from prior years. Reclamation would evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect or a greater range of an adverse effect, not considered under this alternative, Reclamation would not open the DCC. During a DCC gate opening between December 1 and January 31, the CVP and SWP would divert at health and safety pumping levels.

From May 21 to June 15, Reclamation would close the DCC gates for 14 days during this period, consistent with D-1641. Reclamation and DWR's risk assessment would consider the Knights Landing Rotary Screw Trap, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information, Delta Simulation Model II – DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation would evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change would create a new adverse effect not considered under Alternative 1, Reclamation would not open the DCC.

Table 3.4-4. Delta Cross Channel October 1–November 30 Action

Date	Action Triggers	Action Responses
October 1–November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index or Sacramento Catch Index is greater than five fish per day.	Within 48 hours, close the DCC gates and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites.
	Water quality criteria per D-1641 are met and either Knights Landing Catch Index or the Sacramento Catch Index are greater than three fish per day but less than or equal to five fish per day.	Within 48 hours of trigger, DCC gates are closed. Gates would remain closed for 3 days.
	Water quality criteria per D-1641 are met, real-time hydrodynamic and salinity modeling shows water quality concern level targets are not exceeded during 28-day period following DCC closure, there is no observed deterioration of interior Delta water quality.	Within 48 hours of start of lower Mokelumne River attraction flow release, close the DCC gates for up to 5 days (dependent upon continuity of favorable water quality conditions).
	Water quality criteria per D-1641 are met and real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14-day period following DCC closure.	No closure of DCC gates.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	Monitoring groups review monitoring data and provide to Reclamation. Reclamation and DWR determine what to do with a risk assessment.

DCC = Delta Cross Channel, DWR = California Department of Water Resources, KLCI = Knights Landing Catch Index, SCI = Sacramento Catch Index

Table 3.4-5. Water Quality Concern Level Targets

Water Quality Concern Level Targets (Water Quality Model Simulated 14-day Average Electrical Conductivity)	
Jersey Point	1,800 μmhos/cm
Bethel Island	1,000 μmhos/cm
Holland Cut	800 μmhos/cm
Bacon Island	700 μmhos/cm

μmhos/cm = micromhos per centimeter

3.4.5.2 *North Bay Aqueduct Operations*

The NBA and Barker Slough Pumping Plant would continue to operate under applicable regulatory requirements and remove sediment and aquatic weeds as needed.

Sediment Removal

Sediment accumulates in the concrete apron sediment trap in front of the Barker Slough Pumping Plant fish screens and within the pump wells behind the fish screens. Sediment removal from the sediment trap and the pump wells would be removed as needed.

Accumulated sediment from the apron in front of the fish screen and in the pump wells behind the fish screen would be removed by suction dredge. Removal of sediment from within the pump wells would occur as needed, year-round. Removal of sediment from the apron area in front of the fish screens would occur during summer and early fall months and during the annual North Bay Aqueduct shutdown in March. The North Bay Aqueduct is annually taken off-line for one-to-two weeks for routine maintenance and repairs, and the Barker Slough Pumping Plant is non-operational during the shutdown.

Aquatic Weed Removal

Aquatic weeds would be removed, as needed, from in front of the fish screens at Barker Slough Pumping Plant. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. The aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the Barker Slough Pumping Plant pumps, would lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds would be transported to two aggregate base spoil sites located near the pumping plant. Removal of aquatic weeks from the fish screens would typically occur during summer and fall months when aquatic weed production is highest. Floating aquatic vegetation (i.e., water hyacinth) may need to be removed during spring months if it becomes entrained into Barker Slough and accumulates in front of the fish screens.

3.4.5.3 *Contra Costa Water District Operations*

Contra Costa Water District facilities would continue to be operated and maintained under applicable permits.

3.4.5.4 *Water Transfers*

Reclamation and DWR would continue to transfer project and nonproject water supplies through CVP and SWP facilities, including north-to-south transfers and Sacramento River north-to-north transfers. Alternative 1 would include the same volume of transfers as included in the No Action Alternative, but Reclamation and DWR would provide an extended transfer window from July 1 through November 30. Allowing fall transfers is expected to have water supply benefits and may provide flexibility to improve Sacramento River temperature operations during dry conditions, such as those that occurred during the 2014–2015 drought conditions. Quantities and timing would be similar to the transfers implemented in 2014.

3.4.5.5 *Clifton Court Aquatic Weed Removal*

DWR would continue to apply copper-based aquatic herbicides and algaecides to control aquatic weeds and algal blooms and use mechanical harvesters on an as-needed basis in CCF (as described in the No Action Alternative), but would also apply Aquathol® K aquatic herbicide and peroxygen-based algaecides (e.g. PAK 27) and extend the treatment window beyond July 1 to August 31. DWR could apply Aquathol K, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate), a copper carbonate compound, or other copper-based herbicides. Algaecides may include peroxygen-based algaecides (e.g., PAK 27). These products are used to control algal blooms that can degrade drinking water quality through production of taste and odor compounds of algal toxins and can cause excessive filter clogging at drinking water treatment plants. Treatment areas would typically be about 900 acres and no more than 50% of the 2,180 total surface acres.

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, cyanotoxin concentration from the harmful algal blooms, or concentration of taste and odor compounds. Operational procedures would minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in CCF. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and steelhead in the Central Valley Delta region and of Delta Smelt. Applications of aquatic herbicides and algaecides would be contained within CCF. The radial intake gates to CCF would be closed prior to, during, and following the application. More detail on these procedures is included in Appendix D, Section 4.3.5.4.

3.4.5.6 *Old and Middle River Management*

Reclamation and DWR would operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net flow from Old and Middle River provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. OMR management, in combination with other environmental variables, can minimize or avoid the entrainment of fish in the south Delta and at CVP and SWP salvage facilities. Reclamation and DWR would maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for OMR management to focus protections for fish when necessary and provide flexibility where possible, consistent with the Water Infrastructure Improvements for the Nation Act Sections 4002 and 4003. Estimates of species distribution would be described by multiagency, Delta-focused technical teams.

From the onset of OMR management to the end, Reclamation and DWR would operate to an OMR index no more negative than a 14-day moving average of −5,000 cfs unless a storm event occurs (see below for storm-related OMR flexibility). Grimaldo et al. (2017) indicate that −5,000 cfs OMR is an inflection point for fish entrainment. The OMR could be more positive than −5,000 cfs if additional real-time OMR restrictions are triggered (described below), or constraints other than OMR control exports. Reclamation and DWR would operate to an OMR index computed using an equation. An OMR index allows for shorter-term operational planning and real-time adjustments. Reclamation and DWR would make a change to exports within 3 days of the trigger when monitoring, modeling, and criteria indicate protection for fish is necessary. The 3-day trigger would allow for efficient power scheduling.

3.4.5.6.1 <u>Onset of OMR Management</u>

Reclamation and DWR would start OMR management when one or more of the following conditions have occurred:

- Integrated Early Winter Pulse Protection (First Flush Turbidity Event) – To minimize project influence on migration (or dispersal) of Delta Smelt, Reclamation and DWR would reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period would not be more negative than −2,000 cfs, in response to “First Flush” conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polanksy et al. 2018). “First flush” may be triggered between December 1 and January 31 and include:
    - Running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and

  - o Running 3-day average of the daily turbidity at Freeport is 50 Nephelometric Turbidity Unit (NTU) or greater or
  - o Real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.

  This "First Flush" action may only be initiated once during the December through January period and would not be required if:

  - o Water temperature reaches 12°C based on a three station daily mean at Honker Bay, Antioch, and Rio Vista; and/or
  - o Ripe or spent Delta Smelt are collected in a monitoring survey.

- Salmonids Presence: After January 1, if more than 5% of any one or more salmonid species (wild young-of-year Winter-Run, wild young-of-year Spring-Run, or wild California Central Valley Steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling.

3.4.5.6.2 Additional Real-Time OMR Restrictions and Performance Objectives

Reclamation and DWR would manage to a more positive OMR than −5,000 cfs based on the following conditions:

- Turbidity Bridge Avoidance (South Delta Turbidity) –After the Integrated Early Winter Pulse Protection or February 1, whichever comes first, and prior to April 1, Reclamation and DWR would manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to protect Delta Smelt from damaging levels of entrainment after a First Flush and in years when a First Flush does not occur. This action seeks to avoid the formation of a continuous turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of pre-spawning adult Delta Smelt. If the daily average turbidity at Bacon Island could not be maintained at less than 12 NTU, Reclamation and DWR would manage exports to achieve an OMR no more negative than −2,000 cfs until the average turbidity at Bacon Island drops below 12 NTU. After 5 days, Reclamation and DWR could determine that real-time OMR restrictions were not required to avoid damaging levels of entrainment based on the distribution of Delta Smelt in real-time monitoring and the absence of detections in salvage (i.e., less than 5% of the population).
- Larval and Juvenile Delta Smelt – When Q-West (net flow on the San Joaquin River at Jersey Point) is negative and larval or juvenile smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR would run hydrodynamic models informed by the Enhanced Delta Smelt Monitoring Program (EDSM), 20 mm, or other relevant survey data to estimate the percentage of larval and juvenile smelt that could be entrained and operated to avoid greater than 10% loss of modeled larval and juvenile cohort Delta Smelt. Typically, this would come into effect beginning the middle of March.
- Cumulative Loss Threshold:
  - o Reclamation and DWR would avoid exceeding cumulative loss thresholds over the duration of the 2019 Biological Opinions for wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April 1 through June 15th. Wild Central Valley Steelhead would be

separated into two time periods to protect San Joaquin origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.

- The cumulative loss thresholds would be based on cumulative historical loss from 2010 through 2018. Reclamation's and DWR's performance objectives would set a trajectory such that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) would not be exceeded by 2030.
- If, at any time prior to 2024, Reclamation and DWR would exceed 50% of the cumulative loss threshold, Reclamation and DWR would convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.
- In the year 2024, Reclamation and DWR would convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.
- If, during real-time operations, Reclamation and DWR would exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of Alternative 1. The purpose of the independent review would be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish

- Single-Year Salvage Threshold:
  - In each year, Reclamation and DWR would avoid exceeding an annual loss threshold equal to 90% of the greatest salvage loss that occurred in the historical record from 2010 through 2018 for each of wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April through June 15. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon would be based on length-at-date criteria.
  - During the year, if Reclamation and DWR would exceed the annual loss from 2010 through 2018, Reclamation and DWR would review recent fish distribution information and operations with the fisheries agencies at the Water Operations Management Team (WOMT) and seek technical assistance on future planned operations. Any agency could elevate from WOMT to a Directors discussion, as appropriate.
  - During the year, if Reclamation and DWR exceed 50% of the annual loss threshold, Reclamation and DWR would restrict OMR to a 14-day moving average OMR index of no more negative than −3,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

- The −3,500 cfs OMR operational criterion adjusted and informed by this risk assessment would remain in effect for the rest of the season. Reclamation and DWR would seek NMFS technical assistance on the risk assessment and real-time operations.
- During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR would restrict OMR to a 14-day moving average OMR index of no more negative than −2,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
- The −2,500 cfs OMR operational criterion adjusted and informed by this risk assessment would remain in effect for the rest of the season. Reclamation and DWR would seek NMFS technical assistance on the risk assessment and real-time operations.
- Risk assessment: Reclamation and DWR would determine and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring detects few fish in the south Delta and few fish are detected in salvage. Reclamation and DWR would share its technical analysis and supporting documentation with USFWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate.
- If, during real-time operations, Reclamation and DWR would exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of Alternative 1. The purpose of the independent review would be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.

- Reclamation and DWR would consider the historical monthly distribution of loss to avoid disproportionately salvaging fish during any single month.

Reclamation and DWR would continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Fish Protection Facility. Reclamation and DWR would continue the release and monitoring of yearling Coleman National Fish Hatchery Late-Fall run as yearling Spring-Run Chinook Salmon surrogates.

3.4.5.6.3 Storm-Related OMR Flexibility

Reclamation and DWR could operate to a more negative OMR up to a maximum (otherwise permitted) export rate of 14,900 cfs (which could result in a range of OMR values) at Banks and Jones Pumping Plants to capture peak flows during storm-related events. Reclamation and DWR would continue to monitor fish in real-time and would operate in accordance with the thresholds in "Additional Real-Time OMR Restrictions" (see Section 3.4.5.5.2).

Under the following conditions, Reclamation and DWR would not cause OMR to be more negative for capturing peak flows from storm-related events:

- Integrated Early Winter Pulse Protection (above) or Additional Real-Time OMR Restrictions (above) are triggered. Under such conditions, Reclamation and DWR would have already determined that more restrictive OMR is required.

- An evaluation of environmental and biological conditions indicates more negative OMR would likely cause Reclamation and DWR to trigger an Additional Real-Time OMR Restriction (above).
- Salvage of yearling Coleman National Fish Hatchery Late-Fall run (as yearling Spring-Run Chinook Salmon surrogates) exceeds 0.5% within any of the release groups.
- Reclamation and DWR identify changes in spawning, foraging, sheltering, or migration behavior beyond those described in the 2019 Biological Opinion for this project.

Reclamation and DWR would continue to monitor conditions and could resume management of OMR to no more negative than −5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in "Additional Real-Time OMR Restrictions", Reclamation and DWR would implement additional real-time OMR restrictions.

3.4.5.6.4 End of OMR Management

OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: When the daily mean water temperature at CCF reaches 77°F for 3 consecutive days.
- Salmonids:
  - When more than 95% of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
  - After daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive).

3.4.5.6.5 Real-Time Decision-Making and Salvage Thresholds

Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR than what is specified in Additional Real-Time OMR Restrictions. Upon mutual agreement, the Directors of NMFS and USFWS may authorize Reclamation to operate to a more negative OMR than the Additional Real-Time OMR Restrictions, but no more negative than −5,000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR than the Additional Real-Time OMR Restrictions, but no more negative than -5,000 cfs.

Figure 3.4-4, Decision Tree for OMR Reverse Flow Management, shows OMR management in a decision tree.

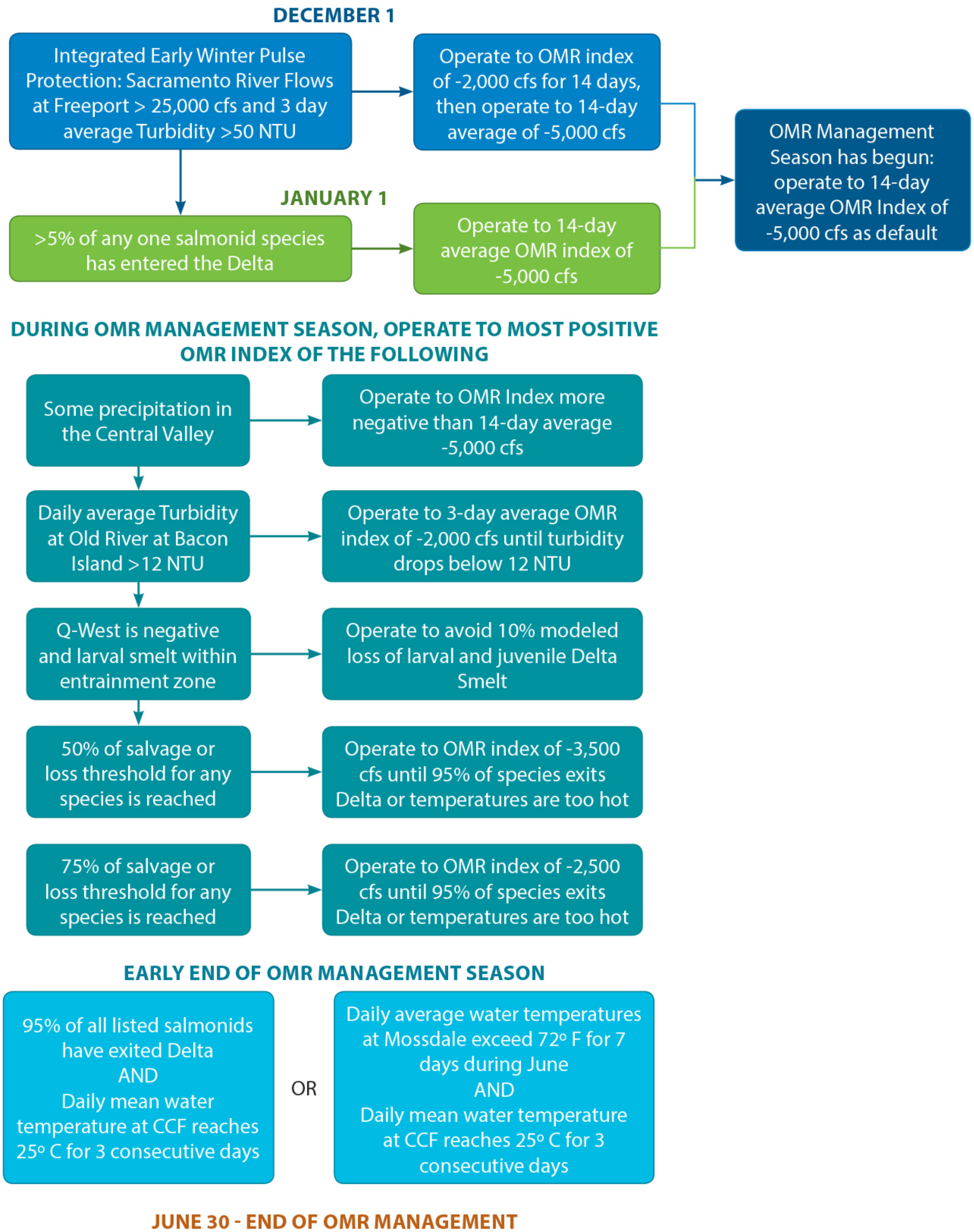


Figure 3.4-4. Decision Tree for OMR Reverse Flow Management

3.4.5.7 *Tracy Fish Collection Facility Carbon Dioxide Injection and Release Sites*

Reclamation would continue to screen fish from Jones Pumping Plant with the TFCF. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an 8 parts per thousand salt solution to reduce stress. The CVP uses two release sites: one on the Sacramento River near Horseshoe Bend and one on the San Joaquin River immediately upstream of Antioch Bridge. Reclamation would increase the number of release sites to reduce predation. Reclamation would conduct studies and physical improvements aimed to improve fish survival and improve TFCF efficiency, reducing mortality through the facility, fish hauling and release operations through the Tracy Fish Facility Improvement Program. Activities include louver improvement and replacement, predation studies and piscivorous predator control, improvement of hydrologic monitoring and telemetry systems, holding area improvements including fish count automation and tank aeration and screening, improvement of data management as well as aquaculture facility maintenance, operation and improvements.

3.4.5.8 *Delta Smelt Summer-Fall Habitat*

Reclamation and DWR would use structured decision-making to implement Delta Smelt habitat actions. In the summer and fall (June through October) of below normal, above normal, and wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following:

- Maintain low salinity habitat in Suisun Marsh and Grizzly Bay when water temperatures are suitable;
- Manage the low salinity zone to overlap with turbid water and available food supplies; and
- Establish contiguous low salinity habitat from Cache Slough Complex to Suisun Marsh.

The Delta Smelt Summer-Fall Habitat action would be incorporated into the “Four Year Review” under the “Governance” section of Alternative 1.

The Delta Smelt Habitat Action described below is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0–6 parts per thousand (ppt), turbidity of approximately 12 NTU or greater, temperatures below 25°C, food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Habitat Action is being undertaken, recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Habitat Action is to provide these habitat components in the same geographic area through a range of action to improve water quality and food supplies.

The action may include, but is not limited to the following components:

- Suisun Marsh Salinity Control Gates (SMSCG) operations for up to 60 days (not necessarily consecutive) in June through October of below normal, above normal, and wet years;
- Project operations to maintain a monthly average 2 ppt isohaline at 80 kilometers (km) from the Golden Gate Bridge in above normal and wet water years in September and October with offramp criteria when:
    - Sufficient habitat acreages in Suisun Marsh, Grizzly Bay, and other adjacent areas are available to support Delta Smelt recruitment (e.g. 0-6 ppt at Hunter’s Cut, non-lethal temperatures, etc.);

  - Suitable recruitment projections based on Service approved lifecycle modeling and/or monitoring to indicate a positive trend in Delta Smelt and a determination that the Summer-Fall Habitat Action is not necessary to continue that trend; or
  - The absence of Delta Smelt in target areas based on EDSM or similar sampling; or other factors that would limit the benefits of the action (lack of suitable habitat, based on presence/absence modeling such as the Hurdle Model or similar).
- Food enhancement actions; for example, those included in the Delta Smelt Resiliency Plan to enhance food supply, the North Delta Food Subsidies and Colusa Basin Drain project, Sacramento River Deepwater Ship Channel lock reoperation, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation).

Through collaborative planning (described in Section 3.4.8), Reclamation and DWR would develop a Summer-Fall Habitat Plan to meet the environmental and biological goals in years when summer-fall habitat actions are triggered. In above normal and wet years, operating to a monthly average X2 of 80 km in September and October is an operational back-stop that would be available to provide a specific acreage of low salinity habitat. In every action year, Reclamation and DWR would propose, based on discussions with the USFWS, a suite of actions that would meet the action’s environmental and biological goals. If it is determined that any of the off-ramps identified above are applicable, Reclamation and DWR would include a discussion of those off-ramps in the Summer-Fall Habitat Plan.

As part of the Delta Smelt Habitat Action, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action would depend on the particular hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases could be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood control limitations are expected. In these scenarios, Reclamation would make releases in a manner that minimizes redd dewatering where possible.

The offramp criteria would be more fully defined and examples of potential implementation developed through the structured decision making or other review process. The review would include selection of appropriate models, sampling programs, and other information to be used. The specific offramp criteria may be modified through the process. The process would be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed.

3.4.5.9 *Additional Operations Components*

In addition to the changes to CVP and SWP export operations, Alternative 1 would continue the San Joaquin Basin Steelhead Telemetry Study. This is a 6-year study on the migration and survival of San Joaquin Origin Central Valley Steelhead. Alternative 1 also includes steelhead lifecycle monitoring on the Stanislaus River, a Sacramento basin CVP tributary (such as Clear Creek, Upper Sacramento River, or American River), and the San Joaquin River.

3.4.5.10 *Habitat Components*

DWR and Reclamation would continue to implement existing and ongoing restoration efforts that are underway but not complete, including:

- Coordination with water users – Reclamation would coordinate with water users to remove predator hot spots in the Bay-Delta, which includes minimizing lighting at fish screens and bridges and possibly removing abandoned structures.
- Small Screen Program – Reclamation and DWR continue to work with existing authorities (Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP and SWP streams and the Bay-Delta.

3.4.5.11 *Intervention Components*

Reclamation and DWR would continue implementation of the following projects to reduce mortality of ESA-listed fish species:

- Head of Old River: Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats.
- Delta Cross-Channel Gate Improvements – Reclamation would modernize the DCC gate materials and mechanics to include adding industrial control systems, and improve physical and biological monitoring associated with the DCC daily and/or tidal operations as necessary to maximize water supply deliveries.
- Tracy Fish Collection Facility Improvements – Reclamation would improve the TFCF to reduce loss by (1) incorporating additional fish exclusion barrier technology into the primary fish removal barriers; (2) incorporating additional debris removal systems at each trash removal barrier, screen, and fish barrier; (3) constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility; (4) constructing additional fish handling systems and holding tanks to improve system reliability; and (5) incorporating remote operation into the design and construction of the facility.
- Skinner Fish Facility Improvements – DWR would continue implementation of projects to reduce mortality of ESA-listed fish species. These measures that would be implemented include (1) electroshocking and relocating predators, (2) controlling aquatic weeds, (3) developing a fishing incentives or reward program for catching predators or predator relocation, and (4) implementing operational changes when listed species are present.
- Release Sites – Reclamation would continue work with DWR to incorporate flexibility in salvage release sites, using DWR's sites, or alternative fish release methods.
- Conservation and Culture Laboratory: The existing Fish Conservation and Culture Laboratory would be used in the interim to begin supplementation of the wild Delta Smelt population with captively produced Delta Smelt prior to construction of the new conservation hatchery.
- Delta Fish Species Conservation Hatchery – Reclamation would partner with DWR to complete construction and operate a conservation hatchery for Delta Smelt, by 2030.

3.4.6 Stanislaus River

As discussed in the No Action Alternative, Reclamation has worked with water users and related agencies to develop an operating plan for New Melones Reservoir to meet the multiple objectives on the system, but a plan is not complete. Alternative 1 includes an operating plan, described below, which is intended to replace often overlapping and conflicting operational components of previous federal and state flow requirements and is representative of Reclamation's contribution to any current or future flow objectives on the lower San Joaquin River at Vernalis.

3.4.6.1 *Seasonal Operations*

Reclamation would meet water rights, contracts, and agreements that are specific to the East Side Division and Stanislaus River. Senior water right holders (Oakdale Irrigation District and South San Juaquin Irrigation District) would receive annual water deliveries consistent with the 1988 agreement and stipulation, and water would be made available to CVP contractors in accordance with their contracts and applicable shortage provisions.

In high storage, high inflow conditions, Reclamation would operate for flood control in accordance with the USACE flood control manual. Reclamation would operate New Melones Reservoir (as measured at Goodwin Dam) in accordance with a stepped release plan (SRP) that varies by hydrologic condition and water year type as shown in Table 3.4-6, New Melones SRP Annual Releases by Water Year Type.

Table 3.4-6. New Melones SRP Annual Releases by Water Year Type

Water Year Type	Annual Release (TAF)
Critically dry	184.3
Dry	233.3
Below normal	344.6
Above normal	344.6
Wet	476.3

TAF = thousand acre-feet

The New Melones SRP would be implemented similarly to the No Action Alternative with a default daily hydrograph and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives. The default daily hydrograph is the same as prescribed under the No Action Alternative for critically dry, dry, and below-normal water year types. The difference occurs in above normal and wet years, where the minimum requirement for larger releases is reduced from the No Action Alternative to promote storage for potential future droughts and preserve coldwater pool. When compared to minimum daily flows from the No Action Alternative, the daily hydrograph for the New Melones SRP is identical for critically dry, and below normal year types; above normal and wet year types follow daily hydrographs for below normal and above normal year types from current operating requirements, respectively.

During the summer, Reclamation would be required to maintain applicable dissolved oxygen standards on the lower Stanislaus River for species protection. Reclamation currently operates to a 7 milligrams per liter dissolved oxygen requirement at Ripon from June 1 to September 30. Reclamation would move the compliance location to Orange Blossom Bridge, where the species are primarily located at that time of year.

3.4.6.2 *Habitat Components*

Alternative 1 includes the following habitat components:

- Spawning Habitat – Under the CVPIA (b)(13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River. Continued gravel placement sites would include River Mile 58 on the lower Stanislaus River, Goodwin Canyon (at the cable crossing and float tube pool), Honolulu Bar, Buttonbush, and Rodden Road. Reclamation would also work with new sites, including Two Mile Bar, Kerr Park, and Goodwin Canyon.

- Rearing Habitat – Reclamation would construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030. Reclamation may improve or add to existing projects at Lancaster Road, Honolulu Bar, Buttonbush, or Rodden Road. Reclamation would also work with new sites at Two Mile Bar or Kerr Park.
- Temperature Management – Reclamation would study approaches to improving temperature for listed species on the lower Stanislaus River to include evaluating the utility of conducting temperature measurements or profiles in New Melones Reservoir.

3.4.7 San Joaquin River

Reclamation would continue to implement the SJRRP as described in the No Action Alternative. Additionally, Reclamation would implement rearing habitat restoration on the lower San Joaquin River. Reclamation would work with private landowners to create a locally driven, regional partnership to define and implement a large-scale floodplain habitat restoration effort in the lower San Joaquin River.

3.4.8 Governance

Reclamation would work with DWR, NMFS, USFWS, CDFW, public water agencies, and other participants to manage operations in multiple ways. Key governance functions are described below.

3.4.8.1 *Core Water Operation*

Reclamation and DWR would operate the CVP and SWP, while reducing the stressors on listed species influenced by those ongoing operations. through real-time monitoring. Reclamation would implement activities, monitor performance, and report on compliance with the commitments in Alternative 1. The Real-Time Water Operations Charter (Charter) establishes how Reclamation and DWR would monitor and report on ESA Section 7 commitments under Alternative 1 and how the five agencies, public water agencies, and other participants would communicate, and coordinate real-time water operations decisions. The Charter also describes the deliverables, schedule, and decision making processes.

NMFS, USFWS, and CDFW would provide information to Reclamation and DWR on the real-time disposition of species through specific monitoring workgroups. This information would inform the risk analysis performed by Reclamation and DWR.

3.4.8.2 *Scheduling*

Fishery agencies and water users in watershed-based groups would provide scheduling recommendations to Reclamation and DWR on duration, timing, and magnitude of specific blocks of water related to Alternative 1 components that have schedule flexibility. Reclamation and DWR would evaluate and consider the recommendations and operate the CVP and SWP to those schedules as feasible.

3.4.8.3 *Collaborative Planning*

As part of Alternative 1, Reclamation would pursue and implement certain actions through collaborative planning with the goal of continuing to identify and undertake actions that benefit listed species. Collaborative planning would make use of the Collaborative Science and Adaptive Management

Program, CVPIA, Interagency Ecological Program, and Delta Plan Interagency Implementation Committee, successors to the forums, or complementary forums (e.g. Voluntary Agreement forums). Each of these programs has established governance, work planning, implementation, reporting, and independent review.

3.4.8.4 *Compliance and Performance Reporting*

Reclamation and DWR would annually report on water operations and fish performance seasonally and in an annual summary. Changes to Alternative 1 would occur based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

a) If the amount or extent of taking specified in the incidental take statement is exceeded;

b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Reclamation would monitor take for the purpose of evaluating trigger (a) above; Reclamation would monitor the effects of Alternative 1 for the purpose of evaluating trigger (b) above. If Reclamation decides to modify Alternative 1, Reclamation would evaluate the changes to Alternative 1 based on trigger (c) above. Consistent with 50 CFR 402.16, the USFWS and/or NMFS could also reinitiate formal consultation as appropriate. Reclamation would coordinate with DWR as an "applicant" and support DWR's coordination with CDFW.

3.4.8.5 *Drought and Dry Year Actions*

Within 18 months of executing the Record of Decision, Reclamation would coordinate with DWR to develop a voluntary toolkit to be exercised at the discretion of Reclamation, DWR, other agencies, participating water users, and/or others for the operation of Shasta Reservoir during critical hydrologic year types. The toolkit would include, at a minimum: measures at the Livingston-Stone National Fish Hatchery; the potential for translocation of fish; and facility improvements to reduce the adverse effects of critical and dry years on listed species. Drought and dry year planning would include the measures under Shasta Cold Water Pool Management Dry Years, Drought Years, and Successive Dry Years.

On October 1st, if the prior water year was dry or critical, Reclamation would meet and confer with USFWS, NMFS, DWR, CDFW, and Sacramento River Settlement Contractors on voluntary measures to be considered if drought conditions continue into the following year, including measures that may be beyond Reclamation and DWR's discretion. If dry conditions continue, Reclamation would regularly meet with this group (and potentially other agencies and organizations) to evaluate current hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit) for the water year.

By February of each year following a critical hydrologic year type, Reclamation would report on the measures employed and assess the effectiveness. The toolkit would be revisited at a frequency of not more than 5 years after the Record of Decision.

3.4.8.6 *Chartering of Independent Panels*

Reclamation and DWR would charter independent panels to review particular actions as described in certain components of Alternative 1. Independent panels would review actions consistent with the standards of the Delta Stewardship Council and applicable Reclamation and DWR guidance. Experts on the panel would provide information and recommendations but would not make consensus recommendations to Reclamation. NMFS and FWS could provide technical assistance and input in the development of the charter. Reclamation and DWR would provide the results of the independent review to NMFS and FWS. Reclamation would coordinate with DWR to document a response to the independent review including whether implementation of alternative strategies would require reinitiation consistent with the reinitiation triggers provided by 50 CFR 402.16. Nothing associated with the chartering of and responding to independent panels precludes NMFS nor FWS from exercising its statutory responsibilities under the ESA.

3.4.8.7 *Four Year Reviews*

In January of 2024 and January of 2028, Reclamation and DWR would charter an independent panel to review the following actions:

- Upper Sacramento Performance Metrics
- OMR management and measures to improve survival through the South delta
- Delta Smelt Summer and Fall Habitat Actions

Reclamation and DWR could incorporate additional information into the reviews in coordination with local, state, and federal partners.

3.5 Alternative 2

Alternative 2 reflects a condition where Reclamation would operate the CVP to meet the legal requirements associated with its water rights but would not release additional flows for fish and wildlife purposes. DWR would continue to operate Lake Oroville according to the most recent FERC license, and Delta operations would be governed by water right requirements. Most of the water right conditions are from D-1641 (SWRCB 2000), which sets forth the water right requirements to meet the objectives in the Bay-Delta WQCP (SWRCB 1995).).

Table 3.5-1, Components of Alternative 2, includes a column that considers if a component is covered at a project or program level of analysis in this EIS. Alternative 2 does not have any components considered program level. Unlike Alternative 1, this table does not include a column for construction effects because Alternative 2 does not have any construction components. If not mentioned in the table, the operations of the No Action Alternative remain. Appendix D includes a comparison of components for each alternative.

Table 3.5-1. Components of Alternative 2

Title	Project-Level Analysis or Program-Level Analysis
Upper Sacramento	
Operations to meet WRO 90-5 downstream temperature targets	Project
Operations to meet Delta standards in D-1641	Project
Trinity	
Whiskeytown Reservoir Operations	Project
Feather River	
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project
American River	
2006 Flow Management Standard Releases	Project
Operations to meet Delta standards in D-1641	Project
Stanislaus	
1987 Reclamation, CDFW agreement	Project
Bay-Delta	
D-1641 control of exports, DCC operations, and Delta outflow	Project

3.5.1 Upper Sacramento River (Shasta and Sacramento Divisions)

As described under Alternative 1, Reclamation has multiple requirements that govern the operation of Shasta Reservoir. For Alternative 2, Reclamation would continue to operate Shasta Reservoir in accordance with water rights, contracts, and agreements specific to the upper Sacramento River, including Orders 990, 90-05, and 91-01 and D-1641; settlement contracts; exchange contracts; refuge contracts; water service contracts; flood control operations developed by USACE; and navigation requirements in the Rivers and Harbors Appropriation Act of 1899 (Rivers and Harbors Act).

3.5.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the 2000 Trinity River ROD with 2017 Lower Klamath ROD augmentation flows.

3.5.3 Clear Creek

Under Alternative 2, Clear Creek base flows would be 50–100 cfs based on the 2000 agreement between Reclamation, USFWS, and CDFW.

3.5.4 Feather River

Alternative 2 would have the same operations as the No Action Alternative and Alternative 1.

3.5.5 American River Division

Alternative 2 would include flow releases to meet D-893 on the American River and the Lower American River FMS and releases to meet Delta standards, as needed.

3.5.6 Bay-Delta

The requirements in D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, M&I, and fishery uses and vary throughout the year and by water year type. One of the requirements is to provide a minimum flow on the Sacramento River at Rio Vista in September through December of 3,000–4,500 cfs, depending on the month and water year type, to protect water quality for Delta water users.

D-1641 includes two Delta outflow criteria: Net Delta Outflow Index, which is specified for all months in all water year types, and spring X2 Delta outflow, which is specified from February through June, to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life.

During February through June, D-1641 limits CVP and SWP exports compared to Delta inflows (also known as the E/I ratio) to reduce potential impacts on migrating salmon and spawning Delta Smelt, Sacramento Splittail, and Striped Bass.

3.5.7 Stanislaus River

Under Alternative 2, Reclamation would operate New Melones Reservoir in accordance with the 1987 CDFW agreement.

3.5.8 San Joaquin River

Alternative 2 would include implementation of the SJRRP and flows required in D-1641. D-1641 conditioned CVP water rights to meet flow requirements on the San Joaquin River at Vernalis from February to June to the extent possible.

D-1422 required Reclamation to operate New Melones Reservoir to maintain average monthly levels of 500 parts per million total dissolved solids in the San Joaquin River at Vernalis as it enters the Delta. D-1641 modified the water quality objectives at Vernalis to include the irrigation and nonirrigation season objectives contained in the Bay-Delta WQCP: average monthly electric conductivity of 0.7 millisiemens per centimeter during April through August and 1.0 millisiemens per centimeter during September through March.

3.6 Alternative 3

Alternative 3 would incorporate the same flow and operations as described in Alternative 2 to meet requirements in D-1641 and other legal requirements but would also incorporate habitat restoration and intervention measures. Table 3.6-1, Components of Alternative 3, includes whether each action is covered at a project or program level of analysis in this EIS. If not mentioned in the table, the operations of the No Action Alternative remain. Appendix D includes a comparison of components for each alternative.

Table 3.6-1. Components of Alternative 3

Title	Project-Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Operations to meet WRO 90-5 downstream temperature targets	Project	–
Operations to meet Delta standards in D-1641	Project	–
Coldwater Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough, Shasta TCD Improvements)	Program	–
Spawning and Rearing Habitat Restoration	Program	X
Small Screen Program	Program	X
Winter-Run Conservation Hatchery Production	Program	–
Adult Rescue	Program	–
Juvenile Trap and Haul	Program	–
Trinity		
Whiskeytown Reservoir Operations	Project	–
Feather River		
FERC Project #2100-134 controls operations; Alt 1 analyzes downstream of the FERC boundary	Project	–
American River		
2006 Flow Management Standard Releases	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Drought Temperature Facility Improvements	Program	X
Stanislaus		
1987 Reclamation, CDFW agreement	Project	–
Spawning and Rearing Habitat Restoration	Program	X
Temperature Management Study	Program	–
San Joaquin		
Lower SJR Habitat Restoration	Program	X
Bay-Delta		
D-1641 control of exports, DCC operations, and Delta outflow	Project	–
Barker Slough PP sediment removal	Project	-
Barker Slough PP aquatic weed removal	Project	-
Clifton Court Aquatic Weed Removal	Project	–
Tracy Fish Collection Facility Operations CO_2 Injection and Release Sites	Project	–
San Joaquin Basin Steelhead Telemetry Study	Project	–
Sacramento Deepwater Ship Channel Food Study	Program	–
North Delta Food Subsidies/Colusa Basin Drain Study	Program	–
Suisun Marsh Roaring River Distribution System Food Subsidies Study	Program	–

Title	Project-Level Analysis or Program-Level Analysis	Construction Effects
Habitat Restoration		
Predator Hot Spot Removal	Program	–
Additional habitat restoration (25,000 acres within the Delta)	Program	X
Facility Improvements		
Delta Cross Channel Gate Improvements	Program	X
Tracy Fish Facility Improvements	Program	X
Skinner Fish Facility Improvements	Program	X
Small Screen Program	Program	X
Fish Intervention		
Reintroduction efforts from Fish Conservation and Culture Laboratory	Project	–
Delta Fish Species Conservation Hatchery	Program	X

3.6.1 Upper Sacramento River

In addition to the operations described for Alternative 2, Alternative 3 would include spawning and rearing habitat restoration within the Sacramento River. These habitat restoration efforts would be the same as described for Alternative 1. Additionally, Alternative 3 would include intervention measures described for Alternative 1 (small screen program, adult rescue, and juvenile trap and haul).

3.6.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the 2000 Trinity River ROD with 2017 Lower Klamath ROD augmentation flows.

3.6.3 Clear Creek

Clear Creek base flows would be 50–100 cfs based on the 2000 agreement between Reclamation, USFWS, and CDFW.

3.6.4 Feather River

Alternative 3 would be the same as the No Action Alternative and other action alternatives for the Feather River.

3.6.5 American River Division

Alternative 3 would follow the operations described for Alternative 2 but would incorporate spawning and rearing habitat restoration as described for Alternative 1.

3.6.6 Bay-Delta

Alternative 3 would have flows and operations as described for Alternative 2 but would incorporate additional habitat and intervention measures. Alternative 3 would include the habitat restoration measures (food subsidies and tidal habitat restoration) described in Alternative 1. Alternative 3 would include the intervention measures described in Alternative 1 (Clifton Court weed removal, TFCF improvements, predator hot spot removal). In addition to 8,000 acres included in the No Action Alternative, Alternative 3 would include 25,000 acres of new habitat restoration within the Delta.

3.6.7 Stanislaus River

Alternative 3 would operate New Melones Reservoir based on the 1987 CDFW agreement as described in Alternative 2. In addition, Alternative 3 would include spawning and rearing habitat restoration as described for Alternative 1.

3.6.8 San Joaquin River

Alternative 3 would include SJRRP and D-1641 flows, as described for Alternative 2. Additionally, Alternative 3 would include rearing habitat restoration on the lower San Joaquin River, as described for Alternative 1.

3.7 Alternative 4

Alternative 4 includes management of storage facilities to preserve coldwater pool and additional instream flows in the Sacramento River and the Delta as proposed during scoping. Alternative 4 strives to meet instream flow targets by balancing instream flows with carryover storage sufficient to protect fish. Overall, this alternative prioritizes and attempts to hold water in storage to maintain the cold water pool while increasing instream flows to the extent possible. It would continue flood management and deliveries to senior water right holders. This alternative also would have the CVP and SWP operate to maintain a positive combined OMR from March through May.

Scoping comments proposed meeting a flow objective of 55% of unimpaired flows year-round to mimic the natural hydrograph. However, a 55% requirement following the natural hydrograph results in high releases during winter and spring months, which constrain Reclamation's ability to meet cold water pool storage targets. Therefore, the flow objectives cannot be met in all conditions. For example, a flow action would not be taken in drier years to ensure cold water pool storage in reservoirs. During drier hydrologic conditions when the flow objectives are not met, Reclamation and DWR would operate the CVP and SWP to follow the operational objectives described in Alternative 1 and maintain the positive OMR. This operational regime would last from March through February, and the flow objectives would resume in the following March.

Table 3.7-1, Components of Alternative 4, shows each of the components of Alternative 4. The table includes a column that considers if a component is covered at a project or program level of analysis in this EIS and whether it involves construction actions. If not mentioned in the table, the operations of the No Action Alternative remain. Appendix D includes a comparison of components for each alternative.

Table 3.7-1. Components of Alternative 4

Title	Project-Level Analysis or Program-Level Analysis	Construction Effects
Upper Sacramento		
Operations to meet minimum instream flow requirement of 55% of unimpaired flow (reduced during Shasta Critical years)	Project	–
Trinity		
Whiskeytown Reservoir Operations	Project	–
Operations to meet Clear Creek water rights and agreements, and minimum instream flow requirement of 55% of unimpaired flow	Project	–
Grass Valley Creek Flows from Buckhorn Dam	Project	–
Feather River		
FERC Project #2100-134 controls operations of dam and low flow channel	Project	–
Minimum instream flow requirement of 55% of unimpaired flows (reduced during years with low storage or inflow conditions)	Project	–
American River		
2017 Flow Management Standard Releases and minimum instream flow requirement of 55% of unimpaired flow (reduced during years with low storage or inflow conditions)	Project	–
Stanislaus		
Stanislaus Stepped Release Plan	Project	–
Alteration of Stanislaus DO Requirement	Project	–
Bay-Delta		
Export constraints from April through May depending on San Joaquin River flows	Project	–
Bypass of reservoir releases for fish so they become Delta outflows	Project	–
Positive OMR from March through May	Project	–
Tracy Fish Collection Facility Operations	Project	–
Skinner Fish Facility Operations	Project	–
U.C. Davis Fish Culture Center Refugial Population	Project	–
South-of-Delta Water Contractors		
Increased Water Use Efficiency	Program	X

3.7.1 Upper Sacramento River

In the Sacramento River system, balancing instream flow releases with water in storage (to maintain the coldwater pool) is critical for operations. Alternative 4 would increase instream flow releases with a target of 55% of unimpaired flows. Reclamation would release water from Shasta Reservoir to meet this flow target at the Sacramento River above Red Bluff and the confluence with the Feather River.

A “Shasta Critical” year is defined in CVP contracts as a year when forecasted inflow to Shasta Reservoir is less than 3.2 MAF, which represents a very dry year. During Shasta Critical years, Reclamation would reduce instream flow releases to less than the 55% target to maintain water in storage for coldwater pool. Model results show that this occurs in about 10% of years.

3.7.2 Trinity River Division

As described in the No Action Alternative and Alternative 1, the Trinity River system would be operated according to the 2000 Trinity River ROD with 2017 Lower Klamath ROD augmentation flows. In addition to these operations, Reclamation would modify operations at Buckhorn Dam, as described below.

3.7.2.1 *Grass Valley Creek Flows from Buckhorn Dam*

Reclamation would release water from Buckhorn Dam to Grass Valley Creek in accordance with requirements published in the Buckhorn Dam and Buckhorn Reservoir standard operating procedures manual for water rights permit 18879 issued to DWR, which establishes the timing and magnitude of minimum flows and flushing flows from the dam. Flow from the dam outlet could be as low as 5 cfs in the bypass channel or as high as 100 cfs from spill during March or April, both of which are dependent on season and the hydrologic conditions. Additional flushing of the channel can occur during the winter months when the reservoir fills and spills water at a natural inflow rate, which may exceed 100 cfs.

In addition, Reclamation would increase flow from the dam outlet works for maintenance of the outlet channel and to cue juvenile salmonids in the reach to begin their downstream migration to the Trinity River. Reclamation would release pulse flows when the reservoir water elevation exceeds 2,803.13 ft above sea level between March 1 and April 15 to the extent feasible. Flow increases could range from 5 cfs to 100 cfs.

Reclamation would increase flow to the extent feasible in the outlet channel when necessary in October and November to provide adult Coho Salmon sufficient flow for upstream migration and spawning.

3.7.3 Clear Creek

Reclamation would release water from Whiskeytown Reservoir into Clear Creek to maintain flows at Igo that are 55% of unimpaired flows.

3.7.4 Feather River

Under Alternative 4, DWR would continue to operate Oroville Dam under the terms of its FERC license. The FERC license includes flow requirements in the Low Flow Channel just downstream from the dam that would govern these operations in Alternative 4. The FERC license also includes requirements downstream from the Thermalito outlet, but Alternative 4 would include additional flow targets. Under Alternative 4, DWR would operate Lake Oroville to maintain flows below the Thermalito outlet that are 55% of unimpaired flows. To balance these flow targets with water in storage, DWR would release less flow during years with low storage or forecasted inflow conditions. Model results show that this occurs in about 35% of years.

3.7.5 American River Division

Reclamation would operate the American River system consistent with the American River 2017 FMS, with an additional target to have 55% unimpaired flow below Nimbus Dam. To balance these flow targets with water in storage, Reclamation would release less flow during years with low storage or forecasted inflow conditions. Model results show that this occurs in about 60% of years.

3.7.6 Bay-Delta

Releases from CVP and SWP reservoirs to meet the upstream flow targets would pass through the Delta and become Delta outflow. Additionally, Alternative 4 would include a positive combined OMR from March through May, subject to minimum health and safety pumping of 1,500 cfs.

3.7.7 Stanislaus River

Alternative 4 would include the SRP described in Alternative 1.

3.7.8 San Joaquin River

Alternative 4 would include SJRRP flows.

3.7.9 South-of-Delta Water Contractors

Alternative 4 includes increased water use efficiency for CVP and SWP contractors. Increased efficiency would not be mandated, but would be in addition to the existing efficiency requirements.

3.7.9.1 *Agricultural Water Use Efficiency*

Under Alternative 4, agricultural water users would increase irrigation efficiency by implementing additional efficient water management practices (EWMPs). A substantial amount of water use efficiency already occurs under the No Action Alternative, which would limit the opportunity for additional water made available through efficient practices. Under the No Action Alternative, Reclamation already requires CVP contractors to implement cost-effective best management practices (BMPs) to manage water use, based on CVPIA Section 3405(e). The CVPIA and Section 210(b) of the Reclamation Reform Act of 1982 require the preparation and submittal of a water management plan. Additionally, the state of California requires EWMPs where they are technically feasible and locally cost-effective. EWMPs could include improvements to on-farm irrigation systems, use of recycled water, and distribution system improvements to reduce losses and improve efficiency.

Alternative 4 would increase water use efficiency above current and proposed practices. Water suppliers and growers would need to identify and invest in additional district-level or on-farm practices to improve irrigation efficiency. Some of these measures would involve construction of new facilities, such as new on-farm irrigation systems or distribution canal improvements.

3.7.9.2 *Municipal and Industrial Water Use Efficiency*

Similar to agricultural water use efficiency measures, a substantial amount of M&I water use efficiency has already been implemented or is planned for implementation under the No Action Alternative. California Executive Order B-37-16 and Senate Bill X7-7 have pushed M&I water providers to implement cost-effective measures to increase water use efficiency. M&I water providers have already implemented aggressive efficiency measures as part of the No Action Alternative. Under Alternative 4, this component would implement additional water use efficiency measures beyond what is already implemented or planned for implementation. Additional measures may include distribution system improvements, in-home modifications (plumbing and public outreach), landscape transformation, and commercial/industrial process improvements. Some of these measures would involve construction, such as distribution system improvements or landscape changes.

Chapter 4 Affected Environment

4.1 Trinity River Region

The Trinity River region includes Trinity Lake, Lewiston Reservoir, the area along the Trinity River from Trinity Lake to the confluence with the Klamath River, and the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Trinity Lake is a 2.4 MAF CVP reservoir, constructed in 1962, on the Trinity River. Trinity Lake storage varies according to upstream hydrology, downstream water demands, and instream flow requirements. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the years when Shasta Lake is at low levels (about 10–15% of years). See Figure 4.1-1, Trinity Lake Storage, for historical storage (DWR 2018a, 2018b).

Lewiston Reservoir is a CVP facility, constructed in 1963, on the Trinity River and is 7 mi downstream of Trinity Dam. Lewiston Reservoir is used as a regulating reservoir for downstream releases to the Trinity River and to Whiskeytown Lake, which is located in the adjacent Clear Creek watershed. The Lewiston Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage. See Figure 4.1-2, Lewiston Reservoir Storage for historical storage (DWR 2018c, 2018d).

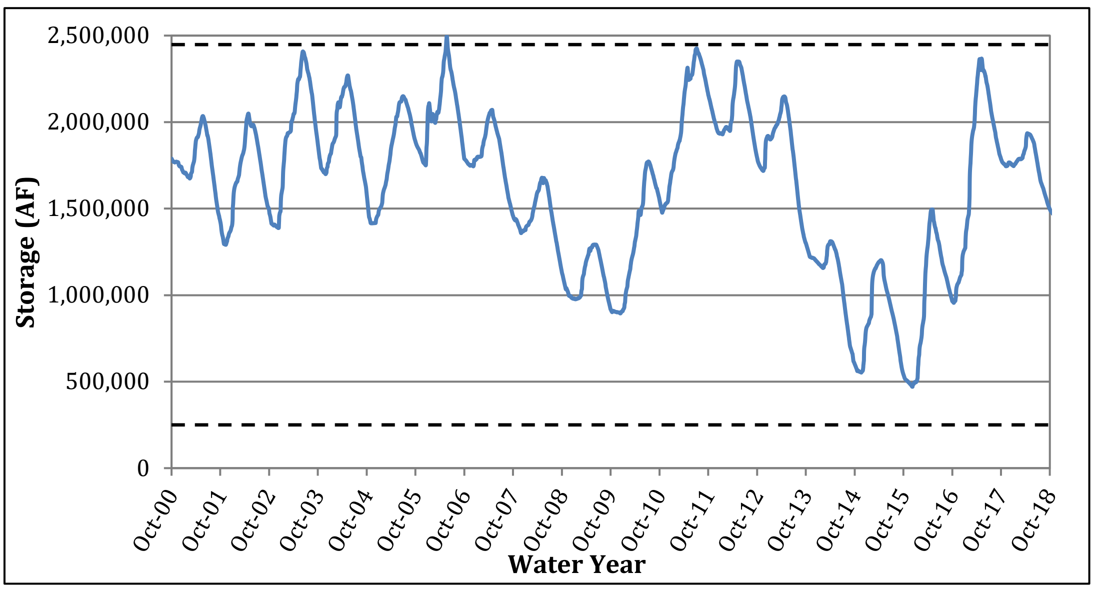


Figure 4.1-1. Trinity Lake Storage

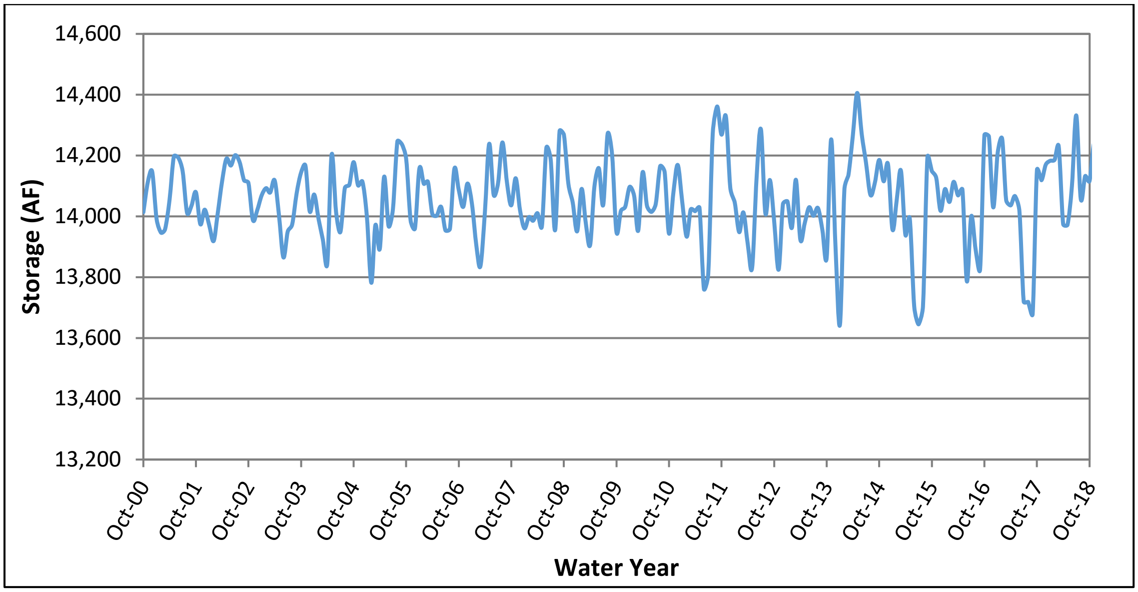


Figure 4.1-2. Lewiston Reservoir Storage

The mean annual inflow to Trinity Lake is 1.26 MAF per year (water years 2001–2017). From water years 1965–1980, an average of 80% of inflow was diverted to the Sacramento basin. Under a secretarial decision, an average of 61% of inflow was diverted for water years 1981–2000. Under a second secretarial decision (the Trinity River ROD), an average of 51% of inflows has since been diverted (water years 2001–2017).

Water is diverted from the lower outlets in Trinity Lake to Lewiston Reservoir to provide coldwater to the Trinity River. Trinity River flows downstream of Lewiston Reservoir at Douglas City are shown in Figure 4.1-3, Trinity River near Douglas City (DWR 2018e). The flow record is limited at the Douglas City gage to 2003 through 2018. The mean monthly flows reflect the wet year pattern in 2006 and the drier year patterns in 2008 and 2009.

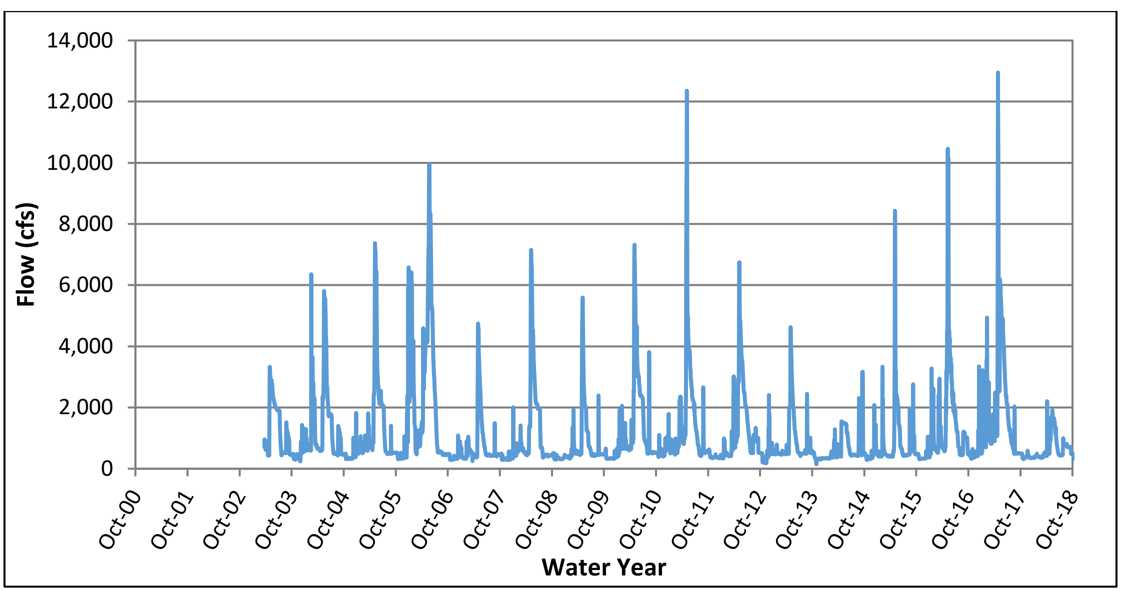


Figure 4.1-3. Trinity River near Douglas City

Trinity River exports are first conveyed through Carr Powerplant, which flows directly into Whiskeytown Lake, a heavily used recreation facility. The average seasonal timing of Trinity River exports for water year 2001–2017 is shown in Table 4.1-1, Average Seasonal Timing of Trinity Lake Exports. The seasonal timing is a result of determining how to make best use of a limited volume of Trinity Lake exports (in concert with releases from Shasta Lake) to help conserve coldwater pools and meet temperature objectives on the upper Sacramento and Trinity Rivers and manage power production economics. A key consideration in the export timing determination is the thermal degradation that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake and in Lewiston Lake during warm weather combined with low rates of export through Carr Tunnel.

Table 4.1-1. Average Seasonal Timing of Trinity Lake Exports

Month	Average Trinity Lake Inflow (AF)	Average Release to Trinity River (AF)	Average Export to CVP (AF)
January	128,945	30,591	15,349
February	147,763	21,423	19,385
March	194,151	21,209	27,709
April	200,039	41,497	36,030
May	237,307	218,873	44,001
June	128,484	110,756	84,820
July	38,753	51,835	114,410
August	11,294	37,399	108,121
September	6,659	38,170	84,144
October	17,921	23,416	61,594
November	34,837	18,777	28,253
December	116,490	19,486	19,282

AF = acre-feet

The Trinity River is the largest tributary to the Klamath River. There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. Because of heavy precipitation and the upstream water supply projects in the Klamath River, approximately 85% of winter flows in the lower Klamath River occur from runoff in the lower watershed, from Shasta River downstream on Klamath, and from North Fork Trinity downstream on Trinity (DOI and CDFG 2012).

Temperature objectives for the Trinity River are set forth in Order 90-05 and are shown in Table 4.1-2, Water Temperature Objectives for the Trinity River. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60°F from July 1 to September 14 and 56°F from September 15 to September 30. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River.

Table 4.1-2. Water Temperature Objectives for the Trinity River

Date	Temperature Objective (°F) Douglas City (RM 93.8)	Temperature Objective (°F) North Fork Trinity River (RM 72.4)
July 1 through September 14	60	–
September 15 through September 30	56	–
October 1 through December 31	–	56

°F = degrees Fahrenheit
RM = River Mile

4.1.1 Trinity River Fisheries

The Trinity River downstream of Lewiston Dam, the lower Klamath River, and tributaries support several native anadromous fish species listed in Table 4.1-3, Focal Fish Species in the Trinity River region. The species' life history attributes, such as timing of juvenile out-migration, and ecological attributes important to the species are discussed below.

Table 4.1-3. Focal Fish Species in the Trinity River Region

Species or *Population*	Federal Status	State Status	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Coho Salmon *Southern Oregon/Northern California Coast ESU*	Threatened	Threatened	Yes	Trinity River, Klamath River
Eulachon *Southern DPS*	Threatened	None	Yes	Klamath River
Green Sturgeon *Northern DPS*	None	None	Yes	Trinity River, Klamath River
Spring-Run Chinook Salmon *Upper Klamath-Trinity River ESU*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Steelhead (Winter-Run and Summer-Run) *Klamath Mountains Province DPS*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Coastal Cutthroat Trout	None	Species of Special Concern	Yes	Trinity River, Klamath River
American Shad	None	None	Yes	Trinity River, Klamath River
Pacific Lamprey	Species of Concern	Species of Special Concern	Yes	Trinity River, Klamath River
White Sturgeon	None	Species of Special Concern	Yes	Trinity River, Klamath River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Trinity Reservoir

ESU = evolutionarily significant unit
DPS = distinct population segment

4.1.1.1 *Coho Salmon*

Coho Salmon exhibit a 3-year life cycle in the Trinity River during which they spend the first year in freshwater before migrating to the ocean. In the ocean, they spend the next 2 years maturing before returning to their natal stream to spawn and die. This strategy makes Coho Salmon especially dependent on freshwater conditions because juveniles remain in the river year-round. Adult Coho Salmon typically enter the Trinity River between August and January. The timing of Coho Salmon river entry is influenced by several factors, including genetics, stage of maturity, and river discharge. Coho Salmon spawning occurs mostly in November and December. Spawning occurs in the mainstem Trinity River and its tributaries with peak Coho Salmon spawning activities in the mainstem Trinity River occurring between Lewiston Dam and the North Fork Trinity River. Spawning is concentrated in riffles or in gravel deposits at the downstream end of pools with suitable water depth, velocity, and substrate size.

Coho Salmon were not the most abundant species of salmon in the Trinity River before dam construction. They were, however, found throughout multiple tributaries to the Trinity River upstream of Trinity Dam. Approximately 109 mi of Coho Salmon habitat in the Trinity Basin became inaccessible after construction of Lewiston and Trinity dams (NMFS 2014a). To mitigate for the loss of upstream habitat, the Trinity River Salmon and Steelhead Hatchery was constructed near Lewiston Dam and produces Coho Salmon with an annual production goal of 300,000 yearling fish (NMFS et al. 2017). Today, wild Coho Salmon are not abundant in the Trinity River, and most of the Coho Salmon that return to the river are of hatchery origin. NMFS (2012) considers this proportion of hatchery fish in the population a high-level risk factor for the continued existence of Coho Salmon in the Trinity Basin. NMFS, Reclamation, and CDFW are working to develop a hatchery and genetics management plan to mitigate the adverse effects of the hatchery program on production of wild Coho Salmon in the Trinity River (NMFS et al. 2017; Reclamation and CDFW 2017).

4.1.1.2 *Spring-Run Chinook Salmon*

Adult Spring-Run Chinook Salmon typically enter the Trinity River from April through September; by the end of July, most fish have arrived at the mouth of the North Fork Trinity. Spawning is concentrated in the reaches immediately downstream of Lewiston Dam to the mouth of the North Fork Trinity River. After entering freshwater, Spring-Run Chinook Salmon remain in deep pools until the onset of the spawning season, which usually peaks in October but typically ranges from the third week of September through November. In the Trinity River, Spring-Run Chinook Salmon fry emerge from the gravel beginning in December, and emergence can last into mid-April. Juvenile Spring-Run Chinook Salmon typically out-migrate after less than a year of growth in the Trinity River. Peak out-migration occurs in May and June as based on monitoring in the lower Trinity River near the town of Willow Creek.

Historically, the spring-run race were the most abundant variant of Chinook Salmon in the Trinity River (Snyder 1931; LaFaunce 1967). Spring-Run Chinook Salmon historically spawned in the Trinity River and several of its tributaries upstream of Lewiston Dam (e.g., East Fork Trinity River, Stuart Fork, Coffee Creek, Hayfork Creek [Gibbs 1956; Campbell and Moyle 1991]). Completion of dams on the Trinity River in the 1960s blocked access to 59 mi of habitat, most of which was considered prime adult holding, spawning and nursery habitat (Moffett and Smith 1950).

4.1.1.3 *Fall-Run Chinook Salmon*

Adult Fall-Run Chinook Salmon typically enter the Trinity River from August through December. Spawning activity usually occurs between October and December with peak spawning activity occurring in November. Spawning activity typically begins just downstream of Lewiston Dam, then extends farther downstream as the season progresses. Fall-Run Chinook Salmon spawn throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998). Similar to Spring-Run Chinook Salmon, emergence of Fall-Run Chinook Salmon fry begins in December and continues into mid-April. Juvenile Fall-Run Chinook Salmon typically spend a few months rearing in the Trinity River before they out-migrate. Within the Trinity River near Lewiston Dam, out-migration occurs from March through May, with peak out-migration occurring in early May while out-migration farther downstream peaks in May and June.

4.1.1.4 *Klamath Mountains Province DPS Steelhead*

Steelhead in the Trinity River exhibit two primary life history strategies, including a summer-run that matures after entering freshwater and a winter-run that matures in the ocean. The ocean maturing strategy is often further divided into a third group for Fall-Run Steelhead based upon the timing of the adult migration. Adult Summer-Run Steelhead enter the Trinity River from May through October and over-summer in deep pools within the mainstem or upper reaches of cool tributaries until they reach sexual maturity (Busby et al. 1996). Adult Fall-Run Steelhead enter the Klamath River Basin in September and October (Hill 2010) and spawn from January through April. Adult Winter-Run Steelhead begin their upstream migration in the Klamath River from November through March (USFWS 1997). Winter-Run Steelhead primarily spawn in the Trinity River from January through April (USFWS 1997), with peak spawn timing in February and March (NRC 2004). Steelhead fry emerge in the spring, and juveniles remain in freshwater for up to 3 years.

Steelhead exhibit substantial life history variation throughout their range, but the “half-pounder” life history is limited to several rivers in northern California and southern Oregon, including both Klamath and Trinity rivers. Half-pounders are steelhead that return to freshwater in late summer through fall as immature fish after spending just 3–5 months at sea and support valuable freshwater fisheries. In the Trinity River, historically and at present, the half-pounder life history remains common among Fall-Run Steelhead.

4.1.1.5 *Coastal Cutthroat Trout*

Coastal cutthroat trout belong to the Southern Oregon/California Coasts ESU and are distributed primarily within smaller tributaries to the 22 miles of the Klamath River mainstem upstream of the estuary (NRC 2004), but also within tributaries to the Trinity River (Moyle et al. 1995).

Coastal cutthroat trout have not been extensively studied in the Trinity River region, but their life history is similar to fall- and winter-run steelhead in the Klamath River (NRC 2004). Both resident and anadromous life histories of coastal cutthroat trout have been observed. Anadromous adults enter the river to spawn in the fall. Moyle (2002) noted that upstream migration in northern California spawning streams tends to occur from August to October after the first substantial rain. Generally, spawning of anadromous and resident coastal cutthroat trout may occur from September to April (Moyle 2002). Anadromous or “sea-run” adults spend some time in the ocean without fully adopting a fixed anadromous life history may either return to rivers in summer to feed or return in September or October to spawn and/or possibly overwinter (NRC 2004). Cutthroat with a resident life history remain in freshwater for their entire lives and may use mainstem and/or tributary habitats.

Juvenile coastal cutthroat trout may spend anywhere from one to three years in freshwater to rear. Sea-run juveniles outmigrate from April through June, at the same time as Chinook Salmon juvenile downstream migration (Moyle 2002, NRC 2004). These juveniles also appear to spend at least some time rearing in the estuary. Wallace (2004) found that estuary residence time ranged from 5 to 89 days, with a mean of 27 days, based on a mark-recapture study.

4.1.1.6 *Northern DPS Green Sturgeon*

Green Sturgeon in the Trinity River region belong to the Northern DPS; however, data from the Trinity River are limited, so most information on life history characteristics for Green Sturgeon in the Trinity River is based on data from the Klamath River. Green Sturgeon are long-lived fish with an expected life span of at least 50 years. They reach maturity around age 16 and typically spawn once every 4 years (Klimley et al. 2007). Surveys of adult Green Sturgeon in the Klamath River found fish ranging in age from 16 to 40 years (Van Eenennaam et al. 2006). Adult migration occurs from February through July with most spawning taking place from the middle of April to the middle of June (NRC 2004). Green Sturgeon are known to spawn in the lower section of mainstem Trinity River from the confluence with the Klamath River upstream approximately 43 mi to Grays Falls near Burnt Ranch.

After spawning, most Green Sturgeon hold in mainstem pools until the onset of fall rainstorms and increased river flow when they move downstream and leave the river system (Benson et al. 2007). A small proportion (around 25%) of Green Sturgeon migrate directly back to the ocean after spawning (Benson et al. 2007). After moving downstream juvenile Green Sturgeon may rear in larger river sections, such as the lower Klamath River, or in the Klamath River estuary for another year or two before they migrate to the Pacific Ocean (NRC 2004; FERC 2007; CALFED Bay-Delta Program 2007).

4.1.1.7 *White Sturgeon*

White Sturgeon are uncommon in the Klamath and Trinity Rivers (NRC 2004). Historically there may have been small spawning runs in these rivers; however, there are no recent reports of White Sturgeon spawning in this system. Almost all sturgeon found in the Klamath River Basin above the estuary are Green Sturgeon (Moyle 2002).

4.1.1.8 *Pacific Lamprey*

Pacific Lamprey are an anadromous species important to both Hoopa Valley and Yurok tribes, and support ceremonial and subsistence fisheries on the lower Trinity and Klamath rivers. Adult Pacific Lamprey may begin their upstream migration during all months of the year, but peak upstream migration typically occurs from December through June (Larson and Belchik 1998; Petersen Lewis 2009). After entering freshwater, Pacific Lamprey hold through summer and most of the winter before reaching sexual maturity. Pacific Lamprey undergo a secondary migration in the late winter or early spring from holding areas to spawning grounds, with spawning occurring during the spring (Robinson and Bayer 2005; Clemens et al. 2012; Lampman 2011). Therefore, adult Pacific Lamprey can be found in the Trinity River throughout the year. Ammocoetes (the larval stage of lamprey) rear within fine substrates in depositional areas and remain in the Trinity River and tributaries for up to 7 years before out-migrating to the ocean (Moyle 2002; Reclamation and Trinity County 2006).

4.1.1.9 *American Shad*

American Shad are a nonnative anadromous fish species that have established in the Klamath and Trinity Rivers. Adult fish leave the ocean in late spring or early summer to spawn in freshwater. American Shad spawn shortly after entering freshwater. American Shad are primarily found in the lower Klamath River but are known to occur in the lower sections of the Trinity River up to Grays Falls, based on landings in recreational fisheries and capture of juveniles during salmonid out-migrant monitoring (Scheiff et al. 2001; Pinnix and Quinn 2009; Pinnix et al. 2013).

4.2 Sacramento River

Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, was completed in 1945 and has a maximum storage capacity of 4.552 MAF. Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles (sq mi). Water in Shasta Lake is released through or around the Shasta Powerplant to the Sacramento River, where it is re-regulated downstream by Keswick Dam.

Historical water storage volumes for Shasta Lake for water years 2001–2018 are shown in Figure 4.2-1, Shasta Storage (DWR 2018f, 2018kg). Shasta Lake storage varies according to upstream hydrology, downstream water demands, and instream flow requirements. For example, storage declined during the drier years in 2008 and 2009.

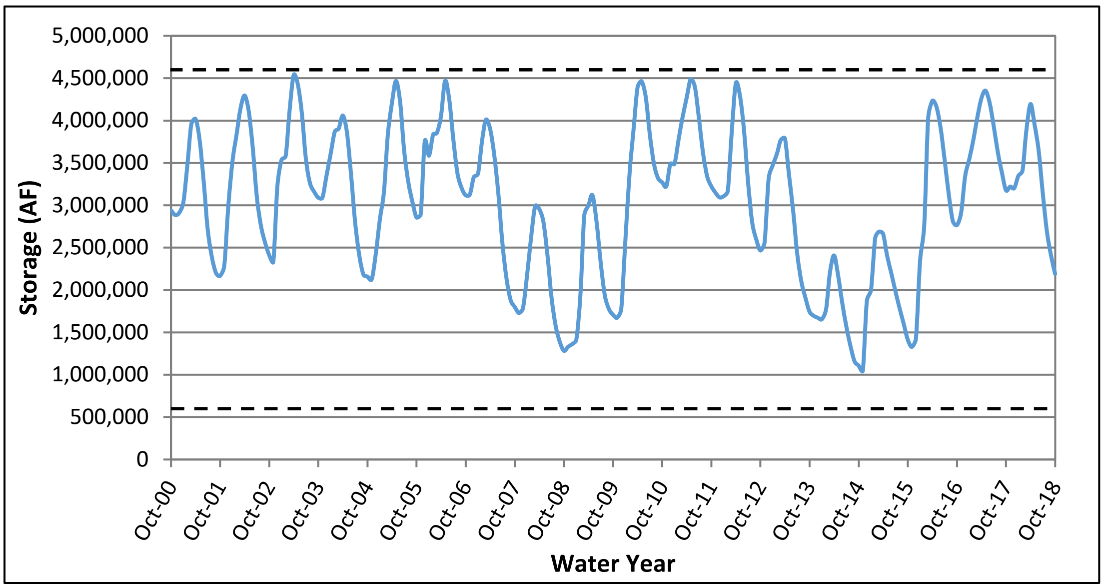


Figure 4.2-1. Shasta Storage

Keswick Reservoir was formed when Keswick Dam was completed in 1950. It has a capacity of approximately 23.8 TAF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Powerplant. The Keswick Reservoir water storage volume is more consistent throughout the year because the reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage, as shown in Figure 4.2-2, Keswick Reservoir Storage (DWR 2018h, 2018i).

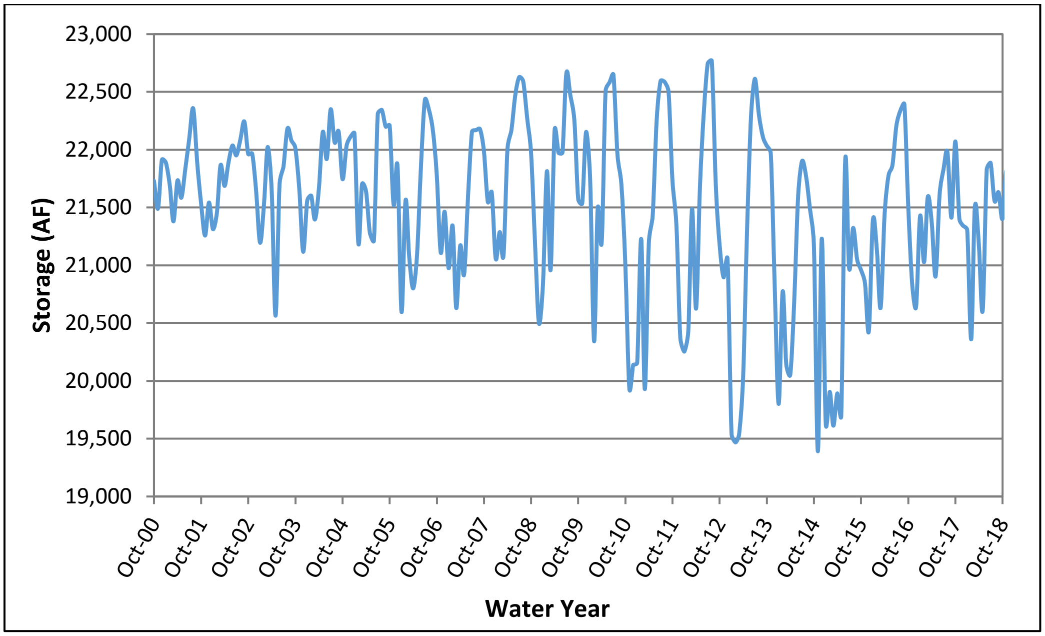


Figure 4.2-2. Keswick Reservoir Storage

The Sacramento River Division includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Pumping Plant, Corning Pumping Plant, and Corning and Tehama-Colusa Canals. Total authorized diversions for the Sacramento River Division are approximately 2.8 MAF.

4.2.1 Sacramento River from Keswick Dam to Red Bluff

The Sacramento River between Keswick Dam and the City of Red Bluff flows through the northern foothills of the Sacramento Valley. Flows are influenced by outflow from Keswick Reservoir and inflows from Clear Creek and by Cow Creek, Bear Creek, Cottonwood Creek, Battle Creek, and Paynes Creek, which provide 15–20% of the flows in this reach as measured at Bend Bridge. There are several moderate major diversions along the Sacramento River upstream of Red Bluff, including the CVP Wintu Pumping Plant to provide water for the Bella Vista Water District, and the Anderson-Cottonwood Irrigation District diversion. Flow patterns on one major tributary in this reach, Battle Creek, are undergoing changes as the Battle Creek Salmon and Steelhead Restoration Project is implemented to restore ecological processes along 42 mi of Battle Creek and 6 mi of tributaries while minimizing reductions to hydroelectric power generation through the decommissioning of five powerplants.

4.2.2 Sacramento River from Red Bluff to the Delta

Between Red Bluff and Colusa, the Sacramento River is a meandering stream, migrating through alluvial deposits between widely spaced levees. From Colusa to the northern boundary of the Delta near Freeport, flows increase due to the addition of the Feather and American Rivers flows.

The Sacramento River between Red Bluff and Chico Landing, the Sacramento River Flood Control Project has provided bank protection and incidental channel modification since 1958 (DWR 2013b). Between Chico Landing and Colusa, the flood management facilities consist of levees and overflow areas. Black Butte Reservoir regulates Stony Creek flood flows, which enter the Sacramento River downstream of Hamilton City. The natural Sutter Basin overflow (Sutter Bypass) to the east of the Sacramento River and downstream of Sutter Buttes was included in the Sacramento River Flood Control Project. The Sutter Bypass conveys floodwaters from the Butte Basin Overflow Area, Butte Creek, Wadsworth Canal, and Reclamation Districts 1660 and 1500 drainage plants, state drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather Rivers. Downstream of Colusa, Reclamation Districts 70, 108, and 787 pump flood waters from adjacent closed basin lands into the river.

The Colusa Basin Drain provides drainage for a large portion of the irrigated lands on the western side of the Sacramento Valley in Glenn, Colusa, and Yolo Counties and supplies irrigation water to lands in this area. Water from the drain is discharged to the Sacramento River through the Knights Landing Outfall, a gravity flow structure, and prevents the Sacramento River from flowing into the Colusa Basin.

Recent mean daily flows in the Sacramento River at Bend Bridge (near Red Bluff), Verona (downstream of the Feather River confluence), and Freeport (downstream of the American River confluence and near the northern boundary of the Delta) are shown in Figures 4.2-3, Sacramento River at Bend Bridge, 4.2-4, Sacramento River at Verona, and 4.2-5, Sacramento River at Freeport (DWR 2018j, 2018k, 2018l, 2018m, 2018n, 2018o).

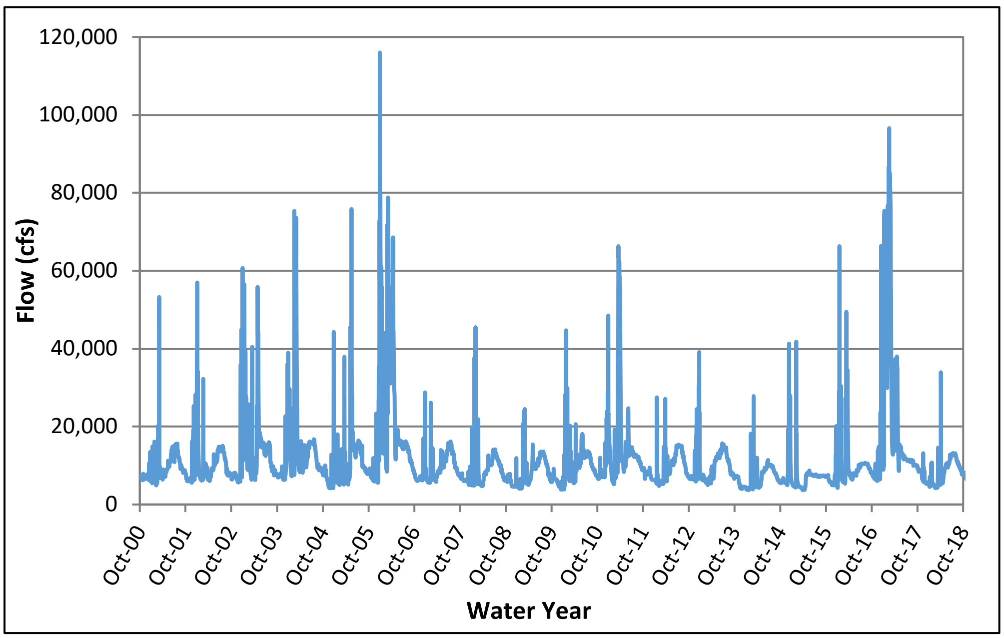


Figure 4.2-3. Sacramento River at Bend Bridge

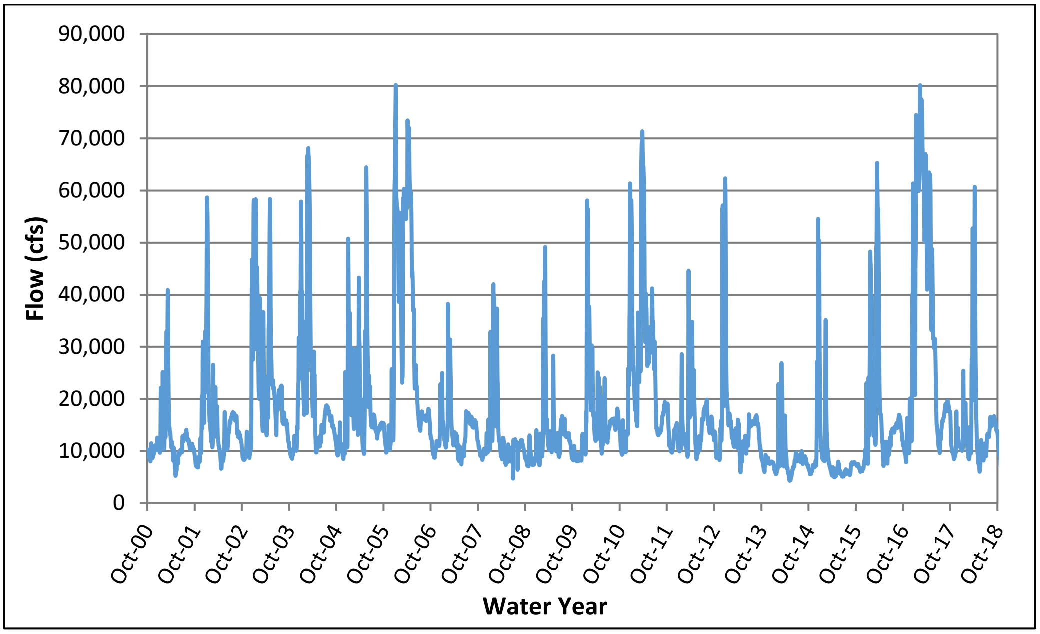


Figure 4.2-4. Sacramento River at Verona

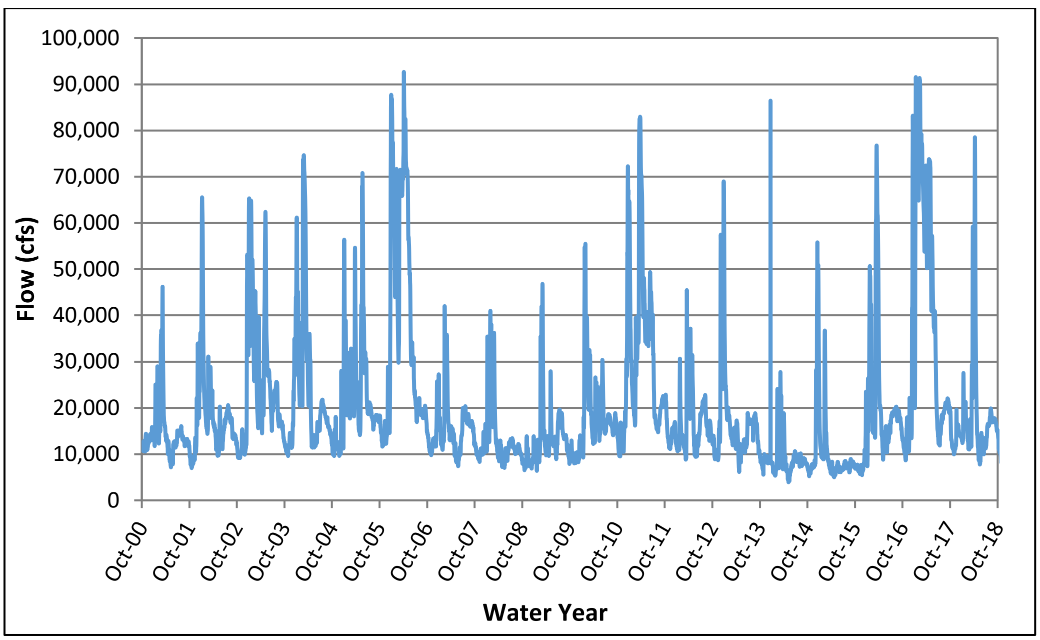


Figure 4.2-5. Sacramento River at Freeport

Reclamation operates the Shasta, Sacramento River, and Trinity River Divisions of the CVP to meet, to the extent possible, the provisions of Order 90-05 Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years. Table 4.2-1, Minimum Flow Requirements and Objectives on the Sacramento River below Keswick Dam, shows the minimum flow requirements and objectives.

Dedication of (b)(2) water on the Sacramento River provides instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions (the fish and wildlife requirements specified in Order 90-05 and the temperature criteria formalized in the 1993 NMFS Winter-Run Chinook Salmon BO as the base). Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for Winter-Run Chinook Salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmon spawning, incubation, rearing, and migration.

Table 4.2-1. Minimum Flow Requirements and Objectives on the Sacramento River below Keswick Dam

Period	Order 90-05 (cfs)	Order 90-05 (cfs)
Water Year Type	Normal	Critically dry
January 1–February 28(29)	3,250	2,000
March 1–March 31	2,300	2,300
April 1–April 30	2,300	2,300
May 1–August 31	2,300	2,300
September 1–September 30	3,250	2,800
October 1–November 30	3,250	2,800
December 1–December 31	3,250	2,000

cfs = cubic feet per second

4.2.3 Sacramento River Fisheries

Many fish and aquatic species use the study area during all or some portion of their lives; however, certain fish and aquatic species were selected to be the focus of the analysis of alternatives considered in this EIS based on their sensitivity and their potential to be affected by changes in the operation of the CVP and SWP implemented under the action alternatives considered in this EIS, as summarized in Table 4.2-2, Focal Fish Species in the Central Valley. While many of the species identified in Table 4.2-2 occur in tributaries to the major rivers, the focus of this EIS is on the waterbodies influenced by operations of the CVP and SWP. Focal fish species in the Sacramento River, Clear Creek, Feather River, American River, Stanislaus River, San Joaquin River, and Bay-Delta regions are further described below and in the following sections.

Table 4.2-2. Focal Fish Species in the Central Valley

Species or *Population*	**Federal Status**	**State Status**	**Tribal, Commercial, or Recreational Importance**	**Occurrence within Area of Analysis**
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes	Sacramento River, Delta, and Suisun Marsh
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes	Clear Creek, Sacramento River, Feather River, American River, Delta, and Suisun Marsh
Steelhead *Central Valley DPS*	Threatened	None	Yes	Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta, and Suisun Marsh
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Feather River, Sacramento River, Delta, and Suisun Marsh
Delta Smelt	Threatened	Endangered	No	Delta and Suisun Marsh
Longfin Smelt *Bay Delta DPS*	Candidate	Threatened, Species of Special Concern	No	Delta and Suisun Marsh
Fall-Run/Late Fall-Run Chinook Salmon *Central Valley ESU*	Species of Concern	Species of Special Concern	Yes	Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta, and Suisun Marsh
Sacramento Splittail	None	Species of Special Concern	No	Feather River, American River, Sacramento River, Delta, Suisun Marsh, and San Joaquin River
Hardhead	None	Species of Special Concern	No	Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, and San Joaquin River
Sacramento-San Joaquin Roach	None	Species of Special Concern	No	Clear Creek, Feather River, American River, Sacramento River, Delta, Stanislaus River, and San Joaquin River
River Lamprey	None	Species of Special Concern	Yes	Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, and San Joaquin River
Pacific Lamprey	Species of Concern	Species of Special Concern	Yes	Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, and San Joaquin River

Species or *Population*	Federal Status	State Status	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
White Sturgeon	None	Species of Special Concern	Yes	Feather River, Sacramento River, American River, San Joaquin River, Delta, and Suisun Marsh
American Shad	None	None	Yes	Feather River, American River, Sacramento River, Delta, Suisun Marsh, Stanislaus River, and San Joaquin River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Feather River, American River, Sacramento River, Delta, Suisun Marsh, Stanislaus River, and San Joaquin River
Striped Bass	None	None	Yes	Feather River, American River, Sacramento River, Delta, Suisun Marsh, Stanislaus River, and San Joaquin River

4.2.3.1 *Winter-Run Chinook Salmon*

Adult Winter-Run Chinook Salmon return to freshwater during winter but delay spawning until spring and summer. Adults enter freshwater in an immature reproductive state, similar to Spring-Run Chinook Salmon, but Winter-Run Chinook Salmon move upstream much more quickly, then hold in the cool waters downstream of Keswick Dam for an extended period before spawning. Juveniles spend about 5–9 months in the river and estuary systems before entering the ocean. This life history pattern differentiates the Winter-Run Chinook Salmon from other Sacramento River Chinook Salmon runs and from all other populations within the range of Chinook Salmon (CDFG 1985, 1998b).

Access to approximately 58% of the original Winter-Run Chinook Salmon habitat has been blocked by the existence of dams (Reclamation 2008a). The remaining accessible habitat occurs in the Sacramento River downstream of Keswick Dam and in Battle Creek. The number of Winter-Run Chinook Salmon in Battle Creek is unknown. If they do occur, they are scarce (Reclamation and SWRCB 2003), although they are currently being reintroduced as part of the Battle Creek Restoration Program.).

Adult Winter-Run Chinook Salmon migrate upstream past the location of the Red Bluff Diversion Dam (RBDD) beginning in mid-December and continuing into early August. Most of the run passes RBDD between January and May, with the peak in mid-March (CDFG 1985). Winter-Run Chinook Salmon spawn only in the upper Sacramento River and tributaries, above RBDD. The majority spawn upstream of Clear Creek, based on aerial redd survey data collected after modifications at the Anderson-Cottonwood Irrigation District diversion to allow fish passage. Aerial redd surveys indicated the Winter-Run Chinook Salmon spawning distribution has shifted upstream since gravel introductions began in the upper river near Keswick Dam; a high proportion of Winter-Run Chinook Salmon spawn on the placed gravel (USFWS and Reclamation 2008a). Spawning occurs May through August, with the peak in early June. Fry emergence occurs from mid-June through mid-October and fry disperse to areas downstream for rearing. Juvenile migration past RBDD begins in July, generally peaks in September through November, depending on pulse flows, and continues until late winter (USFWS 2018). The majority (75%) of Winter-Run Chinook Salmon out-migrate past RBDD as fry (Martin et al. 2001), where they rear before out-migrating to the Delta, primarily in December through April. Between 44 and 81% (mean 65%) of juvenile Winter-Run Chinook Salmon used areas downstream of RBDD for nursery habitat. The relative usage of rearing habitat upstream and downstream of RBDD appeared to be influenced by river flow during fry emergence (Martin et al. 2001). Winter-run Chinook Salmon usually migrate past Knights Landing once flows at Wilkins Slough rise to about 14,000 cfs. Most juvenile Winter-Run Chinook Salmon out-migrate past Chipps Island by the end of March (del Rosario et al. 2013).

4.2.3.2 *Spring-Run Chinook Salmon*

Historically, Spring-Run Chinook Salmon in the Sacramento River Basin were found in the upper and middle reaches (1,000–6,000 ft) of the American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers, as well as smaller tributaries of the upper Sacramento River downstream of Shasta Dam (NMFS 2009a). Estimates indicate that 82% of the approximately 2,000 mi of salmon spawning and rearing habitat available in the mid-1800s is unavailable or inaccessible today (Yoshiyama et al. 1996). Naturally spawning populations of Spring-Run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, the Feather River, Mill Creek, and the Yuba River (CDFG 1998b). Most of these reaches are outside the study area; however, all Spring-Run Chinook Salmon migratory life stages must pass through the study area.

In freshwater, juvenile Spring-Run Chinook Salmon rear in natal tributaries, the Sacramento River mainstem, and nonnatal tributaries to the Sacramento River (CDFG 1998b). Out-migration timing is highly variable, as they may migrate downstream as young of the year (YOY)) or as juveniles or yearlings. The out-migration period for Spring-Run Chinook Salmon extends from November to early May, with up to 69% of the YOY fish out-migrating through the lower Sacramento River and Delta during this period (CDFG 1998b). Peak movement of juvenile Spring-Run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and in March (Snider and Titus 1998, 2000b, 2000c, 2000d; Vincik et al. 2006; Roberts 2007). Migratory cues such as increased flows, increased turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams may spur out-migration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (NMFS 2009a). Spring-run juveniles that remain in the Sacramento River over summer are confined to approximately 100 mi of the upper mainstem, where cool water temperatures are maintained by dam releases.

4.2.3.3 *Fall-Run and Late Fall-Run Chinook Salmon*

Fall-Run Chinook Salmon are an ocean-maturing type of salmon adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River, and Late Fall-Run Chinook Salmon are mostly a stream-maturing type (Moyle 2002). Similar to spring-run, adult Late Fall-Run Chinook Salmon typically hold in the river for 1–3 months before spawning while Fall-Run Chinook Salmon generally spawn shortly after entering freshwater. Fall-Run Chinook Salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late Fall-Run Chinook Salmon migrate upstream past RBDD from August to March and spawn from January to April (NMFS 2009a; TCCA 2008). The majority of young Fall-Run Chinook Salmon migrate to the ocean during the first few months following emergence, although some may remain in freshwater and migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in freshwater, at 150–170mm in fork length, considerably larger and older than Fall-Run Chinook Salmon (Moyle 2002).

The primary spawning area used by Fall- and Late Fall-Run Chinook Salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for each of the runs are generally highest in this reach.

Annual Fall-Run and Late Fall-Run Chinook Salmon escapement to the Sacramento River and its tributaries has declined in the last decade, following peaks in the late 1990s to early 2000s (Azat 2018).

4.2.3.4 *Central Valley DPS Steelhead*

Although steelhead can be divided into two life history types, Summer-Run Steelhead and Winter-Run Steelhead, based on their state of sexual maturity at the time of river entry, only Winter-Run Steelhead are found in Central Valley rivers and streams. Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, Clear, Battle and Mill Creeks and the Yuba River.

Adult steelhead migrate upstream past the Fremont Weir between August and March, primarily from August through October; they migrate upstream past RBDD during all months of the year, but primarily during September and October (NMFS 2009a). The primary spawning area used by steelhead in the mainstem Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2–4 years before out-migrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to out-migration. The Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS 2009a).

4.2.3.5 *Southern DPS Green Sturgeon*

The Sacramento River provides habitat for Green Sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for Green Sturgeon in the Sacramento River upstream and downstream of RBDD (Reclamation 2008a). Although the upstream extent of historical Green Sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as Inks Creek confluence and possibly up to the Cow Creek confluence (Brown 2007; Poytress et al. 2013). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFG (2002) indicated that Green Sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June. Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the Anderson-Cottonwood Irrigation District diversion dam (NMFS 2009b), rendering approximately 3 mi of spawning habitat upstream of the diversion dam inaccessible.

Green Sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al. 2004), although individuals can range widely (Lindley et al. 2008). Larval Green Sturgeon have been regularly captured during their dispersal stage (July – August) at about 2 weeks old (24–34 mm fork length) in rotary screw traps at RBDD (CDFG 2002a) and at about 3 weeks old when captured at the Glenn-Colusa Irrigation District (GCID) intake (Van Eenennaam et al. 2001).

Young Green Sturgeon appear to rear for the first one to two months in the Sacramento River between the Clear Creek confluence and Hamilton City (Heublein 2017b). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

4.2.3.6 *White Sturgeon*

In California, White Sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River; a small part of the population is also thought to spawn in the Feather

River (Moyle 2002). In addition to spawning, White Sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle 2002; Israel et al. 2008). White Sturgeon are found in the Sacramento River primarily downstream of RBDD (TCCA 2008), with most spawning between Knights Landing and Colusa (Schaffter 1997).

The population status of White Sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Spawning stage adults generally move into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter 1997; McCabe and Tracy 1994). Most spawning in the Sacramento River occurs primarily between Knights Landing and Colusa during April and May ((Moyle et al. 2015; Kohlhorst 1976).). YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994; Israel et al. 2008).

4.2.3.7 *Sacramento Splittail*

Historically, Sacramento Splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908, as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult Sacramento Splittail migrate upstream in the lower Sacramento River to above near the mouth of the Feather River and into Sutter and Yolo Bypasses (Sommer et al. 1997; Feyrer et al. 2005; Sommer et al. 2007b). Each year, mainly during the spring spawning season, a small number of individuals have been documented at the Red Bluff Pumping Plant and the entrance to the GCID intake (Moyle et al. 2004).

Nonreproductive adult Sacramento Splittail are most abundant in moderately shallow, brackish areas but can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in freshwater on inundated floodplains in March and April (Moyle et al. 2004; Sommer et al. 2007b). In the Sacramento River drainage, the most important spawning areas appear to be the Yolo and Sutter Bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile Sacramento Splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995; Sommer et al. 2007b). The production of YOY Sacramento Splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997; Moyle et al. 2004; Feyrer et al. 2006).

4.2.3.8 *Hardhead*

Hardhead are a California Species of Special Concern (CDFW 2016). They exist throughout the Sacramento-San Joaquin River Basin and are fairly common in the Sacramento River and in the lower reaches of the American and Feather rivers, but in other parts of their range, populations have declined or have become increasingly isolated (Moyle, 2002). Hardhead can also inhabit reservoirs and are abundant in a few impoundments where water level fluctuations prevent bass from reproducing in large numbers (Moyle, 2002). Hardhead tend to be absent from areas that have been highly altered (Moyle et al., 1995) or that are dominated by introduced fish species, especially centrarchids (species of the sunfish family) (Moyle et al., 1995). Hardhead are omnivorous; their diet consists mostly of benthic invertebrates and aquatic plants, but also includes drifting insects. In reservoirs, hardhead also prey upon zooplankton (Moyle et al., 1995).

Hardhead spawn mainly in April and May, but some may spawn as late as August in the foothill regions of the upper San Joaquin River (Wang, 2010). They migrate upstream and into tributary streams as far as 45 miles to spawning sites. Spawning behavior has not been documented, but it is assumed to be similar to that of the pikeminnow, which deposit their eggs over gravel-bottomed riffles, runs, and at the head of pools (Moyle et al., 1995). Spawning substrates may also include sand and decomposed granite (Wang, 2010).

Hardhead larvae and juveniles likely inhabit stream margins with abundant cover and move into deeper habitats as they grow larger. Adults occupy the deepest part of pools. Juvenile and adult Hardhead are present in the Sacramento River year-round. They tend to prefer water temperatures near 67 degrees Fahrenheit (Thompson et al. 2012), but have been captured at RBDD, where water temperatures are generally much cooler (USFWS 2002) (Table SR-5).

4.2.3.9 *Central California Roach*

California Roach primarily inhabit small streams, although they may occur in backwaters with dense riparian cover along the mainstem rivers (Baumsteiger and Moyle 2019). Roach are adaptable fish, with a broad range of habitat types and temperature tolerances (Moyle 2002).

4.2.3.10 *Pacific Lamprey*

Pacific Lampreys are anadromous, rearing in freshwater before out-migrating to the ocean, where they grow to full size prior to returning to their natal streams to spawn. Data from mid-water trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and tributaries from late fall (November) through early summer (June) (Hanni et al. 2006). Adult Pacific Lampreys, either immature or spawning stage, have been detected at the GCID diversion from December through July and nearly all year at RBDD (Hanni et al. 2006). Hannon and Deason (2008) documented Pacific Lampreys spawning in the American River between early January and late May, with peak spawning typically in early April. Spawning in the Sacramento River is expected to occur during a similar time frame. Pacific Lamprey ammocoetes rear in parts of the Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that out-migration of Pacific Lamprey peaks from early winter through early summer, but some out-migration is observed year-round at both RBDD and the GCID diversion dam (Hanni et al. 2006).

4.2.3.11 *River Lamprey*

River Lamprey are found in large coastal streams from just north of Juneau, Alaska, to the San Francisco Bay (Vladykov and Follett, 1958, Wydoski and Whitney, 1979). The Sacramento and San Joaquin basins are at the southern edge of their range (Moyle et al., 2009). River lamprey seem to be primarily associated with the lower portions of certain large river systems, and most records for the state are from the lower Sacramento-San Joaquin system, especially the Stanislaus and Tuolumne rivers (Moyle et al., 1995, Moyle, 2002). In the Sacramento River, they have been documented upstream to at least Red Bluff Diversion Dam (RBDD) (Hanni et al., 2006; Moyle et al., 2009). River Lamprey have also been collected in the Feather River, American River, Mill and Cache creeks (Vladykov and Follett, 1958; Hanni et al., 2006; Moyle et al., 2009). Quantitative data on populations are extremely limited, but loss and degradation of historical habitats suggest populations may have declined. The river lamprey is considered a species of special concern by CDFW (2016).

River Lamprey life history is poorly known, especially in California (Moyle et al. 2015). The adults migrate from the ocean to spawning areas during the fall and late winter (Beamish 1980). Spawning is believed to occur from February through May in small tributary streams (Moyle 2002). The redds are built at the upstream end of small riffles (Moyle 2002). After the larvae (ammocoetes) emerge, they drift downstream and burrow into sediments in pools or side channels where they rear. After several years, the larvae metamorphose in late July and the juvenile (macrothalmia) migrate downstream in the following year from May to July (Moyle 2002).

River flow potentially affects survival of River Lamprey eggs and larvae, and migratory habitat of the juveniles and adults. River lamprey build their spawning redds in shallow water (Moyle et al. 2015), so reductions in water level can dewater the redds. Assuming River Lamprey larvae habitat requirements are similar to those of Pacific Lamprey, the larvae select habitats, often off-channel, with low flow velocity and shallow depths, so they are vulnerable to stranding by reductions in water level.

4.2.3.12 *Striped Bass*

Striped Bass are anadromous; adult Striped Bass are distributed mainly in the lower bays and ocean during summer and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al. 2001), at which time Striped Bass swim upstream to spawning grounds. Most Striped Bass spawning occurs in the lower Sacramento River between Colusa and the confluence of the Sacramento and Feather Rivers (Moyle 2002). Most eggs are spawned in the Sacramento River and the remainder in the Delta (Leet et al. 2001) After spawning, most adult Striped Bass move downstream into brackish and salt water for summer and fall. Adult striped Bass are found upstream of RBDD, where they are major predators on young salmon (TCCA 2008).

Eggs are free-floating and negatively buoyant, hatching as they drift downstream with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin Rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. The Sacramento River functions primarily as a migration and spawning corridor for both adults and drifting eggs/larvae.

4.3 Clear Creek

The Clear Creek watershed is 238 sq mi, extending from the Trinity Mountains to the confluence with the Sacramento River downstream of the City of Redding (DWR 1986; WSRCD 2004). Hydrology in the watershed is divided into the upper 238 sq mi watershed upstream of Whiskeytown Dam at River Mile 18.1 and the lower 49 sq mi watershed downstream of the dam. Clear Creek flows approximately 17 mi from the Trinity Mountains into Whiskeytown Lake. Clear Creek continues for 18.1 mi downstream of Whiskeytown Lake into the Sacramento River downstream of the CVP Keswick Dam and south of the City of Redding.

Whiskeytown Dam, a CVP facility constructed in 1963, is the only dam on Clear Creek and has a storage capacity of 0.241 MAF. The facility regulates runoff from Clear Creek and diversions from the Trinity River watershed. Flows from Lewiston Reservoir in the Trinity River watershed are diverted to Whiskeytown Lake through Clear Creek Tunnel. Clear Creek Tunnel between Lewiston Reservoir and Whiskeytown Lake has a capacity of 3,200 cfs (Reclamation 2011b).

Water storage volume related to Whiskeytown Lake for water years 2001–2018 are shown in Figure 4.3-1, Whiskeytown Lake Storage (DWR 2018p, 2018q). Although it stores up to 241 TAF, storage is fairly constant from May through October in most years due to agreements between Reclamation and the National Park Service to maintain certain winter and summer lake elevations for recreation.

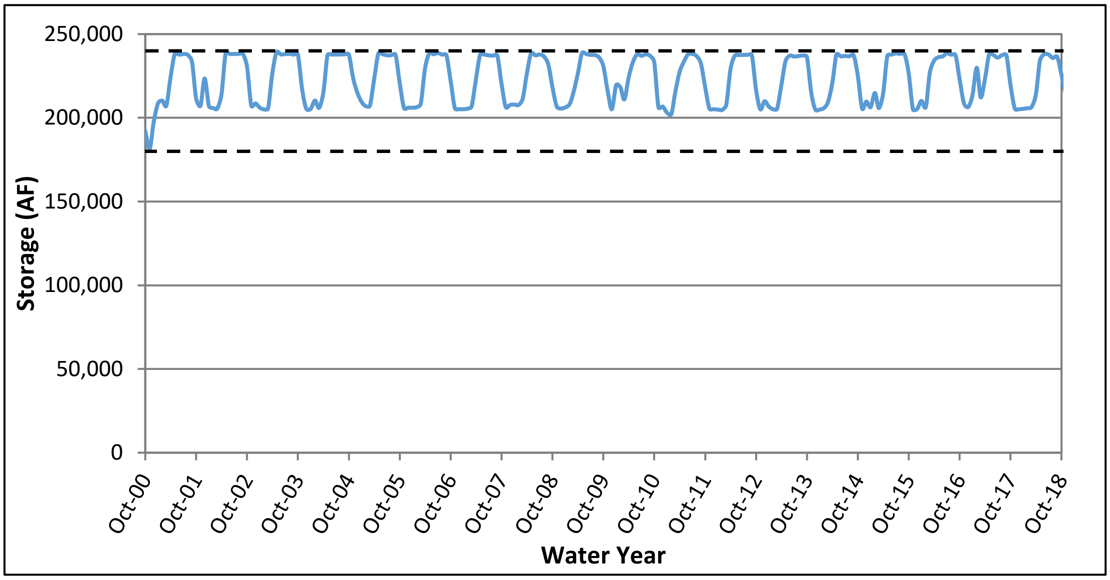


Figure 4.3-1. Whiskeytown Lake Storage

Construction of Whiskeytown Dam modified the hydraulics, gravel loading, and sediment transport in the lower Clear Creek. The overall average annual flow in the lower Clear Creek was reduced by 87% following construction of the dam (DWR 1984, 1986). The dam reduced gravel loading into the lower Clear Creek and the frequency of high flow events that move the gravel and remove fine sediments from riffles. This change in hydrology and loss of gravel loading adversely affected the salmonid habitat downstream of Whiskeytown Dam, including compaction of riffles with sand. Recently, minimum flow releases from Whiskeytown Lake into Clear Creek occur in accordance with federal and state requirements.

Clear Creek flows at Igo between 2001 and 2018 are shown in Figure 4.3-2, Clear Creek Near Igo (DWR 2018r). High flow events (1) naturally moved gravel placed downstream of Whiskeytown Dam and along Clear Creek; (2) developed and maintained Clear Creek channel and adjacent floodplain habitat for Spring-Run and Fall-Run Chinook Salmon and Central Valley Steelhead; (3) created and maintained deep pools in the channel to support spawning of Spring-Run Chinook Salmon and steelhead and created appropriate salmonid habitat within and along Clear Creek; and (4) established and maintained nesting and foraging habitat for neotropical migrant birds, native resident birds, and amphibians.

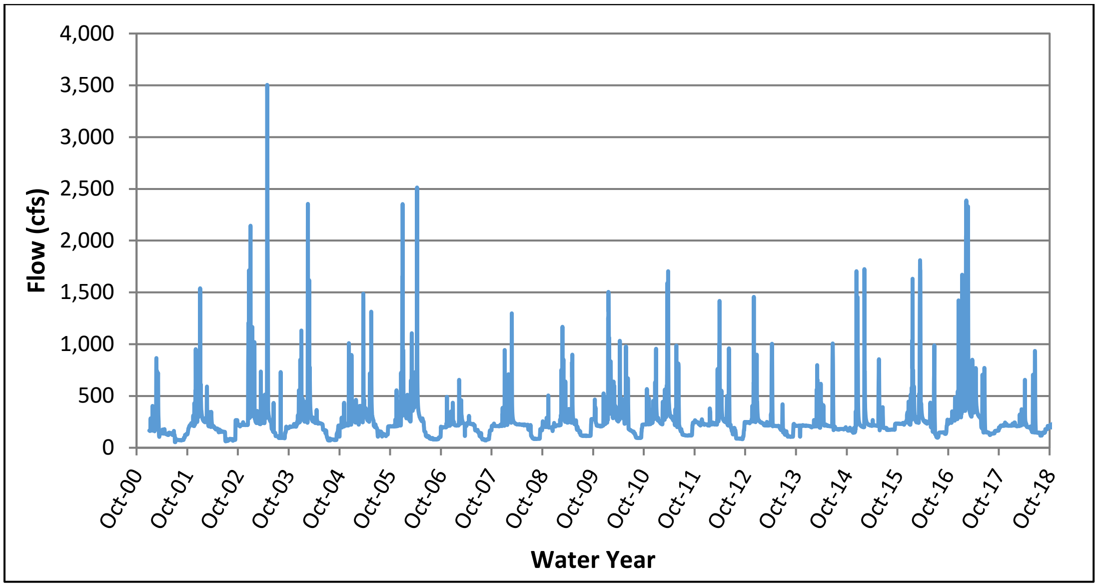


Figure 4.3-2. Clear Creek Near Igo

CVPIA (b)(2) operations and water rights permits issued by SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. The 1960 MOA with CDFW established minimum flows to be released to Clear Creek at Whiskeytown Dam, as listed in Table 4.3-1, Minimum Flows at Whiskeytown Dam.

Table 4.3-1. Minimum Flows at Whiskeytown Dam

Period	Minimum flow (cfs)
1960 MOA with CDFW	
January 1–February 28(29)	50
March 1–May 31	30
June 1–September 30	0
October 1–October 15	10
October 16–October 31	30
November 1–December 31	100
1963 USFWS Proposed Normal year flow	
January 1–October 31	50
November 1–December 31	100
1963 USFWS Proposed Critical year flow	
January 1–October 31	30
November 1–December 31	70
2002 Water Right Modification for Critical year flow	
January 1–October 31	50
November 1–December 31	70

cfs = cubic feet per second
MOA = Memorandum of Agreement
CDFW = California Department of Fish and Wildlife
USFWS = U.S. Fish and Wildlife Service

4.3.1 Clear Creek Fisheries

Table 4.2-2 lists focal species in the Central Valley, including Clear Creek. Life histories of focal species are described under Section 4.2.3, *Sacramento River Fisheries*. Distinctions for Clear Creek are described in this section. Clear Creek supports ESA-listed Central Valley Spring-Run Chinook Salmon, unlisted Fall-Run and Late Fall-Run Chinook Salmon, ESA-listed California Central Valley Steelhead, and the California species of special concern, Pacific Lamprey. Whiskeytown Dam blocks access to 25 mi of historical Spring-Run Chinook Salmon and Central Valley Steelhead spawning and rearing habitat. Prior to 2000, the McCormick-Saeltzer Dam was a barrier to upstream migration for anadromous salmonids. Its removal opened an additional 12 mi of habitat for anadromous fish and contributed to the reestablishment of Spring-Run Chinook Salmon and California Central Valley Steelhead in Clear Creek. The gravel augmentation program has recreated substantial spawning habitat and is assessed by direct observation of the habitat used by Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead for spawning. The proportional use of injected gravels versus native gravels has steadily increased. By 2017, over 80% of the steelhead and nearly 70% of the salmon that spawned in Clear Creek spawned on gravel that had been injected into the system (CCTT 2018).

Chinook Salmon and California Central Valley Steelhead populations in Clear Creek are faring relatively well when compared to other Central Valley populations. Anadromous fish escapement, redd counts, and carcass indices in Clear Creek have either increased, remained stable, or decreased substantially less than their Central Valley counterparts in the years after implementation of habitat improvements; however, spawning habitat continues to limit anadromous fish production in Clear Creek (NMFS 2014a).

4.4 Feather River

The Feather River is the largest tributary to the Sacramento River below Shasta Dam (Reclamation 1997; DWR 2007a). The Feather River drainage area is 3,607 sq mi on the east side of the Sacramento Valley, and the largest two tributaries are the Yuba and Bear Rivers). The Feather River enters the Sacramento River from the east at Verona.

The Yuba River is a major tributary to the Feather River and historically has contributed over 40% of the lower Feather River flows (Reclamation 1997). The Yuba River watershed extends over 1,339 sq mi in the Sierra Nevada. The major reservoir in the watershed is the 970 TAF New Bullards Bar Reservoir that is owned and operated by Yuba County Water Agency. New Bullards Bar is operated to provide flood control, water storage, and hydroelectric generation (YCWA 2012). The Yuba River watershed includes over 400 TAF additional storage in reservoirs located upstream of New Bullards Bar Reservoir.

Oroville Dam and its related facilities comprise a multipurpose complex. Lake Oroville Reservoir was created by Oroville Dam. Lake Oroville has a total storage capacity of 3,538 TAF. The major inflows to Lake Oroville are the north, middle, and south forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 MAF. Historical water storage volumes for Lake Oroville for water years 2001–2018 are shown in Figure 4.4-1, Lake Oroville Storage (DWR 2018s, 2018t).

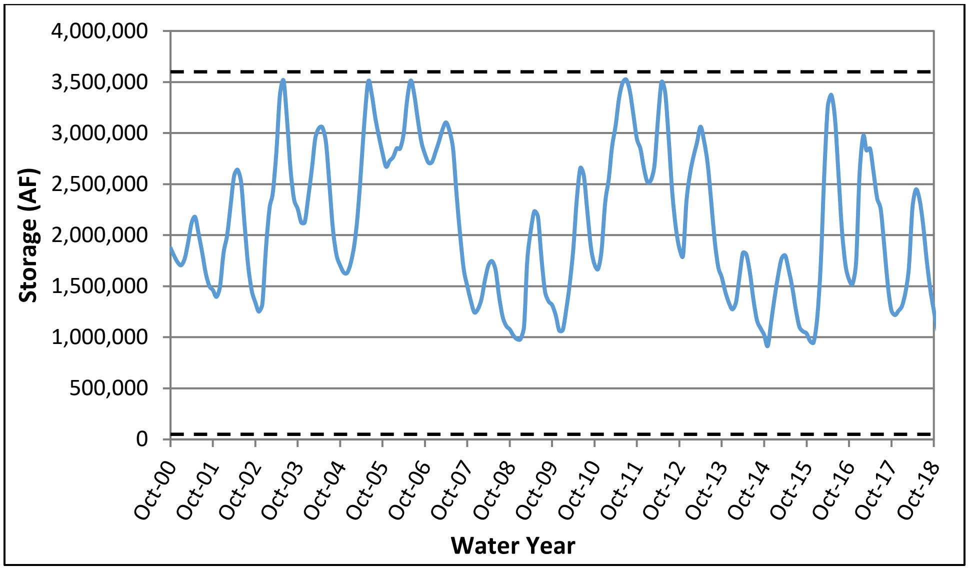


Figure 4.4-1. Lake Oroville Storage

A maximum of 16,950 cfs can be released through the Edward Hyatt Powerplant, located underground near the left abutment of Oroville Dam. Approximately 4 mi downstream of Oroville Dam and Edward Hyatt Powerplant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot-long concrete gravity section with a regulated spillway that releases water to the low flow channel of the Feather River.

The purpose of the diversion dam is to divert water into the 2-mile-long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (Thermalito Diversion Pool) for Edward Hyatt Powerplant. The Thermalito Diversion Pool acts as a forebay when the powerplant is pumping water back into Lake Oroville. The Thermalito Diversion Dam Powerplant, with a capacity of 615 cfs that releases water to the low-flow section of the Feather River, on the left abutment. The Feather River mean daily flows from water years 2001–2018 are shown in Figure 4.4-2, Feather River near Gridley (DWR 2018u).

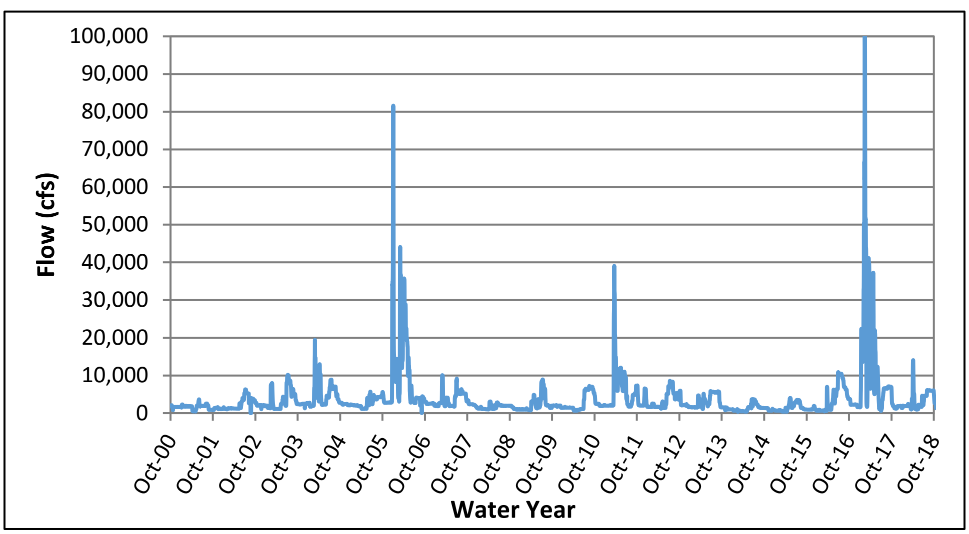


Figure 4.4-2. Feather River near Gridley

The temperature of the water released from Oroville Dam is per the temperature requirements for the Feather River Fish Hatchery, under the 1983 CDFW Agreement, and the 2004 NMFS BO for Robinson Riffle while conserving the coldwater pool in Lake Oroville. Current Feather River Fish Hatchery intake water temperatures, as required by the 1983 CDFW Agreement, are shown in Table 4.4-1, Feather River Fish Hatchery Temperature Requirements.

Table 4.4-1. Feather River Fish Hatchery Temperature Requirements

Period	Temperature (°F)
April 1–May 15	51 (±4°F Allowed)
May 16–May 31	55 (±4°F Allowed)
June 1–June 15	56 (±4°F Allowed)
June 16–August 15	60 (±4°F Allowed)
August 16–August 31	58 (±4°F Allowed)
September 1–September 30	52 (±4°F Allowed)
October 1–November 30	51 (±4°F Allowed)
December 1–March 31	No greater than 55

°F = degrees Fahrenheit

The original FERC license to operate the Oroville Project expired in January 2007. Since 2007, annual license renewals have been issued, requiring DWR to operate to the original FERC license conditions; FERC has not adopted the new license. Until FERC issues a new license for the Oroville Project, DWR will continue to operate the Oroville facilities per the current (original) license conditions.

4.4.1 Feather River Fisheries

Table 4.2-2 lists focal species in the Central Valley, including the Feather River. Life histories are described under Section 4.2.3, and distinctions for the Feather River are described in this section. The Feather River supports Fall-Run and Spring-Run Chinook Salmon, California Central Valley Steelhead, Green Sturgeon, and some non-natal rearing of Winter-run in the lowermost reaches. The Fish Barrier Dam on the Feather River restricts the distribution of the approximately 44 anadromous and resident, whether native or introduced, fish species potentially occurring in the lower Feather River to the 67 mi between the dam and the confluence with the Sacramento River (FERC 2007).

The lower Feather River contains 67 mi of suitable spawning and rearing habitat for Fall- and Spring-Run Chinook Salmon, California Central Valley Steelhead, and Green Sturgeon 2001; with the spawning habitat concentrated in the uppermost 21 miles.). Extensive mining, irrigation, and other dams substantially reduced the amount of suitable habitat and abundance of these species well before Oroville Dam was completed (Yoshiyama et al. 2001). Currently, most spawning for these salmonids is concentrated in the uppermost eight 3 mi of accessible habitat downstream of the Feather River Fish Hatchery). As a result, spawning of Chinook Salmon is sometimes concentrated at unnaturally high levels directly downstream of the Fish Barrier Dam in the low- flow channel which contributes to increased occurrence of redd superimposition and introgression.

According to DWR (2002), optimum Chinook Salmon flow suitability for spawning is about 800 to 825 cfs and 1,200 cfs in the low-flow and high-flow channels, respectively. California Central Valley Steelhead appeared to have no optimum flow for spawning in the low-flow channel; however, optimum flow was just under 1,000 cfs in the high-flow channel (DWR 2004).

4.5 American River

The American River Division includes facilities that provide storage and conveyance of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Powerplant; Nimbus Dam and Powerplant; and Lake Natoma.

Reclamation's Folsom Reservoir, the largest reservoir in the American River watershed, has a capacity of 967 TAF. Folsom Dam is located approximately 30 mi upstream from the confluence with the Sacramento River. Folsom Dam is operated as a major component of the CVP. The facility serves water to M&I users in Placer and Sacramento Counties.

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate flows of the American River and to direct water into the CVP Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant when releases are less than 5,000 cfs or the spillway gates for higher flows. The American River flows 23 mi between Nimbus Dam and the confluence with the Sacramento River. Water storage volumes for Folsom Lake and Lake Natoma for water years 2001–2018 are shown in Figures 4.5-1, Folsom Lake Storage, and 4.5-2, Lake Natoma Storage (DWR 2018v, 2018w, 2018x, 2018y). Mean daily flows in American River at Fair Oaks, downstream of Nimbus Dam are shown in Figure 4.5-3, American River at Fair Oaks (DWR 2018z).

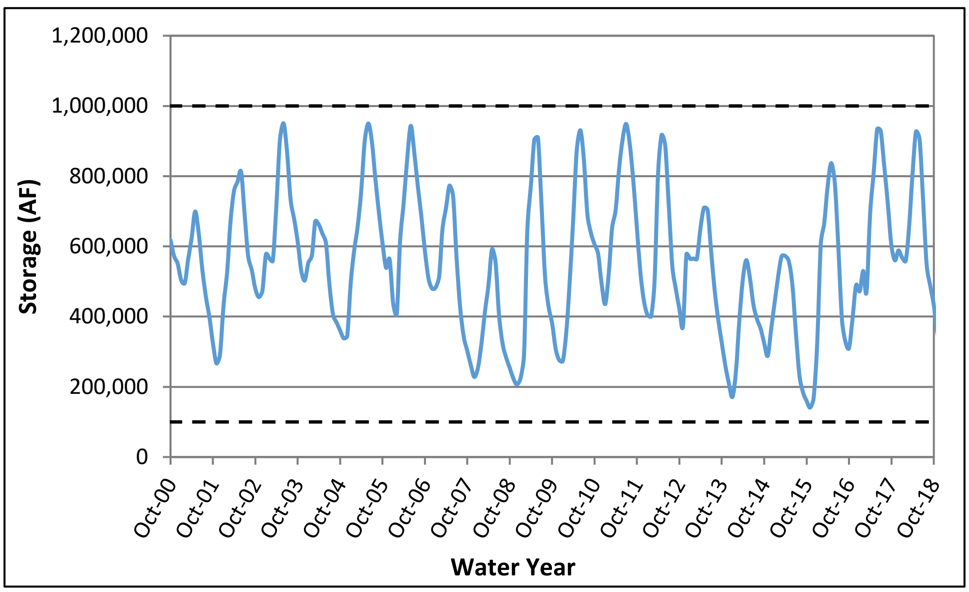


Figure 4.5-1. Folsom Lake Storage

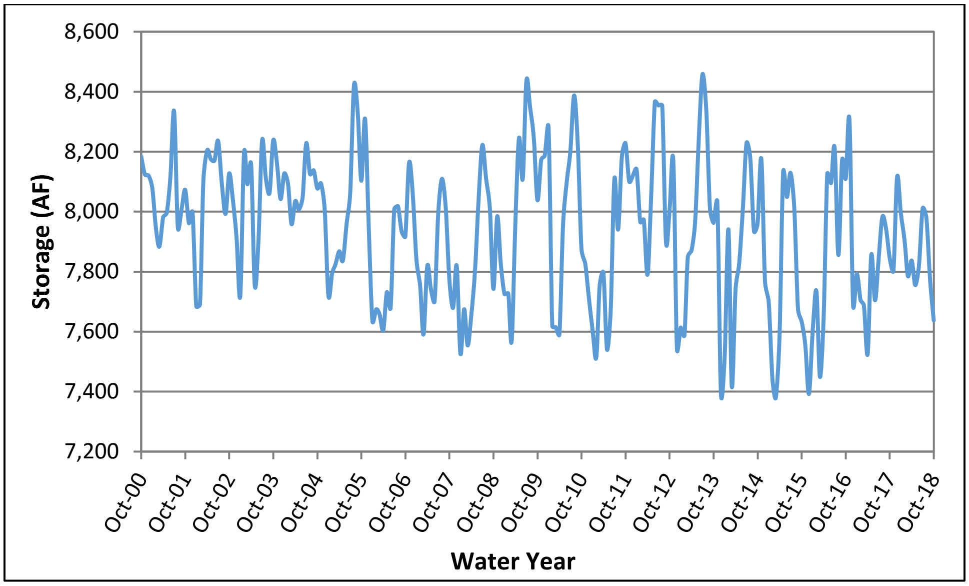


Figure 4.5-2. Lake Natoma Storage

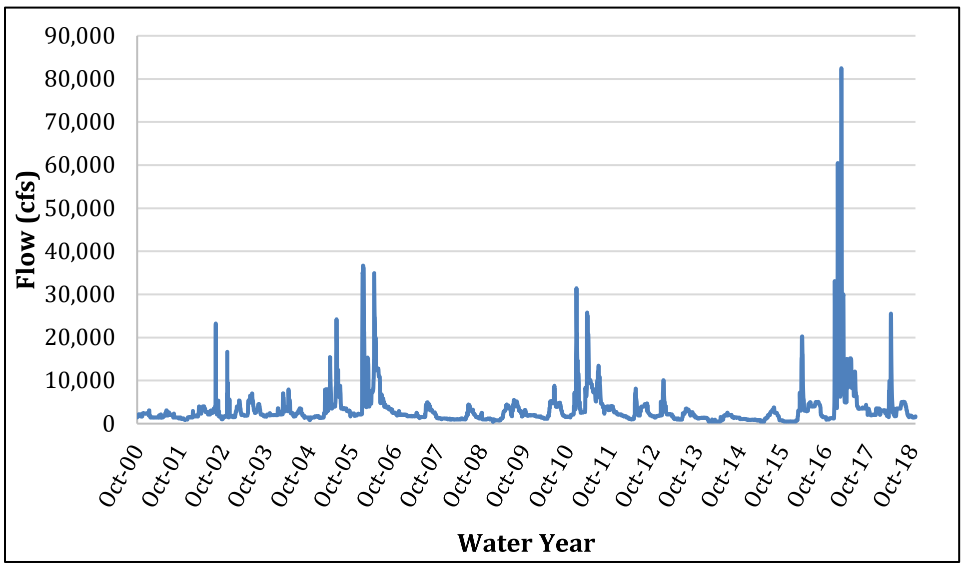


Figure 4.5-3. American River at Fair Oaks

4.5.1 American River Fisheries

Table 4.2-2 lists focal species in the Central Valley region, including the American River. Life histories are described under Section 4.2.3, Sacramento River Fisheries. Distinctions for the American River are described in this section.

Since 1955, Nimbus Dam has blocked upstream passage by anadromous fish and restricted available habitat in the lower American River to the approximately 23 river miles between the dam and the confluence with the Sacramento River. Additionally, Folsom Dam has blocked the downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species.

In 2008, Reclamation, in coordination with USFWS and the Sacramento Water Forum, began implementation of salmonid habitat improvement in the lower American River. An estimated 5,000 cubic yards (cu yd) of gravel and cobble were placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated 7,000 cu yd adjacent to the Nimbus Fish Hatchery in fall 2009. In September 2010, approximately 11,688 cu yd of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook Salmon and steelhead in the lower American River (Merz et al. 2012).

During higher flows, channel geomorphology in the lower American River is characterized by bar complexes and side channel areas, which may become limited at lower flows (NMFS 2009a). Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization at flows of 50,000 cfs or greater (Reclamation 2008a). At 115,000 cfs (the highest flow modeled), particles up to 70 mm median diameter would be moved in the high-density spawning areas around Sailor Bar and Sunrise Avenue.

Reclamation operates a fish diversion weir approximately 0.25 mi downstream of Nimbus Dam, which functions to divert adult steelhead and Chinook Salmon into Nimbus Fish Hatchery. The weir is annually installed during September prior to the arrival of Fall-Run Chinook Salmon and steelhead and is removed at the conclusion of Fall-Run Chinook Salmon immigration in early January (Reclamation and CDFG 2011). Some steelhead may be trapped prior to weir removal, but they are returned to the river. A new fish passageway is being implemented in the Nimbus Dam stilling basin, commonly referred to as Nimbus Shoals. The passageway will replace the existing fish diversion weir with a new flume and fish ladder that will connect to the existing fish ladder near Nimbus Fish Hatchery (Reclamation and CDFG 2011).

Historically, the American River supported Fall-Run and Late Fall-Run Chinook Salmon (Williams 2001). Both naturally produced and hatchery-produced Chinook Salmon spawn in the lower American River. Analysis by CDFG and USFWS (2010) indicated that approximately 84% of the natural Fall-Run Chinook Salmon spawners in the American River are of hatchery-origin. Kormos et al. (2012) reported that 79% of the Fall-Run Chinook Salmon entering the Nimbus Fish Hatchery in 2010 and 32% of the fish spawning in the American River were of hatchery origin.

Adult Fall-Run Chinook Salmon enter the lower American River from mid-September through January, with peak migration from approximately mid-October through December (Williams 2001). Spawning occurs from about mid-October through early February, with peak spawning from mid-October through December. Chinook Salmon spawning occurs within an 18-mi stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 mi (CDFG 2012). Chinook Salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. There is high variability from year to year; however, most incubation occurs from about mid-October through February. Chinook Salmon fry emergence occurs from January through mid-April, and juvenile rearing extends from January to about mid-July (Williams 2001). Most Chinook Salmon out-migrate from the lower American River as fry between December and July, peaking in February to March (Snider and Titus 2002; PSMFC 2014).

Adult steelhead enter the American River from November through April with a peak occurring from December through March (SWRI 2001). Results of a spawning survey conducted from 2001–2007 indicate that steelhead spawning occurs in the lower American River from late December through early April, with the peak occurring in late February to early March (Hannon and Deason 2008). Redd count based population estimates indicated that there were approximately 200 to 500 in river spawners in these years. Spawning density is highest in the upper 7 mi of the river, but spawning occurs as far downstream as Paradise Beach. About 90% of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008).

4.6 Stanislaus River

The Stanislaus River originates in the western slopes of the Sierra Nevada and drains a watershed of approximately 900 sq mi. The median annual unimpaired runoff in the basin is approximately 1.08 MAF per year (SWRCB 2012). Snowmelt from March through early July contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June.

The north, middle, and south forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. The 2.4 MAF New Melones Reservoir is located approximately 60 mi upstream from the confluence of the Stanislaus River and the San Joaquin River. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010). Tulloch Reservoir is owned and operated by the Tri-Dams Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir flows downstream to Goodwin Reservoir, where water is either diverted to canals to serve Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District or released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012). Reservoir storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Below Goodwin Dam, the lower Stanislaus River flows approximately 40 mi to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals also enter the lower Stanislaus River.

Recent water storage volumes for water years 2001–2018 in New Melones and Goodwin Reservoirs are shown in Figures 4.6-1, New Melones Reservoir Storage, and 4.6-2, Goodwin Reservoir Storage (DWR 2018aa, 2018ab, 2018ac, 2018ad). Recent mean daily flows in the Stanislaus River downstream of Goodwin Dam are shown in Figure 4.6-3, Stanislaus River at Orange Blossom Bridge (DWR 2018ae).

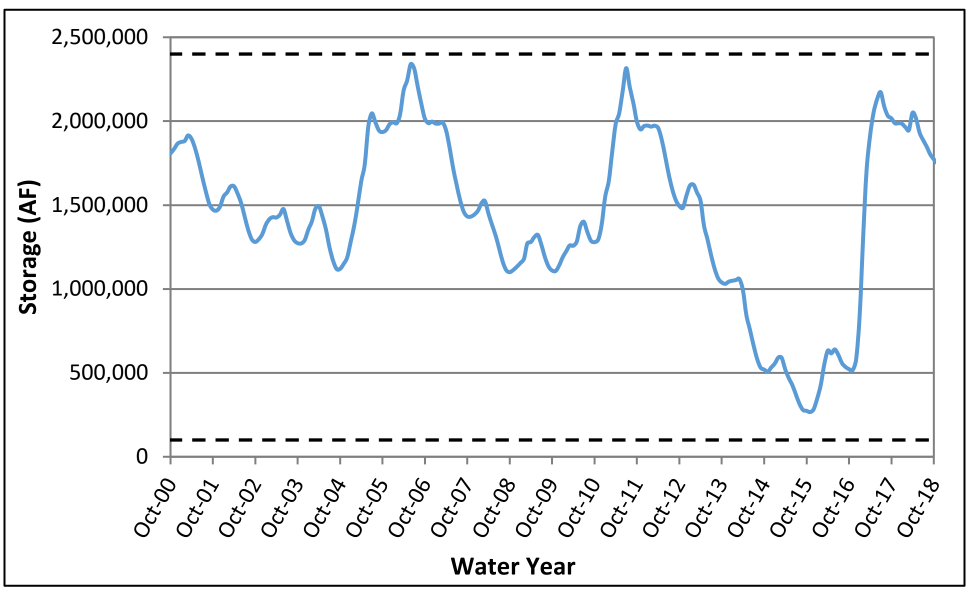


Figure 4.6-1. New Melones Reservoir Storage

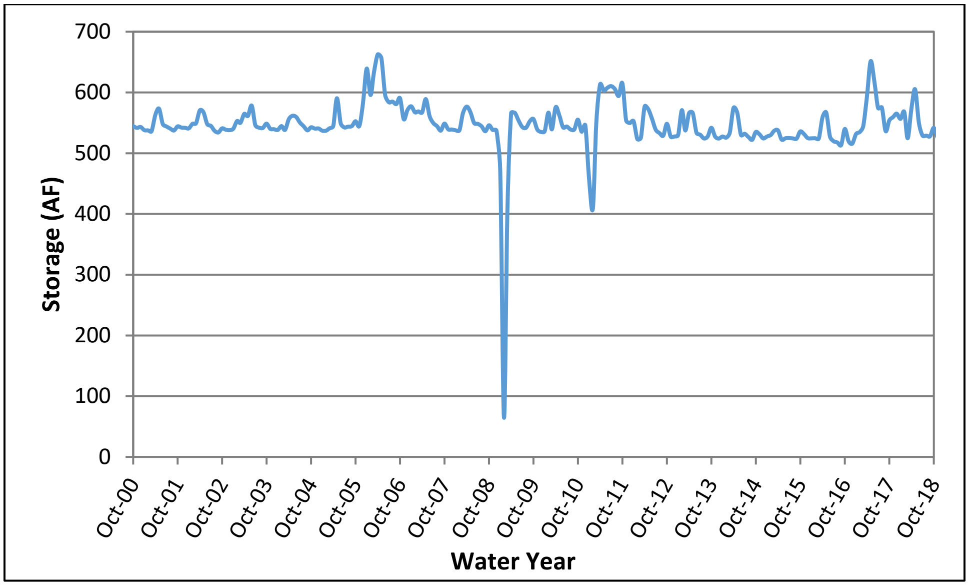


Figure 4.6-2. Goodwin Reservoir Storage

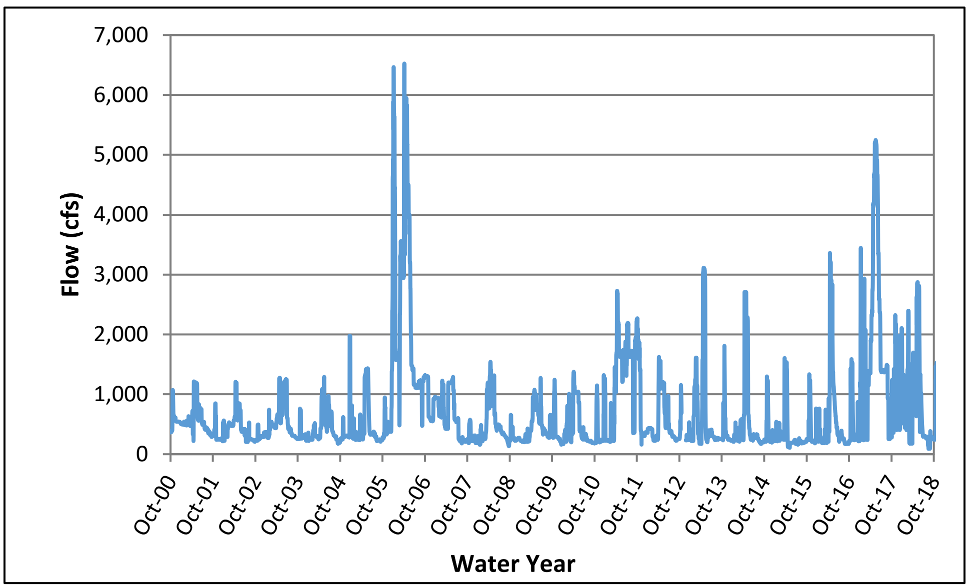


Figure 4.6-3. Stanislaus River at Orange Blossom Bridge

4.6.1 Stanislaus River Fisheries

Table 4.2-2 lists focal species in the Central Valley region, including the Stanislaus River. Life histories are described under Section 4.2.3, Sacramento River Fisheries, . Distinctions for the Stanislaus River are described in this section. California Central Valley Steelhead and Fall-Fun Chinook Salmon currently occur in the lower Stanislaus River. Historically, Spring-Run Chinook Salmon were believed to be the primary salmon run in the Stanislaus River. Native Spring-Run Chinook Salmon have been extirpated from all tributaries in the San Joaquin River Basin, which represents a large portion of their historical range and abundance (NMFS 2014a). Other anadromous fish species occurring in the lower Stanislaus River include Striped Bass, American Shad, and an unidentified species of lamprey (SRFG 2003).

Upstream dams have suppressed channel-forming flows that replenish spawning beds in the Stanislaus River (Kondolf et al. 1996). The physical presence of the dams impedes normal sediment transportation processes. Kondolf et al. (2001) identified levels of sediment depletion at 20,000 cu yd per year because of a variety of factors, including mining and geomorphic processes associated with past and ongoing dam operations. In 2011, 5,000 tons of gravel were placed in Goodwin Canyon downstream of Goodwin Dam, of which around 70% was transported into nearby downstream areas during high flows (SOG 2012).

Data collected by private fishery consultants, nonprofit organizations, and CDFW demonstrate the majority of Fall-Run Chinook Salmon adults migrate upstream from late September through December with peak migration from late October through early November. Most Chinook Salmon spawning occurs between Riverbank (River Mile 33) and Goodwin Dam (River Mile 58.4) (Reclamation 2012). By late October, the amount of spawning in downstream locations increases as water temperatures decrease, and the median redd location is typically around Knights Ferry (SWRCB 2015). Rotary screw trap data indicate that about 99% of salmon juveniles migrate out of the Stanislaus River from January through May (SRFG 2004). Fry migration generally occurs from January through March, followed by smolt migration from April through May (Reclamation 2012). For steelhead, adult migration occurs starting in November. Spawning initiates as early as December and extends through potentially April, with emergence occurring in April and becoming abundant by May.

4.7 San Joaquin River

The San Joaquin River flows 100 mi from Friant Dam to the Delta. Flows in the upper San Joaquin River are regulated by the CVP Friant Dam, which forms Millerton Lake. Flows downstream of Friant Dam are influenced by flows from tributary rivers and streams, as described below, including CVP operations of New Melones Reservoir on the Stanislaus River.

Millerton Lake has a volume of 524 TAF, a surface area of 4,905 acres, and an elevation of 580.6 ft above mean sea level (*North American Vertical Datum of 1988*) (elevation 580.6) at top of active storage (Reclamation 2008b). The flood pool elevation is 587.6 while the maximum observed water surface elevation was 583, experienced during the January 1997 flood. Recent water storage volumes and elevations for water years 2001–2018 in Millerton Lake are shown in Figure 4.7-1, Millerton Lake Storage (DWR 2018af, 2018ag).

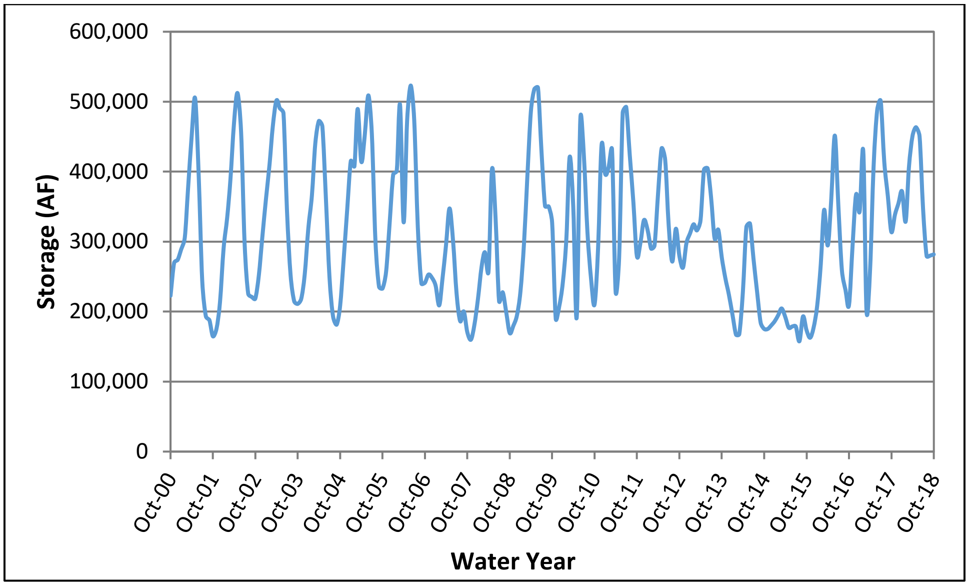


Figure 4.7-1. Millerton Lake Storage

The minimum operating storage of Millerton Lake is 130 TAF, resulting in active available conservation storage of about 390 TAF. Friant Dam is the principal flood damage reduction facility on the San Joaquin River and is operated to maintain combined releases to the San Joaquin River at or below a flow objective of 8,000 cfs. Flood control storage space in Millerton Lake is based on a complex formula, which considers storage in upstream reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately once every 3 years and are managed based on downstream channel design capacity to the extent possible.

In 2006, parties Natural Resources Defense Council et al., v. Rodgers, et al. lawsuit executed the *Stipulation of Settlement in NRDC vs. Kirk Rodgers, et al.* that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook Salmon fishery while reducing or avoiding adverse water supply impacts. The SJRRP implements the stipulation of settlement consistent with the Settlement Act in Public Law 111-11. USFWS issued a BO for the implementation of the SJRRP on August 21, 2012, and NMFS issued a BO on September 18, 2012, for SJRRP flow releases of up to 1,660 cfs from Millerton Lake into the San Joaquin River. The SJRRP includes six water year types for releases depending upon available water supply as measures of inflow to Millerton Lake. The SJRRP includes the flexibility to reshape and retime releases forwards or backwards by 4 weeks during the spring and fall pulse periods. Flood flows may potentially occur and meet or exceed the stipulation of settlement flow targets. If flood flows meet the stipulation of settlement flow targets, then Reclamation would not release additional water from Millerton Lake. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the confluence of the San Joaquin and Merced Rivers and releases are limited accordingly.

Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs, located on the tributary systems, to satisfy contract deliveries and instream flow requirements and operational agreements such as D-1641. Recent mean daily flows in the San Joaquin River at Vernalis (located at the southeastern boundary of the Delta) are shown in Figure 4.7-2, San Joaquin River at Vernalis (DWR 2018ah).

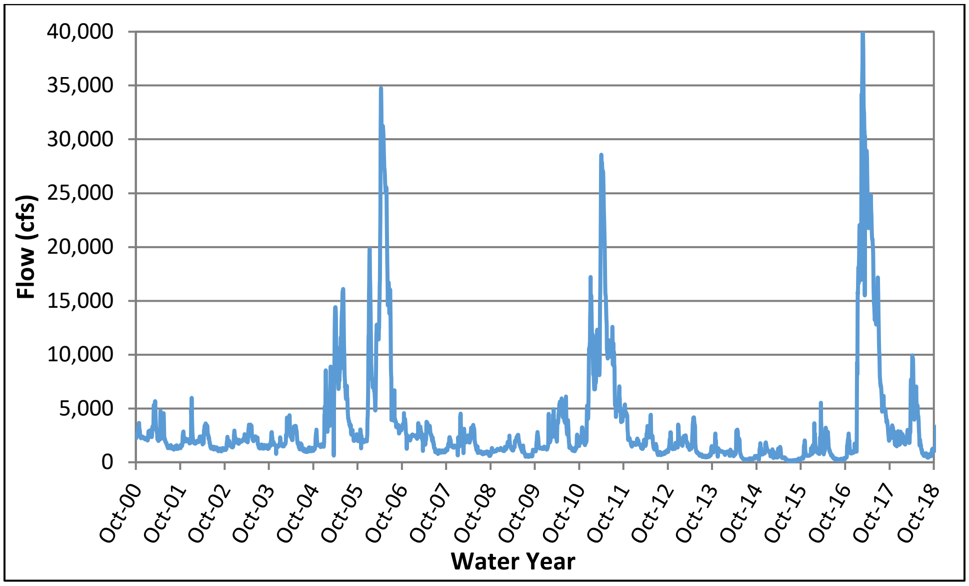


Figure 4.7-2. San Joaquin River at Vernalis

4.7.1 San Joaquin River Fisheries

Table 4.2-2 lists focal species in the Central Valley region, including the San Joaquin River. Life histories are described under Section 4.2.3, Sacramento River Fisheries, . Distinctions for the San Joaquin River are described in this section. Since the construction of Friant Dam, substantial changes in physical (fluvial geomorphic) processes and substantial reductions in streamflows in the San Joaquin River have occurred, resulting in large-scale alterations to the river channel and associated aquatic, riparian, and floodplain habitats. Throughout the area, there are physical barriers, reaches with poor water quality or no surface flow, and false migration pathways that have reduced habitat connectivity for anadromous and resident native fishes (Reclamation and DWR 2011). As a result, there has been a general decline in both the abundance and distribution of native fishes, with several species extirpated from the system (Moyle 2002).

Moyle (2002) reported that of the 21 native fish species historically present in the San Joaquin River, at least eight are now uncommon, rare, or extinct. Anadromous species include Fall-Run Chinook Salmon, California Central Valley Steelhead, Striped Bass, American Shad, White Sturgeon, and several species of lamprey (Reclamation et al. 2003). The Fall-Run Chinook Salmon population is supported in part by hatchery stock in the Merced River. Spawning by anadromous salmonids in the San Joaquin River Basin occurs in the tributaries to the San Joaquin River, including the Merced, Tuolumne, and Stanislaus Rivers (Brown and Moyle 1993). The San Joaquin River Restoration Program has worked over a decade to reintroduce an experimental population of spring-run Chinook and maintain a fall-run Chinook population in the San Joaquin River above the Merced River confluence. The stocks were originally supported by fish from the Feather River Hatchery, but a local conservation hatchery built specifically for the San Joaquin River Restoration Program will replace all Feather River stocks. Any returning adults are trapped in the San Joaquin River above the confluence with the Merced River and trucked to accessible spawning reaches below Friant Dam. In 2019, eighteen Spring-run Chinook salmon adults reintroduced as juveniles by the SJRRP successfully returned to the San Joaquin River (SJRRP). Because of the uncertainty of future restoration success, the experimental designation of current San Joaquin River spring-run and the current lack of natural presence in the San Joaquin River, Spring-Run Chinook Salmon are not included in the analysis of San Joaquin River fish.

4.8 Bay-Delta Operations

The Delta and Suisun Marsh area constitutes a natural floodplain that covers 1,315 sq mi and drains approximately 40% of the state (DWR 2013a). The Delta and Suisun Marsh comprise a complex web of channels and islands located at the confluence of the Sacramento and San Joaquin Rivers.

The CVP Delta Division consists of the CVP facilities in and south of the Sacramento–San Joaquin Delta, including the DCC, Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, Jones Pumping Plant (formerly Tracy Pumping Plant), TFCF, DMC, and Delta-Mendota Canal/California Aqueduct Intertie. Collectively these facilities are used to divert, convey, and store water for irrigation, M&I, and fish and environmental uses in San Joaquin Valley, Santa Clara Valley, Contra Costa County, and San Benito County.

Hydrological conditions in the Delta and Suisun Marsh are affected by structures that route water through the Delta toward the major Delta water diversions in the south Delta, including the Jones Pumping Plant and the Banks Pumping Plant. Diversion patterns for the major facilities are regulated to maintain Delta water quality and to protect fish listed as threatened or endangered species under the ESA per D-1641, 2008 USFWS BO, and 2009 NMFS BO. The diversion patterns are implemented to maintain the ratio of exports at the Banks Pumping Plant and Jones Pumping Plant to the Delta inflow (known as E/I ratio), maintain the ratio of San Joaquin River inflow to exports at the Banks Pumping Plant and Jones Pumping Plant (known as San Joaquin River I/E ratio), and limit net reverse flow in the OMR (known as OMR criteria). Banks Pumping Plant and Jones Pumping Plant operations are affected by downstream CVP and SWP water demands and reservoir operations in San Luis Reservoir, which is jointly used by the CVP and SWP.

Delta channels have been modified to allow transport of Delta inflow to the diversions throughout the Delta, including the CVP and SWP south Delta intakes, and to reduce the effects of pumping on the direction of flows and salinity intrusion within the Delta. Water conveyance from the Sacramento River southward through the Delta to the CVP and SWP south Delta intakes is aided by the DCC (a constructed, gated channel that conveys water from the Sacramento River to the Mokelumne River).

4.8.1 Regulatory Limitations on Operations of Delta Water Diversions

Operations of the CVP and SWP are implemented in accordance with Biological Opinions of the USFWS and NMFS, SWRCB water rights and water quality decisions, including D-1641.

4.8.1.1 *Decision 1641*

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995. The plan became the basis of D-1641 (adopted December 29, 1999 and revised March 15, 2000). D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. (SWRCB grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641.) The requirements in D-1641 address the objectives for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type.

The export to inflow ratio limited exports to 35% of total Delta inflow from February through June. The 35% E/I ratio from February to June required in D-1641 was a substantial change from D-1485. This spring requirement reduced the availability of unstored flow for export and storage in San Luis Reservoir. February to June became an unreliable season for conveying water across the Delta. Spring X2 reduced the unstored flow availability by dedicating a substantial block of water to Delta outflow and salinity goals. The spring X2 Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an X2 location. The X2 standard was established to improve shallow water estuarine habitat in February through June and relates to the extent of salinity movement into the Delta (DWR et al. 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

4.8.1.2 *Joint Point of Diversion*

D-1641 authorized the SWP and CVP to jointly use both Jones Pumping Plant and Banks Pumping Plant in the south Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in D-1641 are:

- Stage 1, for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery, and Musco Family Olive Company) and recovery of export reductions implemented to benefit fish;
- Stage 2, for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3, for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to pursue use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south-of-Delta water supplies;
- When summertime pumping capacity is available at Banks Pumping Plant or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and
- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each JPOD stage has regulatory terms and conditions that must be satisfied to implement JPOD. All stages require a response plan (i.e., water level response plan) to ensure water elevations in the south Delta will not be lowered to the injury of local riparian water users and a response plan to ensure the water quality in the south and central Delta will not be substantially degraded through operations of the JPOD to the injury of water users in the south and central Delta. Stage 2 has an additional requirement to complete an operations plan (that is, a fisheries response plan) that will protect fish and wildlife and other legal users of water. Stage 3 has an additional requirement to protect water levels in the south Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los

Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta Smelt.

4.8.1.3 *Implementation of 2008 USFWS and 2009 NMFS Biological Opinions*

The 2008 USFWS BO and the 2009 NMFS BO restrict CVP and SWP diversions to reduce reverse flows in the OMR. The 2008 USFWS BO includes criteria for fall Delta outflow. The 2009 NMFS BO includes criteria for a San Joaquin River E/I ratio.

4.8.1.4 *2008 USFWS Biological Opinion OMR Criteria*

The 2008 USFWS BO restricts south Delta pumping to preserve certain OMR flows as prescribed in the following three actions.

Action 1: Protects adult Delta Smelt migration and entrainment. Limits exports so that the average daily OMR flow is no more negative than −2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than −2,500 cfs (within 25%).

Action 2: Protects adult Delta Smelt migration and entrainment. An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions. The range of net daily OMR flows will be no more negative than −1,250 to −5,000 cfs. Depending on extant conditions, specific OMR flows within this range are recommended by USFWS Smelt Working Group (SWG) from the onset of Action 2 through its termination. The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and using the most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. USFWS will make the final determination.

Action 3: Protects larval and juvenile Delta Smelt. Minimizes the number of larval Delta Smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval Delta Smelt. Net daily OMR flow will be no more negative than −1,250 to −5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25% of the applicable requirement for the OMR. Depending on extant conditions, specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination.

4.8.1.5 *2009 NMFS Biological Opinion OMR Criteria*

The 2009 NMFS BO includes OMR criteria to protect juvenile salmonids during winter and spring emigration downstream into the San Joaquin River and to increase survival of salmonids and Green Sturgeon entering the San Joaquin River from Georgiana Slough and the lower Mokelumne River by reducing the potential for entrainment at the south Delta intakes.

Actions for OMR criteria are implemented from January 1 through June 15 and reduces exports, as necessary, to limit negative flows to −2,500 to −5,000 cfs in the OMR, depending on the presence of salmonids. The reverse flow is managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range is determined based on the decision tree shown in Table 4.8-1, 2009 NMFS Biological Opinion OMR Criteria.

Table 4.8-1. 2009 NMFS Biological Opinion OMR Criteria

Date	Action Triggers	Action Responses
January 1–June 15	January 1–June 15	−5,000 cfs
January 1–June 15 First Stage Trigger (increasing level of concern)	Daily SWP and CVP older juvenile loss density (fish per TAF): (1) is greater than incidental take limit divided by 2,000, with a minimum value of 2.5 fish per TAF, or (2) daily loss is greater than daily measured fish density divided by 12 TAF, or (3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 TAF.	−3,500
January 1–June 15 Second Stage Trigger (analogous to high concern level)	Daily SWP and CVP older juvenile loss density (fish per TAF) is (1) greater than incidental take limit divided by 1000, with a minimum value of 2.5 fish per TAF, or (2) daily loss is greater than daily fish density divided by 8 TAF, or (3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 TAF.	−2,500
End of Triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72°F for 7 consecutive days (1 week), whichever is earlier.	No OMR restriction

cfs = cubic feet per second; CVP = Central Valley Project; OMR = Old and Middle River; SWP = State Water Project; TAF = thousand acre-feet

4.8.1.6 *2009 NMFS Biological Opinion San Joaquin River I/E Ratio*

The 2009 NMFS BO requires south Delta exports to be reduced during April and May to protect emigrating steelhead from the lower San Joaquin River into the south Delta channels and intakes. The E/I ratio from April 1 through May 31 specifies that Reclamation operates the New Melones Reservoir to maintain the 2009 NMFS BO flow schedule for the Stanislaus River at Goodwin in accordance with Action III.1.3 and Appendix 2-E of the 2009 NMFS BO. In addition, the CVP and SWP pumps are operated to meet the ratios based upon a 14-day running average, as summarized in Table 4.8-2, 2009 NMFS Biological Opinion E/I Ratios.

Table 4.8-2. 2009 NMFS Biological Opinion E/I Ratios

San Joaquin Valley Classification	San Joaquin River Flow at Vernalis (cfs): CVP/SWP Combined Export Ratio (cfs)
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs

cfs = cubic feet per second

During multiple dry years, the ratio will be limited to 1:1 if the New Melones Index related to storage is less than 1,000 TAF and the sum of the "indicator" numbers established for water year classifications in D-1641 (based on the San Joaquin Valley 60-20-20 Water Year Classification in D-1641) is greater than 6 for the past 2 years and the current year. The indicator numbers are 1 for a critically dry year, 2 for a dry year, 3 for a below normal year, 4 for an above normal year, and 5 for a wet year.

Implementation of the E/I ratio under all conditions would allow a minimum pumping rate of 1,500 cfs to meet public health and safety needs of communities that solely rely upon water diverted from the CVP and SWP pumping plants.

4.8.1.7 *2008 USFWS Biological Opinion Fall X2 Criteria*

The 2008 USFWS BO includes an additional Delta salinity requirement in September and October in wet and above normal water years (requirement is often referred to as Fall X2). The salinity requirements require that two Practical Salinity Units (psu) are maintained at 74 km during wet years and 81 km during above normal water years when the preceding year was wet or above normal based upon the Sacramento Basin 40-30-30 index in D-1641. In November of such years, there is no specific X2 requirement; however, there is a requirement that all inflow into SWP and CVP upstream reservoirs be conveyed downstream to augment Delta outflow to maintain X2 at the locations in September and October. If storage increases during November due to salinity requirements, the increased storage volume is to be released in December in addition to the requirements under D-1641 net Delta Outflow Index.

4.8.1.8 *Coordinated Operation Agreement*

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary of the Interior to execute and implement the COA. The CVP and SWP are operated under the SWRCB decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by rediverting releases from storage later in the year or in subsequent years.

SWRCB permits the CVP and the SWP to store water, divert water, and redivert CVP and SWP water stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. SWRCB conditioned the CVP and SWP water rights to protect the beneficial uses of water within the watersheds.

In 2018, Reclamation and DWR modified four key elements of the COA to address changes since COA was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 AFY; and (4) the periodic review.

4.8.1.9 *Obligations for In-Basin Uses*

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under D-1485.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to make additional releases. In excess water conditions, water accounting is not required and some of the excess water is available to CVP water contractors, SWP water contractors, and users located upstream of the Delta; Reclamation and DWR are obligated to export and store as much water as possible within their physical and contractual limits. However, during balanced water conditions, CVP and SWP share responsibility in meeting in-basin uses.

COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80% responsibility of the United States and 20% responsibility of the state of California in wet year types to 60% responsibility of the United States and 40% responsibility of the state of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained and the Delta is in balanced conditions, Reclamation may pump up to 65% of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40.

4.8.2 Bay-Delta Fisheries

The Delta provides unique and, in some places, highly productive habitats for a variety of fish species, including euryhaline and oligohaline resident species and anadromous species. Table 4.2-2 lists focal species in the Bay-Delta and life histories are described under Section 4.2.3, Sacramento River Fisheries, . For anadromous species, the Delta is used by adult fish during upstream migration and by rearing juvenile fish that are feeding and growing as they migrate downstream to the ocean. Conditions in the Delta influence the abundance and productivity of all fish populations that use the system. Fish communities currently in the Delta include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al. 2002; Feyrer and Healey 2003; Nobriga et al. 2005; Brown and May 2006; Moyle and Bennett 2008; Grimaldo et al. 2012). The summary of focal fish species below is drawn from Appendix O, *Aquatic Resources Technical Appendix*, Section O.2.10, *Bay-Delta* where additional information is presented.

4.8.2.1 *Winter-Run Chinook Salmon*

Winter-Run Chinook Salmon adults migrate through the Delta during winter and into late spring (May/June) en route to their spawning grounds in the mainstem Sacramento River downstream of Keswick Dam. After entry into the Delta, juvenile Winter-Run Chinook Salmon remain and rear in the Delta until they are 5–10 months of age (based on scale analysis) (Fisher 1994; Myers et al. 1998).

Although the duration of residence in the Delta is not precisely known, del Rosario et al. (2013) suggested that it can be up to several months. Sampling at Chipps Island in the western Delta suggests that Winter-Run Chinook Salmon exit the Delta as early as December and as late as May, with a peak in March (Brandes and McLain 2001; del Rosario et al. 2013). The peak timing of the out-migration of juvenile Winter-Run Chinook Salmon through the Delta is corroborated by recoveries of Winter-Run-sized juvenile Chinook Salmon from the Skinner Fish Facility and the TFCF in the south Delta (NMFS 2009a).

4.8.2.2 *Spring-Run Chinook Salmon*

Spring-Run Chinook Salmon returning to spawn in the Sacramento River system enter the San Francisco Estuary from the ocean in January to late February and move through the Delta prior to entering the Sacramento River. Juvenile Spring-Run Chinook Salmon show two distinct out-migration patterns in the Central Valley: out-migrating to the Delta and ocean during their first year of life as YOY, or holding over in their natal streams and out-migrating the following fall/winter as yearlings. Peak movement of juvenile Spring-Run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December, and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000b, 2000c, 2000d; Vincik et al. 2006; Roberts 2007). YOY Spring-Run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of spring-run fish at that time of year. However, it is difficult to distinguish the YOY Spring-Run Chinook Salmon out-migration from that of the fall-run due to the similarity in their spawning and emergence times and size.

4.8.2.3 *Fall-Run and Late Fall-Run Chinook Salmon*

Adult Fall-Run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Adult Late Fall-Run Chinook Salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley Fall-Run and Late Fall-Run Chinook Salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway. Most Fall-Run Chinook Salmon fry rear in freshwater from December through June, with out-migration as smolts occurring primarily from January through June. In general, Fall-Run Chinook Salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A small number of juvenile Fall-Run Chinook Salmon spend over a year in freshwater and out-migrate as yearling smolts the following November through April. Late Fall-Run fry rear in freshwater from April through the following April and out-migrate as smolts from October through February (Snider and Titus 2000b). Juvenile Chinook Salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002). Juvenile Fall-Run and Late Fall-Run Chinook Salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh, and Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook Salmon in the estuarine environment is driven by the interaction between tidally influenced salt water intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin Rivers (Healey 1991). In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including Fall-Run Chinook Salmon. Studies have shown that juvenile Salmon may spend 2–3 months rearing in these habitat areas.

4.8.2.4 *Central Valley Steelhead*

Upstream migration of Central Valley Steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996; NMFS 2009a). Populations of steelhead occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams. Upstream migrating adult steelhead enter the Sacramento River and San Joaquin River Basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the south Delta waterways and enter the San Joaquin River through the head of the Old River.

Central Valley Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures in the south Delta waterways and water quality impairment because of low dissolved oxygen at the Port of Stockton have been suggested as potential barriers to upstream migration (NMFS 2009a). Reduced water temperatures and rainfall runoff and flood control release flows provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries.

Adult Central Valley Steelhead may continue entering the San Joaquin River basin through winter. Juvenile steelhead are recovered in trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate a difference in the out-migration timing between wild and hatchery-reared steelhead smolts from the Sacramento and east side tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001; Reclamation 2008a). The timing of wild (unmarked) steelhead out-migration is more spread out, and based on salvage records at the CVP and SWP fish collection facilities, out-migration occurs over approximately 6 months with the highest levels of recovery in February through June (Aasen 2011, 2012). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010 and 1,648 in 2011) (Aasen 2011, 2012).

4.8.2.5 *Green Sturgeon*

Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations the upper Sacramento River between April and June (Heublein 2006; Kelly et al. 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river before moving back downstream in fall (Vogel 2008; Heublein et al. 2009) or they may migrate immediately back downstream through the Delta. Radio-tagged adult Green Sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulses of flow in the river (Heublein et al. 2009). Similar to other estuaries along the west coast of North America, adult and subadult Green Sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Juvenile Green Sturgeon and White Sturgeon are periodically, although rarely, collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (NMFS 2009a; Aasen 2011, 2012). Green Sturgeon are salvaged from the South Delta Project diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (Reclamation 2008a). After hatching, larvae and juveniles migrate downstream toward the Delta. Juveniles are believed to use the Delta for rearing for the first 1–3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the central Delta and Suisun Bay and Marsh.

4.8.2.6 *White Sturgeon*

White Sturgeon are similar to Green Sturgeon in terms of their biology and life history. White Sturgeon are believed to be most abundant within the Bay-Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966; Kohlhorst et al. 1991; Moyle 2002; DWR et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the Bay-Delta (Kohlhorst et al. 1991). The population status of White Sturgeon in the Delta is unclear, but it is not presently listed. Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002; NMFS 2009a). The Delta population of White Sturgeon spawns mainly in the Sacramento and Feather Rivers, with occasional spawning in the San Joaquin River (Moyle 2002; Jackson 2013).

Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994; Schaffter 1997). After absorbing yolk sacs and initiating feeding, YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White Sturgeon larvae have been observed to be dispersed farther downstream in the Delta and Suisun Bay in high outflow years but are restricted to more interior locations in low outflow years (Stevens and Miller 1970).

4.8.2.7 *Delta Smelt*

Delta Smelt are endemic to the Delta and Suisun Marsh (Moyle et al. 1992; Bennett 2005). Studies conducted to synthesize available information about Delta Smelt indicate that Delta Smelt have been documented throughout their geographic range during much of the year (Merz et al. 2011; Sommer and Mejia 2013; Brown et al. 2014). Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta, Suisun Bay, San Pablo Bay, the Sacramento River and San Joaquin River confluence, Cache Slough, and the lower Sacramento River (Murphy and Hamilton 2013). By spring, they move to freshwater areas of the Delta region, including the Sacramento River and San Joaquin River confluence, the upper Sacramento River, and Cache Slough (Brown et al. 2014; Murphy and Hamilton 2013). There is also a freshwater resident life history type (Bush 2017), occurring primarily in the Cache Slough region year-round (Sommer et al. 2011). Sommer et al. (2011) described that during winter, adult Delta Smelt initiate upstream spawning migrations in association with “first flush” freshets. Others report this seasonal change as a multidirectional and more circumscribed dispersal movement to freshwater areas throughout the Delta region (Murphy and Hamilton 2013). After arriving in freshwater staging habitats, adult Delta Smelt hold until spawning commences during favorable water temperatures in the late winter-spring (Bennett 2005; Grimaldo et al. 2009; Sommer et al. 2011).

Delta Smelt spawn over a wide area throughout much of the Delta, including some areas downstream and upstream as conditions allow. Although the specific substrates or habitats used for spawning by Delta Smelt are not known, spawning habitat preferences of closely related species (Bennett 2005) suggest that spawning may occur in shallow areas over sandy substrates. During and after larval rearing in freshwater, many young Delta Smelt move with river and tidal currents to remain in favorable rearing habitats, often moving increasingly into the low salinity zone to avoid seasonally warm and highly transparent waters that typify many areas in the central Delta (Nobriga et al. 2008). During summer and fall, many juvenile Delta Smelt continue to grow and rear in the low salinity zone until maturing the following winter

(Bennett 2005). Some Delta Smelt also rear in upstream areas such as the Cache Slough complex and Sacramento Deep Water Ship Channel, depending on habitat conditions (Sommer and Mejia 2013).

4.8.2.8 *Longfin Smelt*

Longfin Smelt populations occur along the Pacific Coast of North America, and the San Francisco Estuary represents the southernmost population. Longfin Smelt generally occur in the Delta; Suisun, San Pablo, and San Francisco Bays; and the Gulf of the Farallones, just outside San Francisco Bay. Longfin Smelt are anadromous and spawn in fresh or low salinity water in the Bay-Delta (Grimaldo et al. 2017), generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (CDFG 2009a). Previous studies suggested that spawning in the Sacramento River occurs from just downstream of the confluence of the Sacramento and San Joaquin Rivers upstream to about Rio Vista and that spawning on the San Joaquin River extends from the confluence upstream to about Medford Island (Moyle 2002); more recent studies suggest hatching and early rearing occurs in a much broader region and higher salinity (2–12 ppt) than previously recognized (Grimaldo et al. 2017). Spawning likely also occurs in Suisun Marsh and the Napa River (CDFG 2009a).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). As previously noted, larval Longfin Smelt rear in low salinity to brackish water (2–12 ppt; Grimaldo et al. 2017). Larger Longfin Smelt feed primarily on opossum shrimps and other invertebrates (Feyrer et al. 2003). Copepods and other crustaceans also can be important food items, especially for smaller fish (Reclamation 2008a). Longfin Smelt in the San Francisco Estuary are broadly distributed in both time and space, and interannual distribution patterns are relatively consistent (Rosenfield and Baxter 2007). Seasonal patterns in abundance and occurrence in the nearshore ocean suggest that the population is at least partially anadromous (Rosenfield and Baxter 2007; Garwood 2017), and the detection of Longfin Smelt within the estuary throughout the year suggests that, similar to Striped Bass, anadromy is one of several life history strategies or contingents in this population.

4.8.2.9 *Sacramento Splittail*

Sacramento Splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento Splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas but also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adult Sacramento Splittail typically migrate upstream from brackish areas in January and February and spawn in freshwater, particularly on inundated floodplains when they are available, in March and April (Sommer et al. 1997; Moyle et al. 2004; Sommer et al. 2008). A substantial amount of Splittail spawning occurs in the Yolo and Sutter Bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn, as evidenced by spawning in the Napa and Petaluma Rivers (Feyrer et al. 2005). Although juvenile Sacramento Splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995; Feyrer et al. 2005).

4.8.2.10 *American Shad*

American Shad are a recreationally important anadromous species introduced into the Sacramento–San Joaquin River Basin in the 1870s (Moyle 2002). American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba Rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus Rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2–3 months to pass through the Sacramento–San Joaquin Estuary (Painter et al. 1979). Fertilized eggs are slightly negatively buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile Shad rear in the Sacramento River below Knights Landing, the Feather River below Yuba City, and the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing occurs in the American and Yuba Rivers (Painter et al. 1979). Some juvenile shad may rear in the Delta for up to a year before out-migrating to the ocean (USFWS 1995). Out-migration from the Delta begins in late June and continues through November (Painter et al. 1979).

4.8.2.11 *Striped Bass*

Striped Bass is a recreationally important anadromous species introduced into the Sacramento–San Joaquin River Basin between 1879 and 1882 (Moyle 2002). Despite their nonnative status and piscivorous feeding habits, Striped Bass are considered important because they are a major game fish in the Delta. Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped Bass spend the majority of their lives in saltwater, returning to freshwater to spawn. When not migrating for spawning, adult Striped Bass in the Bay-Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult Striped Bass spend about 6–9 months of the year in San Francisco and San Pablo Bays (Hassler 1988). Striped Bass also use deeper areas of many of the larger channels in the Delta, in addition to large embayments such as Suisun Bay. Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin Rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

4.8.2.12 *Pacific Lamprey*

Limited data indicate most adult Pacific Lamprey migrate though the Delta en route to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005; Hanni et al. 2006; Moyle et al. 2009; Clemens et al. 2012; Lampman 2011). Data from the Fall Midwater Trawl (FMWT) Survey (CDFW undated) in the lower Sacramento and San Joaquin Rivers and Suisun Bay suggest that peak out-migration of Pacific Lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some out-migration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006) and in other river systems (Moyle 2002). Some Pacific Lamprey ammocoetes likely spend part of their extended freshwater residence (5–7 years) rearing in the Delta, particularly in the upstream, freshwater portions (DWR et al. 2013).

4.8.3 CVP and SWP Service Areas (South to Diamond Valley)

The 2.027 MAF San Luis Reservoir, formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF operated by the CVP and 1.062 MAF operated by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports.

Water is released from the San Luis Reservoir into the lower portion of the lower Delta Mendota Canal/California Aqueduct that extends to Lake Perris in Riverside County and delivers water to the San Joaquin Valley, Central Coast, and Southern California. The first reach of the California Aqueduct, the San Luis Canal, is jointly owned by the SWP and CVP and extends from San Luis Reservoir to Check 21 near Kettleman City. This reach includes Dos Amigos . Water can also be released from San Luis Reservoir into the Pacheco Pumping Plant where it is pumped into San Benito and Santa Clara Counties Pumping Plants.

The California Aqueduct continues into Southern California through Buena Vista, Teerink, Chrisman, and Edmonston Pumping Plants. Edmonston Pumping Plant is located at the foot of the Tehachapi Mountains and raises the water 1,926 ft into approximately 8 mi of tunnels and siphons that convey water into Antelope Valley. At that location, the California Aqueduct divides into two branches: East Branch and West Branch.

4.8.4 Non-CVP and SWP Reservoirs Storing CVP and SWP Water

The CVP and the SWP water are delivered to water agencies. Some of those water agencies store the water in regional and local reservoirs. In the San Francisco Bay Area region, CVP water is stored in the CCWD Los Vaqueros Reservoir; the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette Reservoirs; Santa Clara Valley Water District Anderson and Calero Reservoirs. The Los Vaqueros Reservoir also stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District and Santa Clara Valley Water District reservoirs primarily store water diverted under separate water rights.

In the Central Coast region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California region, the SWP water is stored in the Metropolitan Water District of Southern California’s Diamond Valley Lake and Lake Skinner; United Water Conservation District’s Lake Piru; City of Escondido’s Dixon Lake; City of San Diego’s San Vicente, El Capitan, Lower Otay, Hodges, and Murray Reservoirs; Helix Water District’s Lake Jennings; Sweetwater Authority’s Sweetwater Reservoir; and San Diego County Water Authority’s Olivenhain Reservoir.

4.9 Nearshore Pacific Ocean on the California Coast

The anadromous fish species use the Pacific Ocean as part of their life cycles. In addition, the Pacific Ocean supports the Southern Resident Killer Whale, which relies upon Chinook Salmon, including Central Valley Fall-Run Chinook Salmon for food.

4.9.1 Pacific Ocean Habitat of the Southern Resident Killer Whale

The Pacific Ocean along the coast of California is included in this description of the affected environment because it provides habitat for the Southern Resident Killer Whale population. The action’s effect, however, is limited to changes in the number of Chinook Salmon produced in the Central Valley entering the Pacific Ocean, which contribute an important component of the killer whale diet. While this apex predator eats a variety of other species, Central Valley Chinook Salmon (all runs) are estimated to make up approximately 40% of the killer whale diet when killer whales are off the California coast and 18% of the killer whale diet when the killer whales are off the Oregon coast. Given that Southern Resident Killer Whales occur during winter months as far south as Monterey Bay and that Central Valley Chinook Salmon compose a large percentage of the Chinook Salmon available south of the Columbia River, it is reasonable to expect that the killer whales could be affected by a change in the availability of Central Valley Chinook Salmon (Reclamation and DWR 2016).

Southern Resident Killer Whales are found primarily in the coastal waters offshore of British Columbia, Washington, and Oregon in summer and fall (NMFS 2008). During winter, killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Hilborn et al. 2012).

The Independent Science Panel reported that Southern Resident Killer Whales depend on Chinook Salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook Salmon were the most frequent prey item for killer whales in two regions of the killer whale's summer range off the coast of British Columbia and Washington; Chinook Salmon represented over 90% of the diet in July and August. Samples indicated that when the killer whales are in inland waters from May to September, they consume Chinook Salmon stocks that originate from regions including the Fraser River, Puget Sound, Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al. 2010).

Substantial changes in food availability for Southern Resident Killer Whales have occurred over the past 150 years due to human impacts on prey species. Salmon abundance has been reduced over the entire range of the killer whales, from British Columbia to California. The *Recovery Plan for Southern Resident Killer Whales* (*Orcinus orca*) (NMFS 2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts, including habitat, harvest, and hatchery management considerations and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base.

Chapter 5 Environmental Consequences

5.1 Scope of Analysis

This EIS identifies environmental consequences of the No Action Alternative and action alternatives on 18 resource categories and mitigation measures for direct and indirect impacts and cumulative impacts. The impacts analysis is organized by resource category. The impact analysis, including affected environment, methods and tools and environmental consequences, are described in detail in the technical appendices for each resource category.

5.1.1 Resources Not Analyzed in Detail

The following resources were not evaluated in detail in this EIS.

5.1.1.1 *Population and Housing*

Typically, impacts on population and housing are the result of actions that would induce population growth either directly or indirectly or actions that would displace large numbers of people and therefore necessitate the construction of additional housing in other locations. Direct impacts would include actions that create additional housing. Indirect impacts include actions that create infrastructure that would induce or support population growth beyond current expectations.

The alternatives evaluated in this document would not cause impacts on population and housing because they are composed primarily of operational changes that would not directly or indirectly affect housing or residential populations. The alternatives would not create additional housing, provide infrastructure to support additional population, or displace existing populations necessitating the creation of housing in another location. Therefore, it is not anticipated that the alternatives would result in either direct or indirect population growth as the result of operations-related activities.

Construction-related activities may have the potential for temporary population displacement, which may necessitate the development of housing elsewhere to provide relocation of residences or to accommodate workers; however, it would be infeasible to predict the number or location of structures, homes, and people affected by construction-related actions because the footprints of these projects are not known yet. If there is potential for such impacts to occur, a site-specific analysis will be undertaken during subsequent project-level environmental documentation.

5.1.1.2 *Traffic and Transportation*

Typically, impacts on traffic and transportation are the result of actions that would either directly or indirectly increase road congestion, thereby potentially increasing travel times on roads, increasing emergency response times, or conflicting with local traffic or transportation plans. Such impacts are typically the result of the addition of new roads, new infrastructure that could lead to increased traffic or population growth, or construction activities that would generate additional truck traffic.

The alternatives evaluated in this document would not cause impacts on traffic and transportation because they are comprised primarily of operational changes that would not directly or indirectly affect traffic.

The operational changes would not induce additional traffic or interfere with existing traffic and transportation patterns. Therefore, it is not anticipated that the alternatives would result in impacts on traffic and transportation as the result of operations-related activities.

Construction-related activities may have the potential for temporary traffic and transportation impacts due to increased truck traffic as the result of construction activities; however, it would be infeasible to predict the number or location of truck trips due to construction activities and any associated changes to traffic patterns because the footprints of these projects are not known yet. If there is potential for such impacts to occur, a site-specific analysis will be undertaken during subsequent project-level environmental documentation. Any such impacts would be temporary in nature and traffic levels would return to normal once construction is completed.

5.1.1.3 *Flood Control*

CVP and SWP reservoirs provide flood control in addition to their other purposes. In theory, changing the operations of the facilities could have the potential to affect flood management; however, Reclamation and DWR are not proposing to alter flood control practices. Each facility has a flood control curve that defines storage throughout the year that must be available to help manage high flows. The action alternatives would not change these flood control curves or operational parameters established in cooperation with the USACE to manage floods. Because Reclamation and DWR would continue to operate with the same flood management procedures under the action alternatives, the alternatives would not affect flood control and it is not discussed further.

5.1.2 Environmental Consequences

Under NEPA, the effects of the alternatives under consideration are determined by comparing effects between alternatives and against effects from the No Action Alternative (40 CFR 1502.14). NEPA requires the analysis of a No Action Alternative, representing a scenario in which the project is not implemented. The NEPA No Action Alternative is intended to account for existing facilities, conditions, land uses, and reasonably foreseeable actions expected to occur in the study area. The No Action Alternative would continue the existing CVP and SWP operations and current management direction regarding actions to protect sensitive species. It also would include reasonably foreseeable actions, such as actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete.

NEPA requires an analysis of the context and the intensity of direct and indirect effects of the action alternatives compared to the No Action Alternative. The effects of the No Action Alternative are similar to existing conditions, but more information is provided for resources where they may vary. Existing conditions are typically defined at the time when the Notice of Intent was published.

In this draft EIS, impacts for each alternative are organized by impact statement, which is a short italicized statement that describes the potential impact. The potential impact is then described and evaluated for each region that may have effects related to that specific resource. The impact analysis includes quantitative and qualitative analyses depending upon availability of acceptable numerical analytical tools and available information. Project-level impacts are described first, followed by program-level impacts.

5.1.3 Mitigation Measures

Mitigation measures are provided to avoid, minimize, rectify, reduce, or compensate for adverse effects of the action alternatives in accordance with NEPA regulations. Mitigation measures are not required to be implemented under NEPA but must be identified and analyzed.

5.1.4 Cumulative Impacts

NEPA requires consideration of cumulative effects in an EIS. Cumulative effects are those environmental effects that, on their own, may not be considered substantial but when combined with similar effects over time, have the potential to result in substantial effects. Cumulative effects are important because they allow decision-makers to look not only at the impacts of an individual proposed project but also at the overall impacts on a specific resource, ecosystem, or human community over time from several different projects.

5.1.5 Modeling Methodology

Many of the impact analyses use modeling to help characterize the differences between alternatives. The No Action Alternative and action alternatives were modeled using CalSim II, which simulates how the CVP and SWP would operate under each alternative. The No Action Alternative and action alternatives are analyzed under future conditions, so this model run also includes median climate change projections. Appendix F, *Model Documentation* includes more detail on CalSim II modeling. Additionally, other resources include resource-specific models such as groundwater and water quality modeling.

The CalSim II model's monthly simulation of an actual daily (or even hourly) operation of CVP and SWP results in several limitations in use of model results. Model results must be used in a comparative manner because of these limitations. CalSim II model output includes minor fluctuations of up to 5% due to model assumptions and approaches. Therefore, if quantitative changes between a specific alternative and the No Action Alternative are 5% or less, conditions under the specific alternative would be considered to be "similar" to conditions under the No Action Alternative. Changes less than 5% are not substantive enough to distinguish between alternatives.

Alternative 1 includes some elements in the Summer-Fall Delta Smelt Habitat Action that could vary year-to-year. The action could include operations of the SMSCG in some years or a fall action to maintain the X2 position at 80 km in some above normal and wet years. Both of these actions would require water and affect CVP and SWP operations, but the frequency of these actions is not specifically defined. The modeling of Alternative 1 in Chapter 5 (and associated appendices) does not include these actions. When these actions are implemented under Alternative 1, they would change late summer or fall operations in the Delta. Generally, the potential impacts and benefits of Alternative 1 could range between what is described in Chapter 5 and the No Action Alternative, which includes a Fall X2 action. Chapter 5 includes qualitative descriptions of how impacts could change in years with a Fall X2 action.

5.2 Water Quality

This impact assessment is based on the technical analysis documented in Appendix G, *Water Quality Technical Appendix*, which includes additional information on water quality conditions and technical analysis of the effects of each alternative.

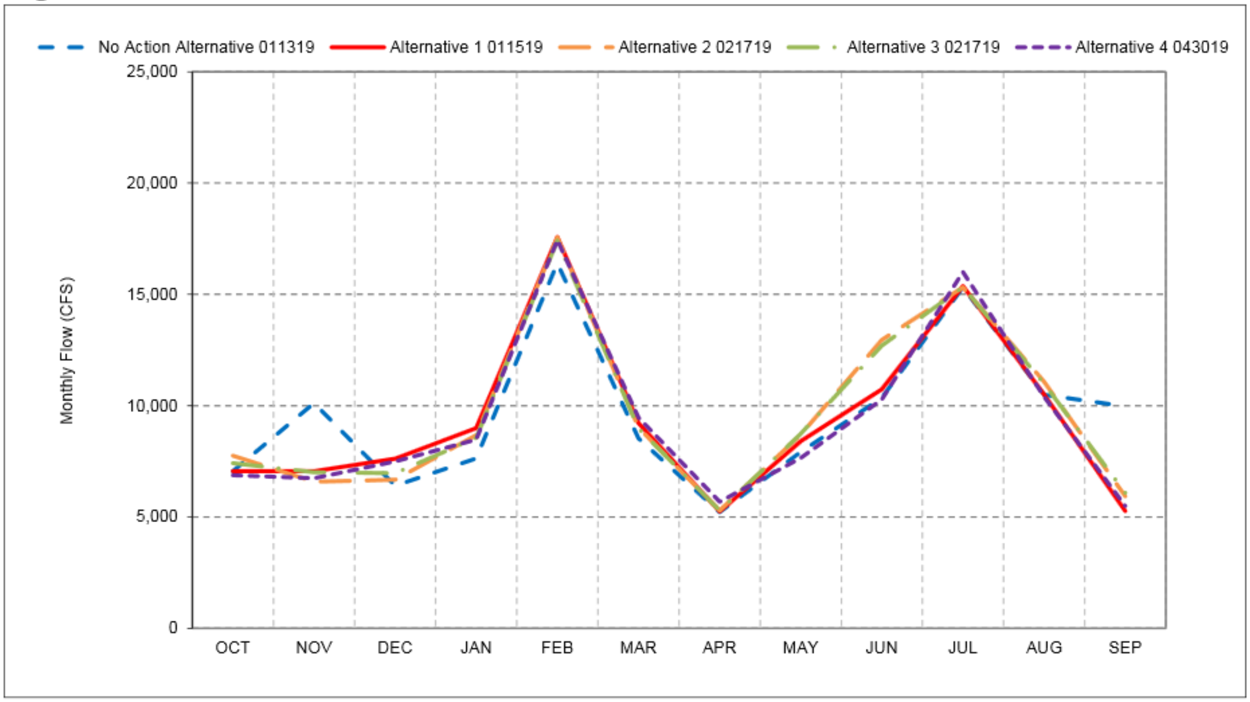
5.2.1 Project-Level Effects

Potential changes in water quality

5.2.1.1 *Trinity, Sacramento, Feather, and American Rivers and Clear Creek*

Relative to the No Action Alternative, the action alternatives would change CVP and SWP operations that then would change river flows and reservoir levels. Salinity and concentrations of constituents of concern can all be positively or negatively affected by increases or decreases in flow and reservoir levels. Generally, substantive increases in flow could increase dilution and benefit water quality, and substantive decreases in flow could reduce dilution and adversely affect water quality. Water temperature is discussed in the fisheries analysis (see Section 5.9, *Aquatic Resources*).

Alternatives 1 through 4 would have only minor changes to river flows as documented in Appendix F. Figure 5.2-1, Sacramento River Flow Downstream of Keswick Reservoir, Above Normal Year Average Flow shows the average monthly flows in the Sacramento River below Keswick Dam during an above normal water year, which is representative of the type of flow changes in the Sacramento River and its tributaries. Changes in flow in all other water year types are of a lesser magnitude. Generally, flow changes, compared to the No Action Alternative, in the fall of wet and above normal water years are driven by changes to fall X2 requirements for Delta Smelt. Under the action alternatives, decreased releases at this time of year and changes to management of Shasta Reservoir shift Sacramento River flows to other times of year. These small changes in flow would not result in exceedances of existing water quality standards and therefore would not adversely affect water quality in the Sacramento River or its tributaries.



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

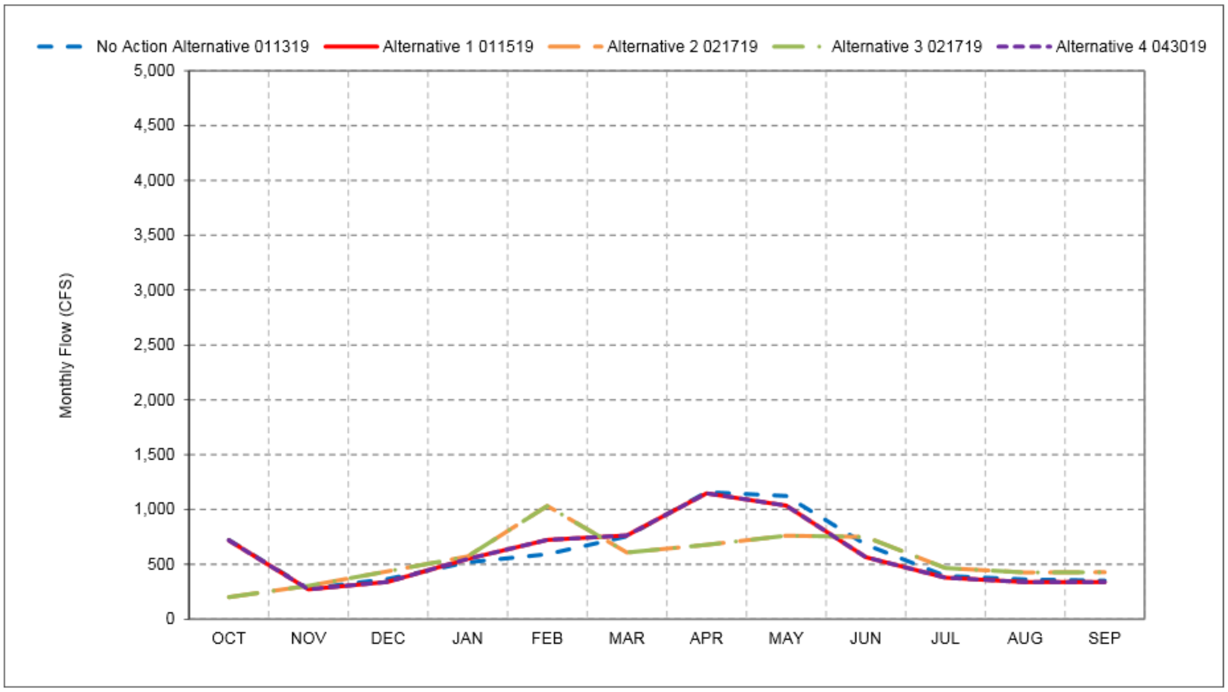
Figure 5.2-1. Sacramento River Flow Downstream of Keswick Reservoir, Above Normal Year Average Flow

5.2.1.2 *Stanislaus and San Joaquin Rivers*

Alternatives 1 through 4 would cause changes in flow in some water year types in the Stanislaus River relative to the No Action Alternative. Alternatives 1 and 4 would change flows on the Stanislaus River because they incorporate the SRP for New Melones Reservoir, which aims to create a release plan that is better able to meet the multiple purposes of the reservoir. Alternatives 2 and 3 would have fewer flow requirements in the Stanislaus River, which would shift flows to different times of year. Figure 5.2-2, Stanislaus River at Goodwin, Long-Term Average Flow illustrates long-term average flows for all action alternatives at the Stanislaus River at Goodwin. At times when flow increases, water quality could improve as more water is available to dilute constituents of concern, specifically pesticide runoff in the Stanislaus River. Flow decreases during spring and summer months of all water year types could cause water quality degradation because less water would be available to dilute pesticide concentrations. While overall changes in flow are not expected to fluctuate greatly, changes such as those noted at Goodwin under Alternatives 1 through 4, for particular water year types, could potentially cause minor changes in the concentration of constituents of concern in the Stanislaus River, potentially resulting in small changes to water quality.

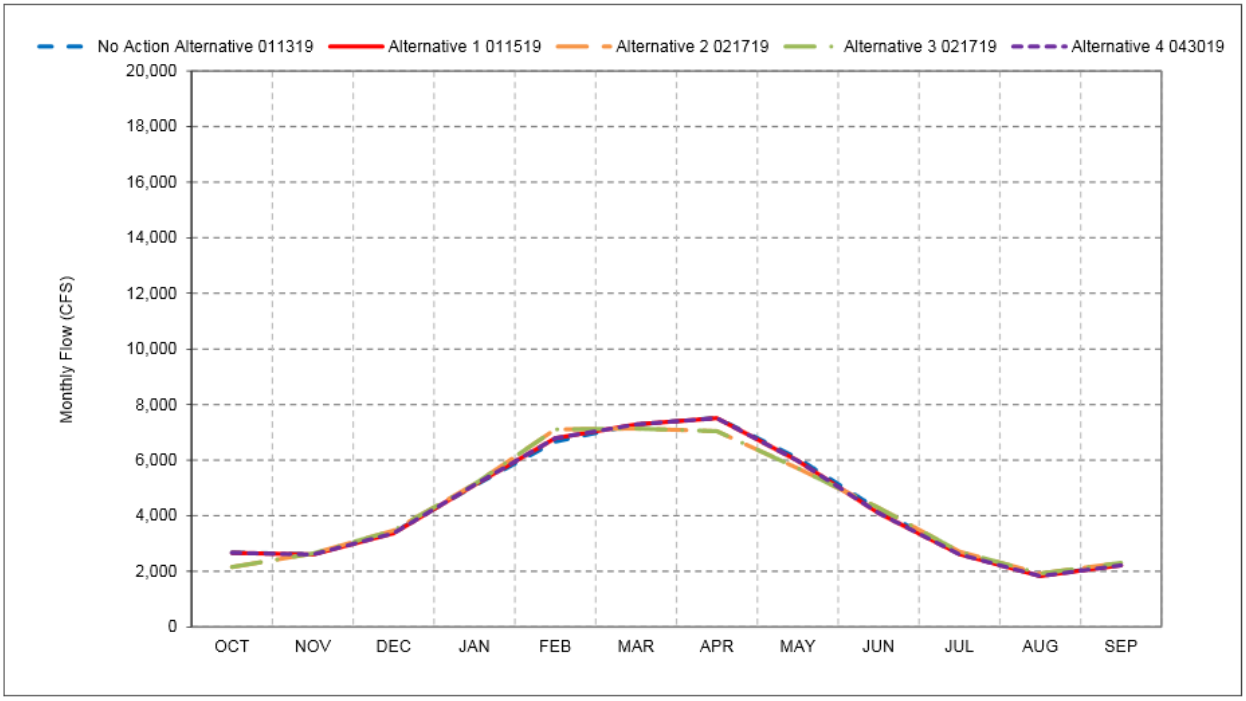
Flows in the San Joaquin River at Vernalis would remain similar between the No Action Alternative and the action alternatives. Figure 5.2-3, San Joaquin River at Vernalis, Long-Term Average Flow illustrates long-term average flows across the model record for all alternatives at the San Joaquin River at Vernalis.

The small changes in flows under the action alternatives would have minimal effect on the concentrations of constituents of concern in the San Joaquin River.



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

Figure 5.2-2. Stanislaus River at Goodwin, Long-Term Average Flow



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

Figure 5.2-3. San Joaquin River at Vernalis, Long-Term Average Flow

5.2.1.3 *Bay-Delta*

For most constituents and constituent groups of concern, water quality within the Delta, Suisun Bay and Marsh, and San Francisco Bay under the action alternatives would not differ substantially from the No Action Alternative or differ in a way that would contribute to adverse effects on beneficial uses compared to No Action Alternative conditions. The constituents for which there would be an appreciable difference in water quality under the action alternatives, relative to the No Action Alternative, are the salinity-related parameters electrical conductivity (EC) and chloride in the Delta. The Bay-Delta Plan established EC objectives for protection of agricultural and fish and wildlife beneficial uses, and chloride objectives for the protection of municipal and industrial uses.

EC levels at certain Delta locations under the action alternatives would be higher than those that would occur under the No Action Alternative, primarily in the months of September through December. Monthly average EC levels in the Sacramento River at Emmaton and Collinsville, and the San Joaquin River at Jersey Point under the action alternatives would be substantially higher than the No Action Alternative EC levels in September through December. Monthly average EC levels at Banks and Jones pumping plants also would be higher under the action alternatives, relative to the No Action Alternative, in September through December. There would be little difference between the monthly average EC levels in the San Joaquin River at Vernalis except under in October Alternatives 2 and 3. An example of higher EC levels in September through December under the action alternatives is shown in Figure 5.2-4, Long-Term Monthly Average EC for the Sacramento River at Emmaton for Water Years 1922–2003. As shown in Figure 5.2-4, the long-term average EC levels under Alternative 1 would be approximately 200–600 micromhos per centimeter (µmhos/cm) higher than the No Action Alternative EC levels in September through December. The Alternative 2 long-term average EC levels would follow a pattern similar to Alternative 1 and would be approximately 400–700 µmhos/cm higher than the No Action Alternative EC levels in September through December. Under Alternative 3, the long-term average EC levels would be approximately 100–400 µmhos/cm higher than the No Action Alternative EC levels in September through December. Alternative 4 EC levels would be approximately 200–700 µmhos/cm. Other Delta locations would have varying magnitudes of higher EC levels relative to the No Action Alternative in the September through December period, with the highest EC relative to the No Action Alternative occurring in the western Delta.

Chloride concentrations at certain Delta locations under the action alternatives would be higher than those that would occur under the No Action Alternative. Monthly average chloride concentrations at Contra Costa Pumping Plant #1, San Joaquin River at Antioch, Banks Pumping Plant, and Jones Pumping Plant would be higher than the No Action Alternative chloride concentrations, primarily in September through January. There would be little to no difference between the chloride concentrations in Barker Slough at the NBA-Barker Slough Intake under the action alternatives relative to the No Action Alternative. An example of higher chloride concentrations in September through January under the action alternatives is provided in Figure 5.2-5, Long-Term Average Chloride at Contra Costa Pumping Plant #1 for Water Years 1922–2003. Contra Costa Pumping Plant #1 is a Bay-Delta Plan compliance location for chloride. As shown in Figure 5.2-5, long-term average chloride concentrations under Alternative 1 would be approximately 10–70 milligrams per liter (mg/L) higher than the No Action Alternative EC levels in September through January. Under Alternatives 2, 3, and 4, long-term average chloride concentrations would be approximately 20–70 mg/L higher than the No Action Alternative chloride concentrations in September through January. In April and May, long-term average chloride concentrations under Alternatives 1, 2, and 3 would be approximately 10–20 mg/L lower than under the No Action Alternative. Alternative 4 long-term average chloride concentrations would be approximately 10–30 mg/L higher in March through May. Long-term chloride concentrations in the other months under Alternatives 1, 2, 3, and 4 would be similar to the No Action Alternative. Other Delta locations would have varying magnitudes of higher chloride concentrations relative to the No Action Alternative in the September through January period, with the highest chloride concentrations occurring in the western Delta.

While there would be higher monthly average EC levels and chloride concentrations under the action alternatives relative to the No Action Alternative at certain Delta locations in some months and water year types, the CVP and SWP would continue to be operated in real-time to meet the Bay-Delta Plan EC and chloride objectives for protection of Delta beneficial uses. Thus, changes to these beneficial uses, as affected by Delta EC levels and chloride concentrations, would not be expected under the action alternatives.

If the Summer-Fall Delta Smelt Habitat Action under Alternative 1 includes operations of the SMSCG or a fall X2 action, EC levels and chloride concentrations under Alternative 1 could be different than discussed above. The fall X2 action could result in EC levels and chloride concentrations being lower than modeled, particularly in the western Delta, resulting in less of a difference between Alternative 1 and the No Action Alternative in the fall. SMSCG operations also could result in different EC levels within Suisun Marsh and the Delta than those modeled for Alternative 1. Reclamation and DWR would coordinate water and SMSCG operations to minimize the potential for unintended salinity changes in the Suisun Bay and the Sacramento-San Joaquin River confluence area. Thus, the proposed operation of the SMSCG would not contribute to adverse effects to salinity parameters, such as EC.

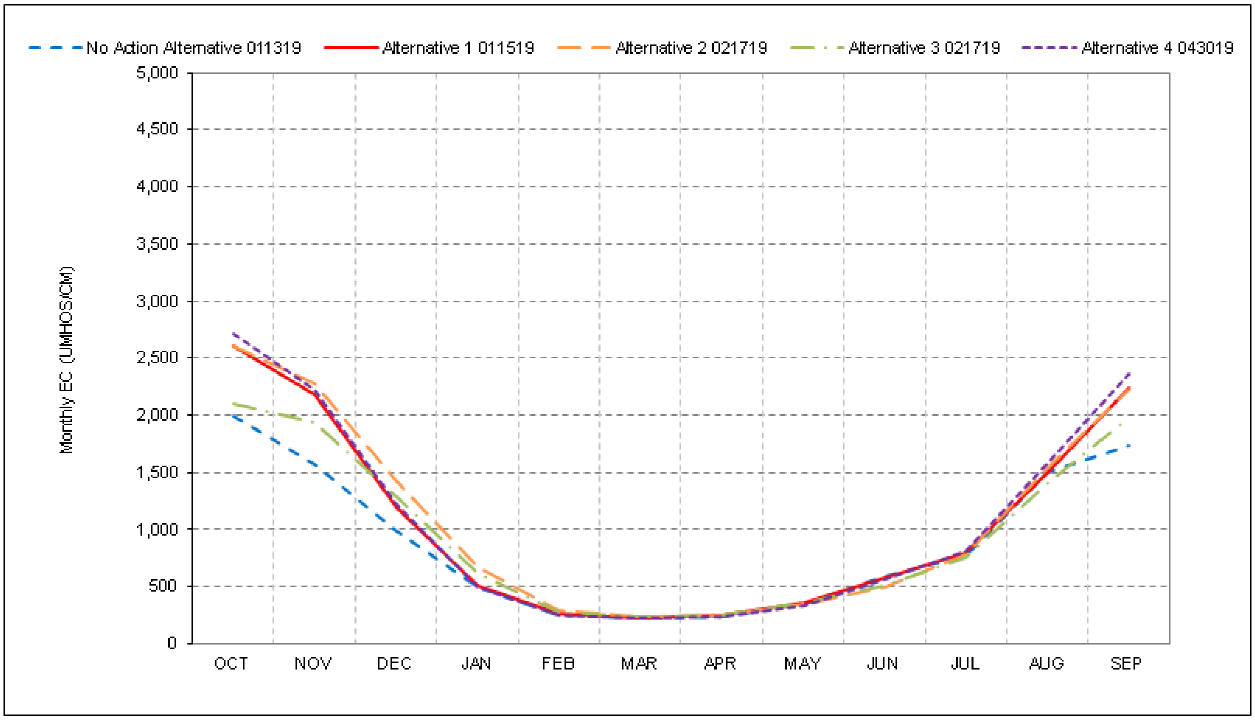


Figure 5.2-4. Long-Term Monthly Average EC for the Sacramento River at Emmaton for Water Years 1922–2003

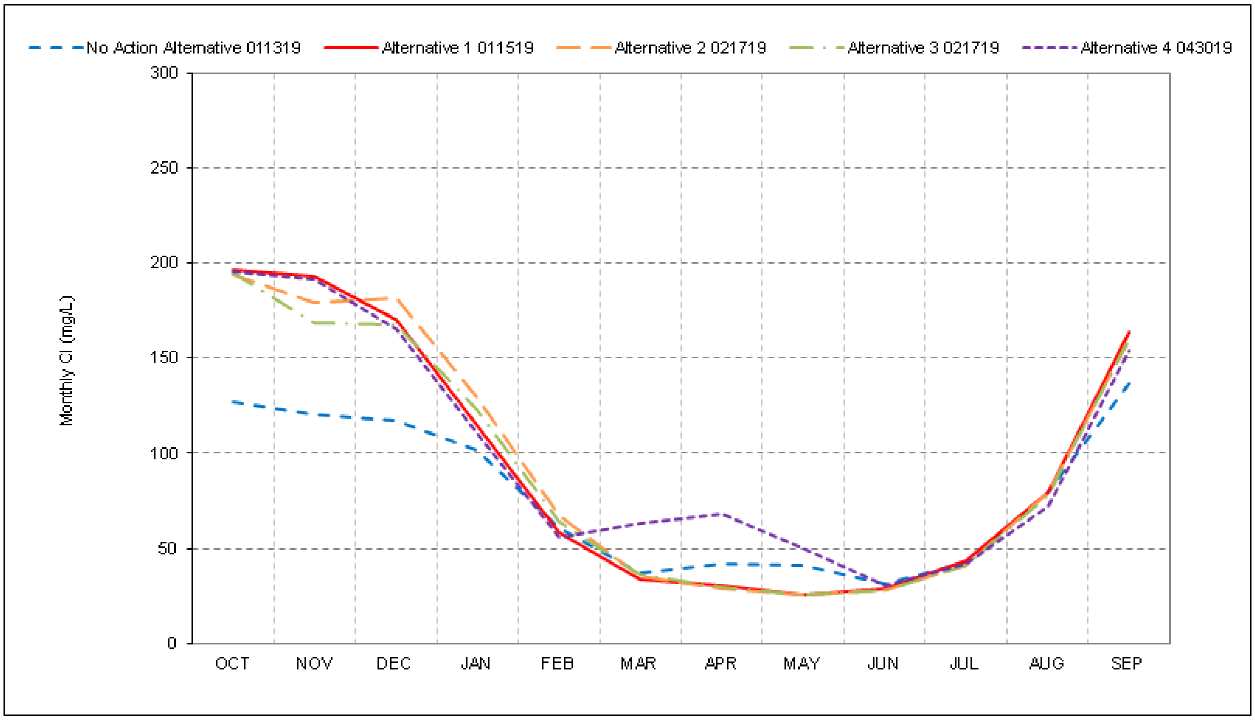


Figure 5.2-5. Long-Term Average Chloride at Contra Costa Pumping Plant #1 for Water Years 1922–2003

5.2.2 Program-Level Effects

5.2.2.1 *Bay-Delta-Specific Effects*

Program-level components would not cause water quality within the Delta, Suisun Bay and Marsh, and San Francisco Bay to be substantially different from the No Action Alternative, with the potential exception of tidal habitat and potential effects on mercury methylation. Newly created tidal habitat areas in the Delta have the potential to result in cycles of wet and dry sediment conditions suitable for the conversion of inorganic mercury to methylmercury and transport of additional methylmercury into the water column. This additional methylmercury could result in bioaccumulation in aquatic organisms residing in or near the new tidal habitat, which could, in turn, pose somewhat greater health risks to fish, wildlife, or humans. The amount of tidal habitat proposed for Alternative 1 is the same as that which would occur under the No Action Alternative. Thus, there would be no increased risk of methylmercury generation under Alternative 1. Alternatives 2 and 4 do not include tidal habitat restoration as a program-level component; therefore, there would not be an increased risk of methylmercury generation. Alternative 3 proposes more than twice as much tidal habitat restoration as under Alternative 1, which could result in a greater potential for additional generation and bioaccumulation of methylmercury and somewhat greater health risks to wildlife and humans that consume fish primarily from these new tidal habitat sites. The degree to which new tidal habitat areas may be future sources of methylmercury to the Delta is under study by others (e.g., DWR) and would depend on the specific restoration design implemented at a particular Delta location.

5.2.2.2 *Construction-Related Activities*

Construction activities necessary to implement facility improvements and habitat restoration under Alternatives 1 and 3 and the water use efficiency component under Alternative 4 could result in the direct discharge of contaminants to adjacent waterways. Construction activities could include clearing vegetation; grading, excavation, and soil placement; and in-channel work such as dredging. Construction activities would be expected to involve transporting, handling, and using a variety of hazardous substances and nonhazardous materials that may adversely affect water quality if discharged inadvertently to construction sites or directly to water bodies. While program-level activities could have short-term effects on water quality, implementation of Mitigation Measures WQ-1 through WQ-4 (listed below) would reduce or eliminate these effects.

5.2.3 Mitigation Measures

The following measures would be required during any construction activities implemented by the action alternatives to avoid or minimize effects on water quality:

- Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan
- Mitigation Measure WQ-2: Implement a Stormwater Pollution and Prevention Plan
- Mitigation Measure WQ-3: Develop a Turbidity Monitoring Program
- Mitigation Measure WQ-4: Develop a Water Quality Mitigation and Monitoring Program

5.3 Surface Water Supply

This impact assessment is based on the technical analysis documented in Appendix H, *Water Supply Technical Appendix*, which includes additional information on water supply conditions and technical analysis of the effects of each alternative. The results are based on CalSim II modeling results that simulate operations of the CVP and the SWP.

5.3.1 Project-Level Effects

Potential changes in CVP and SWP deliveries

5.3.1.1 *Sacramento, Feather, and American Rivers*

CVP and SWP contract deliveries on the Sacramento, Feather, and American Rivers and their tributaries under the No Action Alternative and action alternatives are shown in Figure 5.3-1, Sacramento River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. The alternatives would have minor changes in deliveries relative to the No Action Alternative. Alternatives 1, 2, and 3 decrease (by less than 5%) average annual deliveries to the Settlement Contractors. In addition to the Settlement Contractors, Alternative 4 would decrease (by less than 5%) deliveries to CVP M&I, CVP agricultural, and SWP M&I deliveries. The CalSim II model was used to estimate operations. The CalSim II model depicts operation of the CVP and SWP on a monthly time step and relies on assumptions and approaches that contribute to minor fluctuations of up to 5% in its simulation of real-time operations. Given this depiction, projected changes of less than 5% are considered to be “similar” to the estimated conditions for the No Action Alternative to which they are being compared and are not identified as an adverse or beneficial water supply effect. For Alternatives 1 through 3, the other contract delivery types would have either no change in deliveries from the No Action Alternative or increased deliveries, with the largest increases identified for CVP agricultural water supply ranging on average from approximately 9–10%.

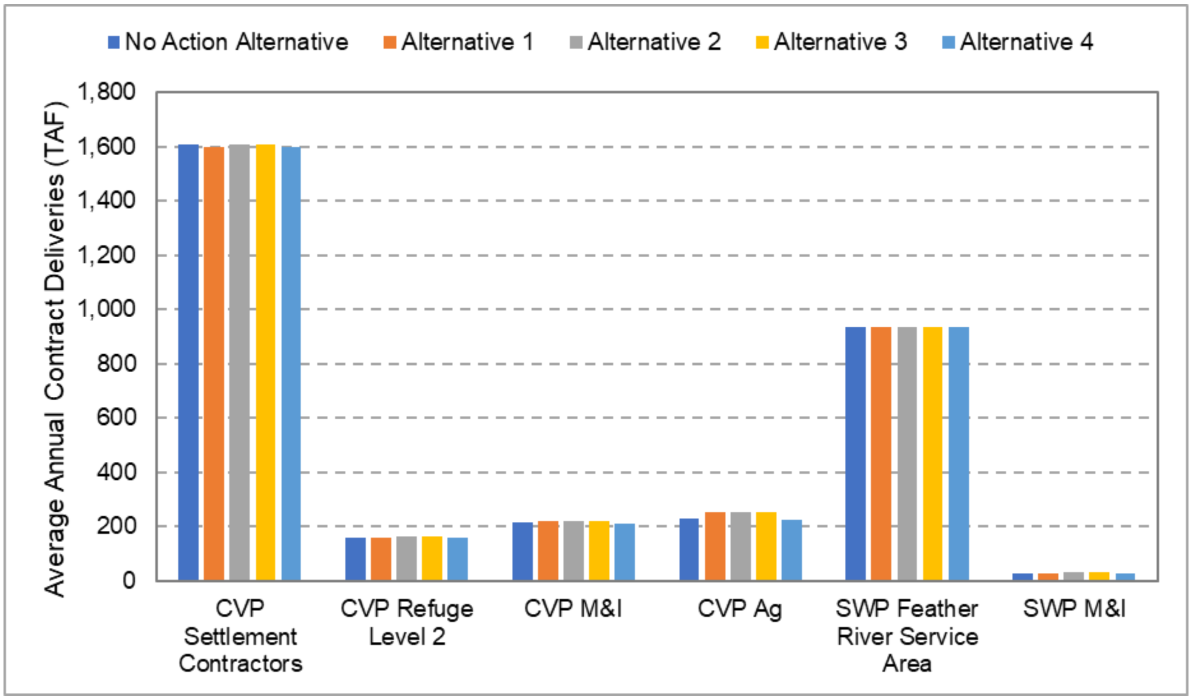


Figure 5.3-1. Sacramento River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2 *CVP and SWP Service Areas*

The sections below describe changes in water supply for different modeled regions of the CVP and SWP service areas. In addition to the modeled estimates of changes to water supply, water transfers could increase water supplies in drier year types (but they are not included in the CalSim II modeling results). Water transfers are the same in Alternatives 2, 3, and 4 as in the No Action Alternative. Alternative 1 would have a longer time period that transfers could move through the Delta pumping facilities, so this alternative would have the potential to increase water supplies a small amount compared to the other action alternatives and the No Action Alternative. The upper limits for transfer amounts would not change, but in many years, transfer quantities are limited by available capacity in the Delta. A longer transfer period would reduce this constraint.

5.3.1.2.1 San Joaquin River Hydrologic Region

CVP and SWP contract deliveries in the San Joaquin River Hydrologic Region under the No Action Alternative and action alternatives are shown in Figure 5.3-2, San Joaquin River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Compared to the No Action Alternative, Alternative 1 would reduce (by less than 5%) average annual CVP Refuge Level 2 deliveries and Alternatives 2 through 4 would generate no measurable change to these deliveries. There would be no measurable change in average annual CVP deliveries to the Exchange Contractors under the action alternatives. Similarly, there would be no measurable change in average annual CVP and SWP M&I deliveries under Alternatives 1, 2, and 3. Under Alternative 4 these CVP and SWP M&I deliveries would be reduced (by less than 5%). Average annual CVP agricultural deliveries would increase under Alternatives 1 through 3 (23%-39%) and decrease (by less than 5%) under Alternative 4. CalSim II depicts operation of the CVP and SWP on a monthly time step and relies on assumptions and approaches that contribute to minor fluctuations of up to 5% in its simulation of real-time operations. Given this depiction, projected changes of less than 5% are considered to be "similar" to the estimated conditions for the No Action Alternative to which they are being compared and are not identified as an adverse or beneficial water supply effect.

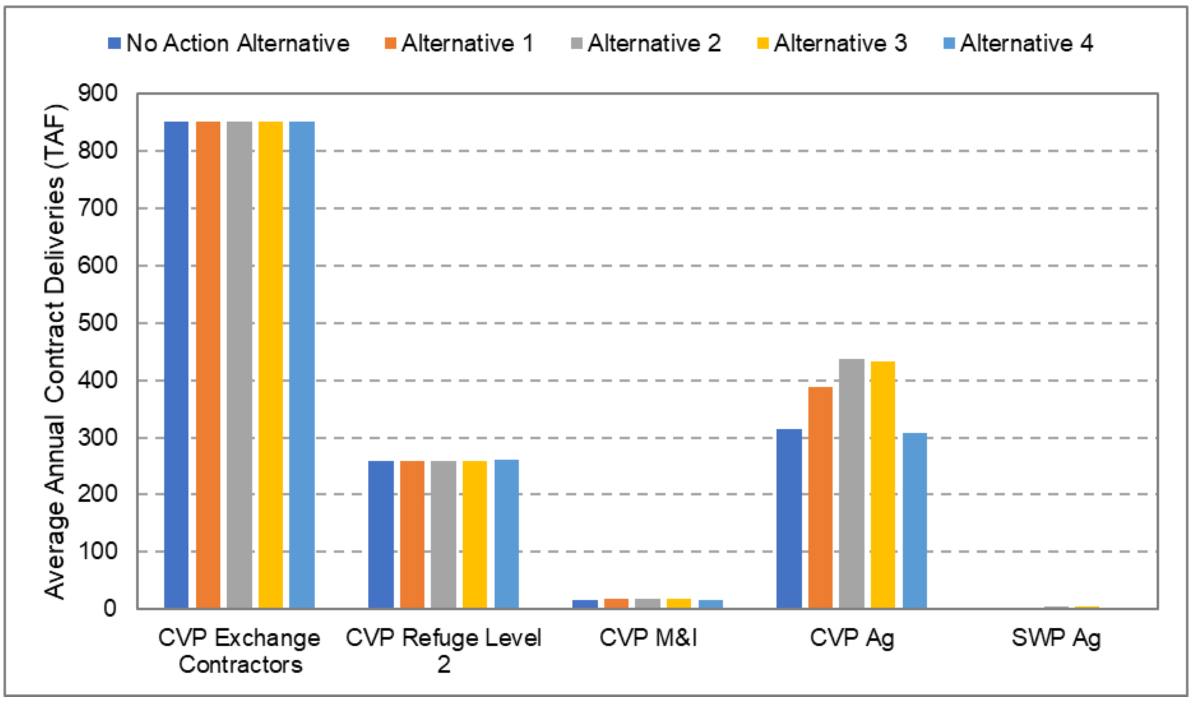


Figure 5.3-2. San Joaquin River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2.2 San Francisco Hydrologic Region

CVP and SWP contract deliveries in the San Francisco Hydrologic Region under the No Action Alternative and action alternatives are shown in Figure 5.3-3, San Francisco Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Alternatives 1 through 3 would increase average annual contract deliveries for CVP and SWP M&I water users and CVP agricultural water users. The increased deliveries have a similar magnitude for Alternatives 1, 2, and 3. Alternative 4 would reduce (by less than 5%) average annual contract deliveries to these same water users.

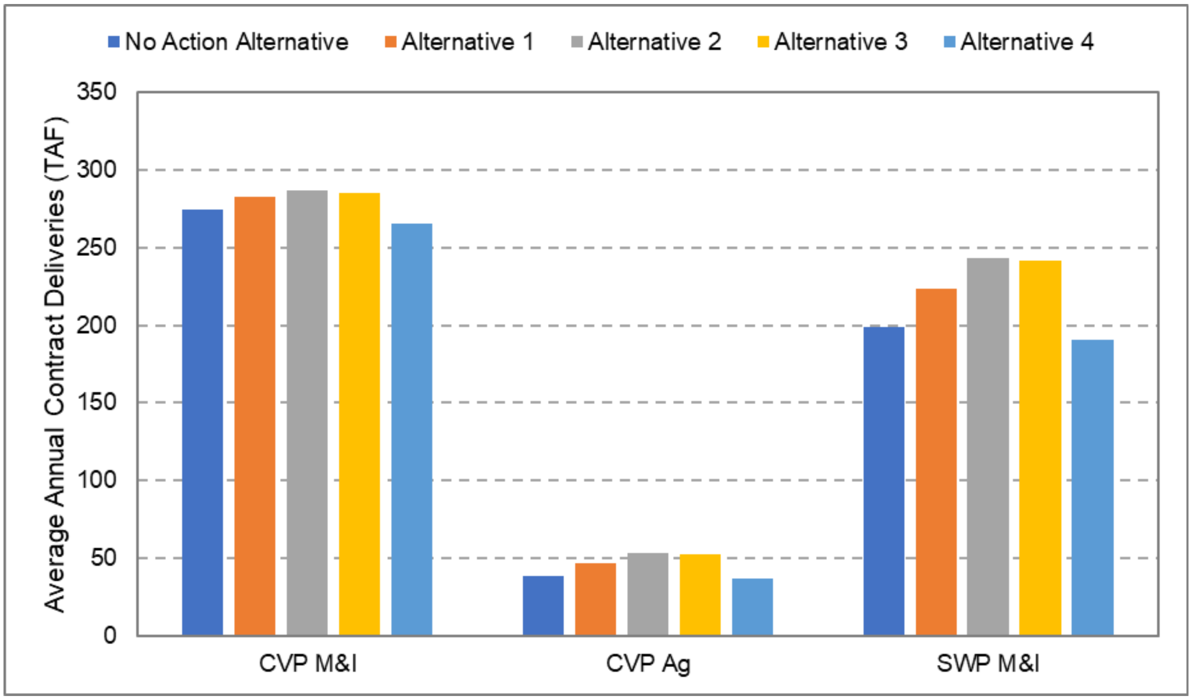


Figure 5.3-3. San Francisco Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2.3 Central Coast Hydrologic Region

SWP contract deliveries in the Central Coast Hydrologic Region under the No Action Alternative and action alternatives are shown in Figure 5.3-4, Central Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Alternatives 1 through 3 would increase average annual contract deliveries for SWP M&I water users. The changes in average annual delivery quantities would range from approximately 11–31%. Alternative 4 would reduce (by approximately 7%) average annual contract deliveries to these water users.

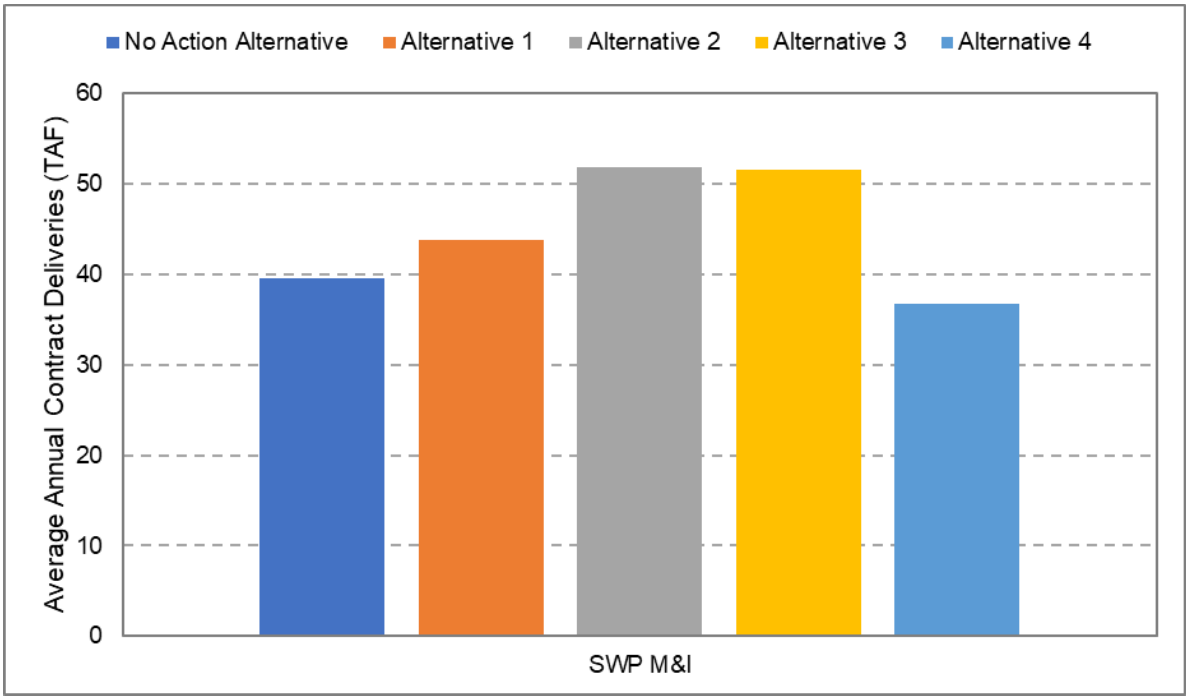


Figure 5.3-4. Central Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2.4 Tulare Lake Hydrologic Region

CVP and SWP contract deliveries in the Tulare Lake Hydrologic Region (which does not include Friant-Kern Canal or Madera Canal water users) under the No Action Alternative and action alternatives are shown in Figure 5.3-5, Tulare Lake Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Compared to the No Action Alternative, only average annual CVP Refuge Level 2 deliveries would be reduced (by less than 5%) by Alternatives 1, 2, and 3. Average annual deliveries to CVP and SWP agricultural water users and SWP M&I water users would increase under Alternatives 1 through 3, with the largest increases forecast under Alternatives 2 and 3. Alternative 4 would not measurably change CVP Refuge Level 2 deliveries but would reduce (by less than 5%) average annual contract deliveries to CVP and SWP agricultural water users and SWP M&I water users.

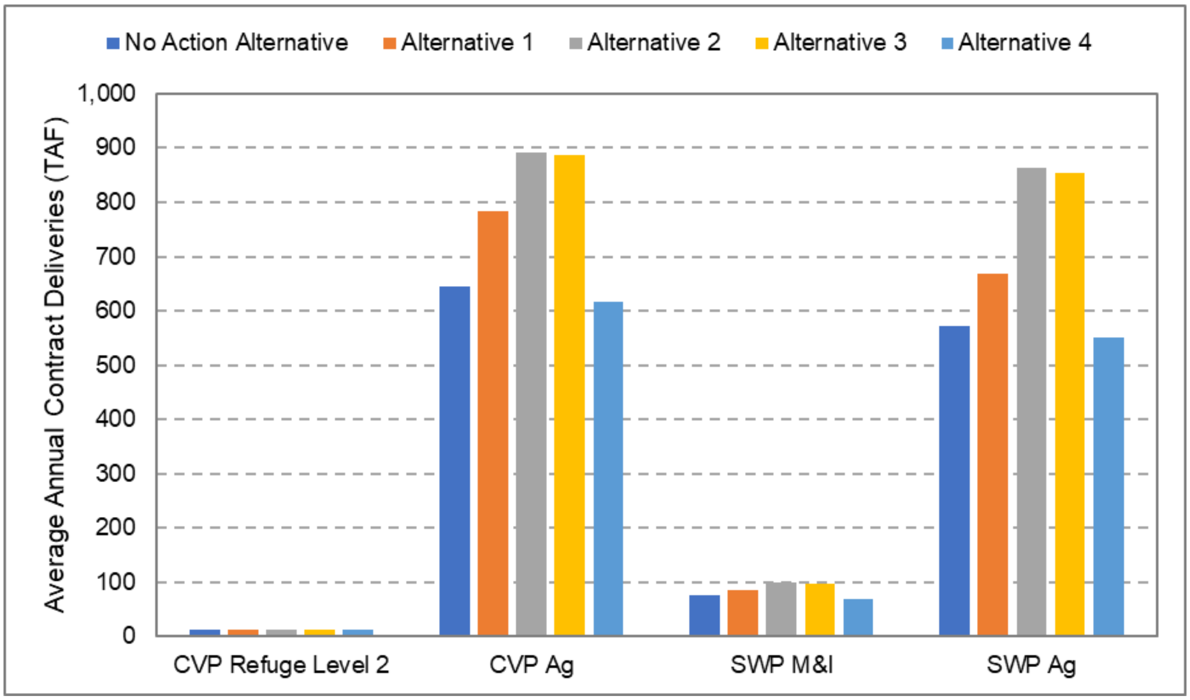


Figure 5.3-5. Tulare Lake Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2.5 South Lahontan Hydrologic Region

SWP contract deliveries in the South Lahontan Hydrologic Region under the No Action Alternative and action alternatives are shown in Figure 5.3-6, South Lahontan Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Alternatives 1 through 3 would increase average annual contract deliveries for SWP M&I water users. The changes generated by Alternatives 1 through 3 in average annual delivery quantities indicated in Figure 5.3-6 would range from approximately 14–26% relative to the No Action Alternative. Alternative 4 would reduce (by approximately 6%) average annual contract deliveries to these water users.

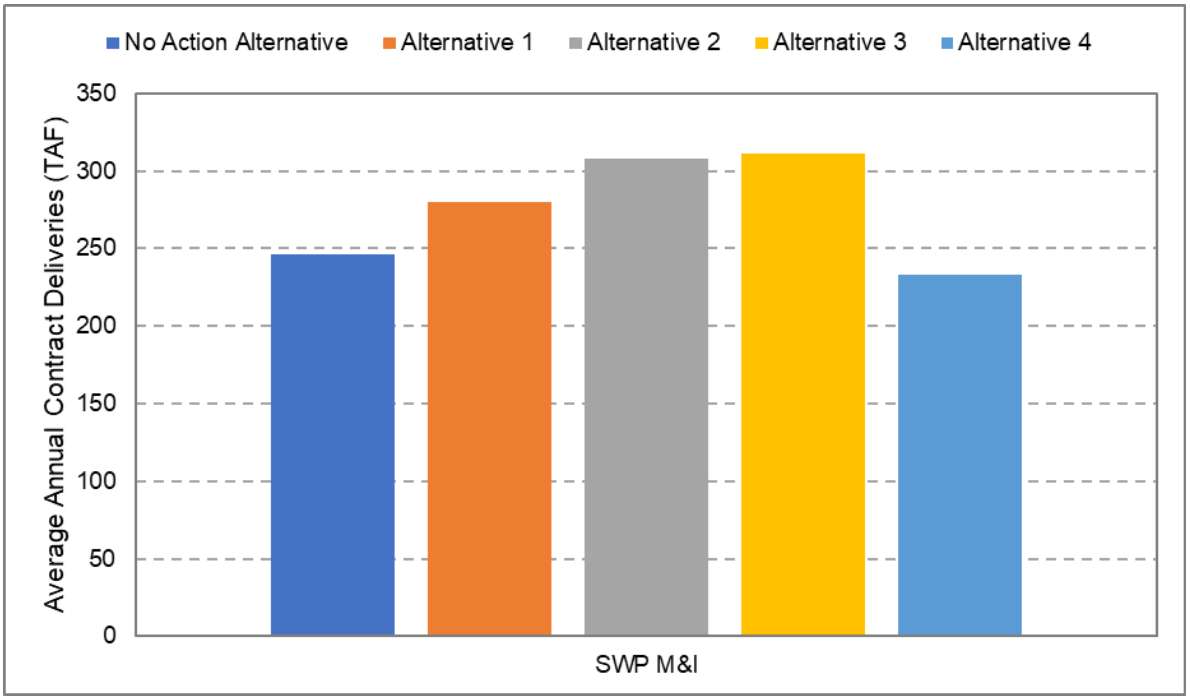


Figure 5.3-6. South Lahontan Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.1.2.6 South Coast Hydrologic Region

SWP contract deliveries in the South Coast Hydrologic Region under the No Action Alternative and action alternatives are shown in Figure 5.3-7, South Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types. Alternatives 1 through 3 would increase annual contract deliveries for SWP M&I water users and SWP agricultural water users relative to the No Action Alternative. Alternative 1 would increase deliveries to SWP M&I water users by approximately 16% relative to the No Action Alternative. Alternatives 2 and 3 would have larger increases in deliveries of 34% and 32%, respectively, compared to the No Action Alternative. Deliveries to SWP agricultural users in the South Coast region would increase by 9% under Alternative 1; 48% under Alternative 2; and a similar increase of 46% under Alternative 3 given CalSim II's depiction of operations of the CVP and SWP and the minor fluctuations in its simulation of real-time operations. Alternative 4 would reduce (by less than 5%) average annual contract deliveries to these water users.

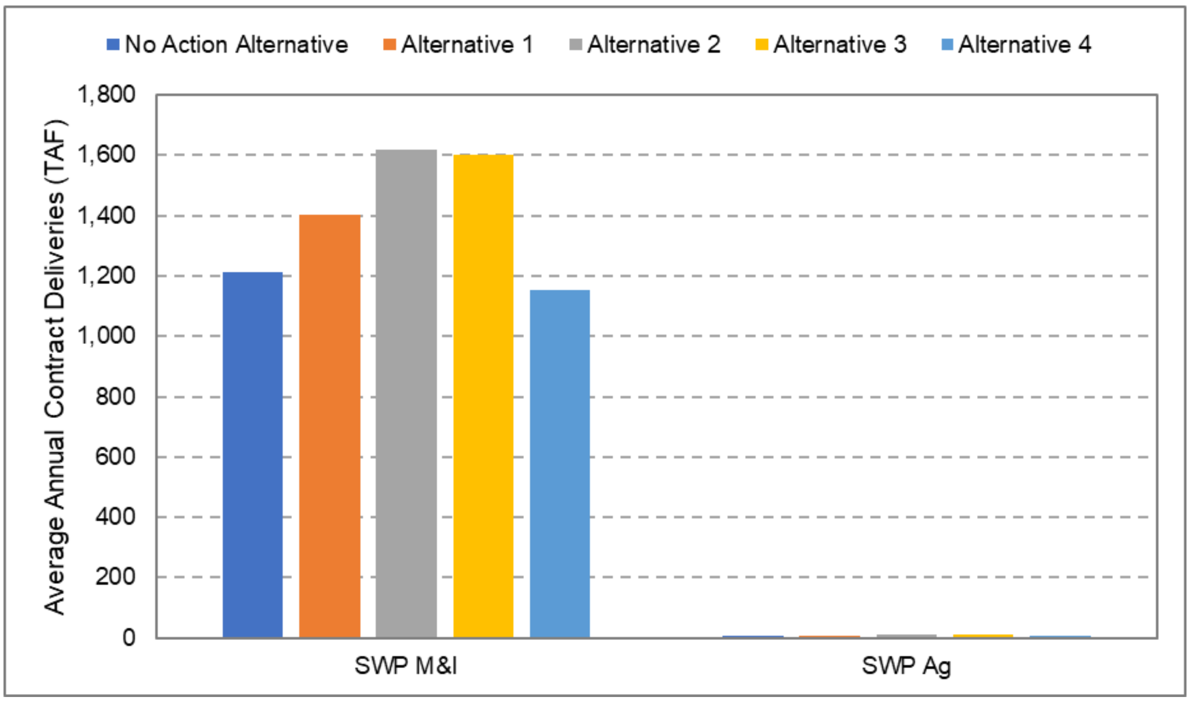


Figure 5.3-7. South Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

5.3.2 Program-Level Effects

The No Action Alternative includes the continued implementation of ongoing operations, maintenance, and protection programs by federal, state, and local agencies and nonprofit groups. Building on these activities, Alternatives 1 and 3 include habitat restoration and improvement projects, fish passage improvements, fish hatchery operation programs, and studies to identify further opportunities for habitat improvement. All these actions are evaluated in this EIS as programmatic activities. Given their collective implementation to improve habitat conditions and survival rates for the biological resources across the study area, it is expected these actions could improve conditions relative to those resources' future survival and population health. Specific to water supply, implementation of these programmatic actions would be expected to help improve conditions for the species that limit operation of the CVP and the SWP and potentially reduce restrictions on CVP and SWP operations in the future. Alternative 4 includes actions to improve water use efficiency for M&I and agricultural water users that would be expected to offset a portion of the reduction in surface water deliveries associated with the implementation of the alternative.

5.4 Groundwater Resources

This impact assessment is based on the technical analysis documented in Appendix I, *Groundwater Technical Appendix*, which includes additional information on groundwater conditions and technical analysis of the effects of each alternative. The analysis is based on results of the Central Valley Hydrologic Model (CVHM), a groundwater model that estimates changes in groundwater conditions based on changes in CVP and SWP deliveries.

5.4.1 Project-Level Effects

5.4.1.1 Central Valley Region

Potential changes in groundwater pumping and groundwater levels

Groundwater is used as a water supply source for multiple uses, including M&I and agriculture. In some areas groundwater may be the sole supply source while in other areas groundwater and surface water may combine to meet demands. Alternatives 1 through 3 are expected to deliver additional surface water supplies to areas such as the Central Valley. Surface water supplies are typically cheaper than the cost of pumping and delivering groundwater. Therefore, the additional surface water supply is expected to reduce the reliance of those areas on groundwater. Alternative 4 is on average expected to deliver less surface water. A decreased surface water supply may result in increased reliance on groundwater.

As discussed in Section 5.3, *Surface Water Supply*, CVP and SWP water deliveries under Alternatives 1 through 4 would have small changes in the Sacramento Valley. Deliveries to CVP agricultural service contractors would increase, but other deliveries would be essentially unchanged. Changes in deliveries associated with Alternatives 1 through 4 would not likely affect groundwater pumping or groundwater levels in the Sacramento Valley.

In general, the amount of groundwater pumped, especially for agriculture, is not measured and reported. With that in mind, CVHM estimates groundwater pumping as the difference between the surface demand and the amount of other water (that is, surface water) delivered to that area. The model then assumes that the balance is pumped from groundwater to meet the demand. The No Action Alternative and action alternatives were simulated in the CVHM, and the simulated groundwater pumping was queried.

Alternatives 1 through 3 resulted in a lower volume of groundwater pumped from the San Joaquin Valley than the No Action Alternative. Alternative 4 increased groundwater pumping in the San Joaquin Valley. Figure 5.4-1, Change in Groundwater Pumping Resulting from Alternatives 1 through 4 compared to the No Action Alternative shows the annual change in the volume of groundwater pumping over the entire 42-year CVHM model simulation, ranging from a decrease of over 1,000 AF to an increase of about 650 AF. The average annual change is shown in Table 5.4-1, Average Annual Change in Groundwater Pumping Compared to the No Action Alternative, with decreases in pumping ranging from 3.7–7.5% for Alternatives 1 through 3 and with an increase in pumping of 0.4% for Alternative 4, on average. One of the input data sets to the CVHM is CalSim II model output of the CVP and SWP monthly operations. The CalSim II model assumptions and approaches contribute to minor fluctuations of up to 5% in its simulation of real-time operations. As discussed in Section 5.3, Surface Water Supply, the changes in water supply due to Alternative 4 are expected to be less than 5% and considered to be "similar" to the estimated conditions for the No Action Alternative to which they are being compared. Therefore, the changes in pumping due to Alternative 4 are also likely to be similar to the No Action Alternative.

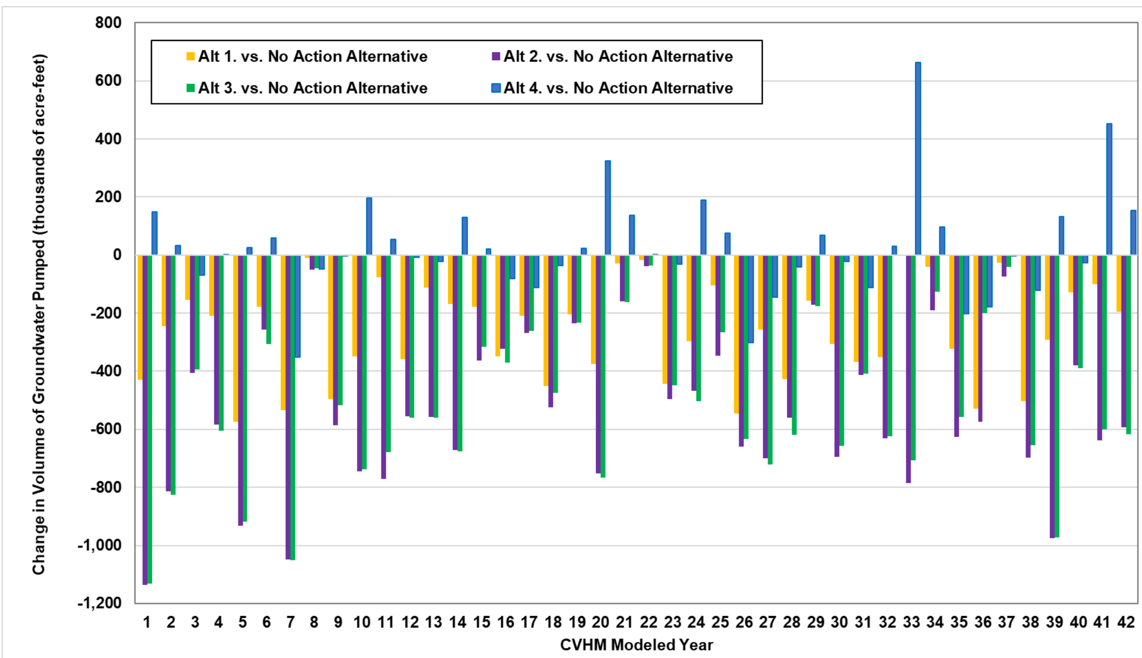


Figure 5.4-1. Change in Groundwater Pumping Resulting from Alternatives 1 through 4 Compared to the No Action Alternative

Table 5.4-1. Average Annual Change in Groundwater Pumping Compared to the No Action Alternative

Project Alternative	Average Annual Change in Groundwater Pumping Compared to the No Action Alternative (TAF)
1	-264 (-3.7%)
2	-535 (-7.5%)
3	-513 (-7.1%)
4	26 (0.4%)

TAF = thousand acre-feet

A reduction in groundwater pumping would likely cause groundwater levels to increase compared to the No Action Alternative. An increase in pumping would cause a groundwater level decrease. The location and amount of change would be tied to the amount of additional surface water supply applied to a certain area and the timing within a year and the type of hydrologic year (e.g., wet versus dry).

Figure 5.4-2, Simulated Change in Groundwater Level for all July of Below Normal Water Years, Alternative 1 versus No Action Alternative shows the simulated change in groundwater level in the Central Valley for the average July in a below normal water year, comparing Alternative 1 to the No Action Alternative. While the information in Figure 5.4-2 shows the spatial distribution of change, the figure does not show how the change in groundwater varies with time. Figure 5.4-3, Simulated Groundwater Elevation in CVHM Area 14, No Action Alternative and Alternatives 1 through 4 shows the simulated groundwater elevation in the center of CVHM area 14 (this location is identified in Figure 5.4-2). Overall, groundwater levels are higher compared to the No Action Alternative for Alternatives 1 through 3 and lower for Alternative 4. Figure 5.4-4, Simulated Change in Groundwater Level in CVHM Area 14, Alternatives 1 through 4 versus No Action Alternative, shows the change in groundwater level for each action alternative compared to the No Action Alternative. Over the course of the 42-year CVHM simulation period, the groundwater level at this location increased by an average of 34 ft in Alternative 1 compared to the No Action Alternative. The average increases for Alternatives 2 and 3 were 60 and 58 ft, respectively. The average groundwater level decreased approximately 7 ft in Alternative 4.

The effects of the 2014 Sustainable Groundwater Management Act (SGMA) legislation were not explicitly simulated as part of the action alternatives. SGMA requires that groundwater basins be operated sustainably by a Groundwater Sustainability Agency (GSA) under a Groundwater Sustainability Plan (GSP) by either January 31, 2020 (for medium- and high-priority basins with overdraft conditions) or January 31, 2022 (for medium- and high-priority basins without overdraft conditions). Basins designated as low or very low priority are not subject to SGMA. Adjudicated basins are not required to develop a GSP. Given the fact that GSPs for areas in the Central Valley have not been fully developed and adopted yet, the exact details of sustainable management under SGMA for each basin and subbasin are not yet known. Groundwater basins are not required to be sustainable until 2040 for medium and high priority basins with overdraft conditions or 2042 for medium and high priority basins without overdraft conditions, which is beyond the range of this analysis. However, there are six identified effects caused by groundwater conditions that are to be sustainable managed under a GSP: (1) chronic lowering of groundwater levels, (2) reduction in groundwater storage, (3) seawater intrusion, (4) degraded water quality, (5) land subsidence, and (6) depletion of interconnected surface water. For the development of the GSP, the GSA is required to manage the basin sustainability according to these criteria. Operation of the action alternatives will need to be incorporated in the development of the GSPs. Groundwater pumping is expected to decrease under Alternatives 1 through 3, resulting in an increase in groundwater levels. These results would aid in attempts to sustainably manage groundwater basins. Groundwater pumping in Alternative 4 is expected to increase, resulting in decreased groundwater levels. The effects of Alternative 4 would need to be incorporated into GSPs for this area.

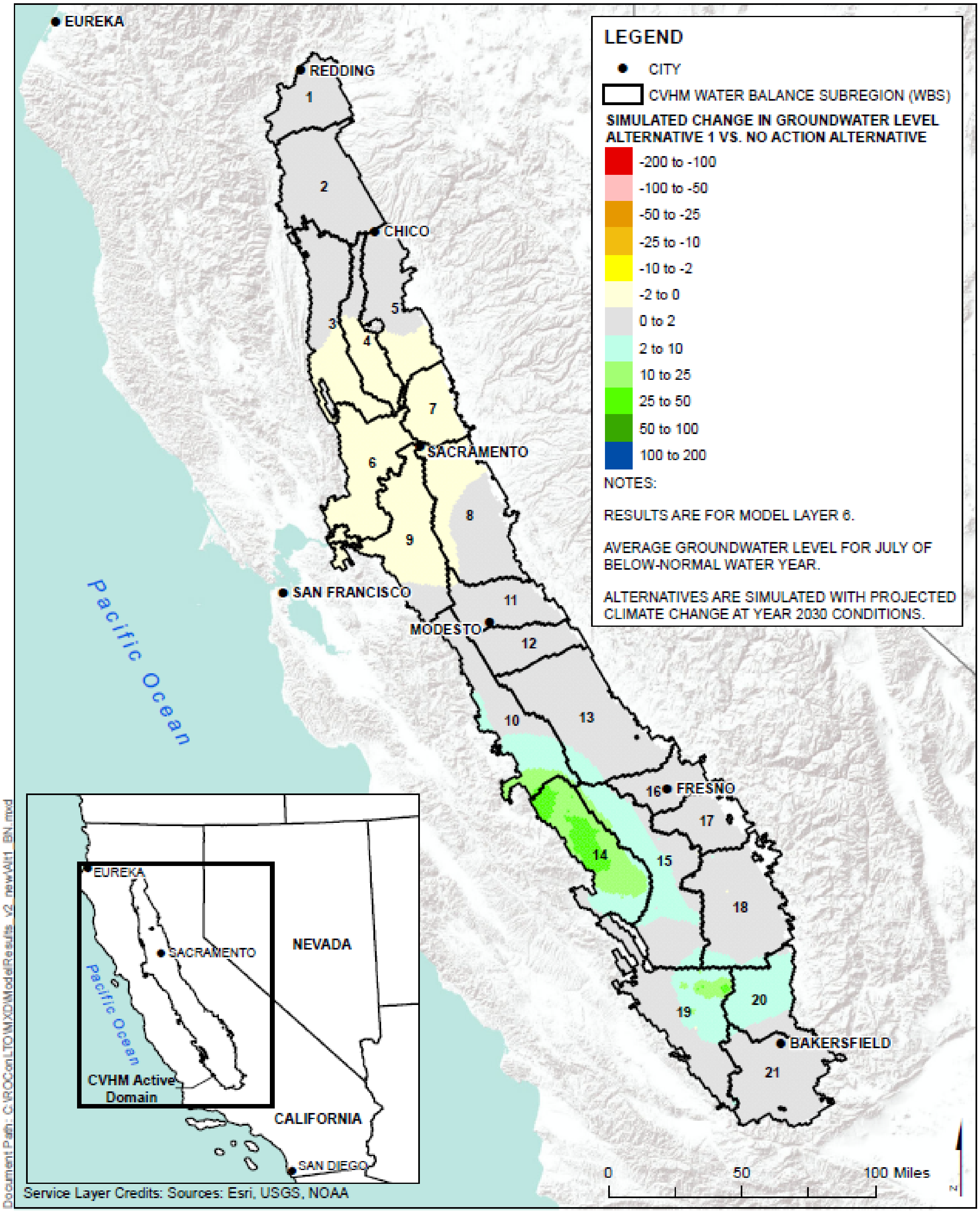


Figure 5.4-2. Simulated Change in Groundwater Level for all July of Below Normal Water Years, Alternative 1 versus No Action Alternative

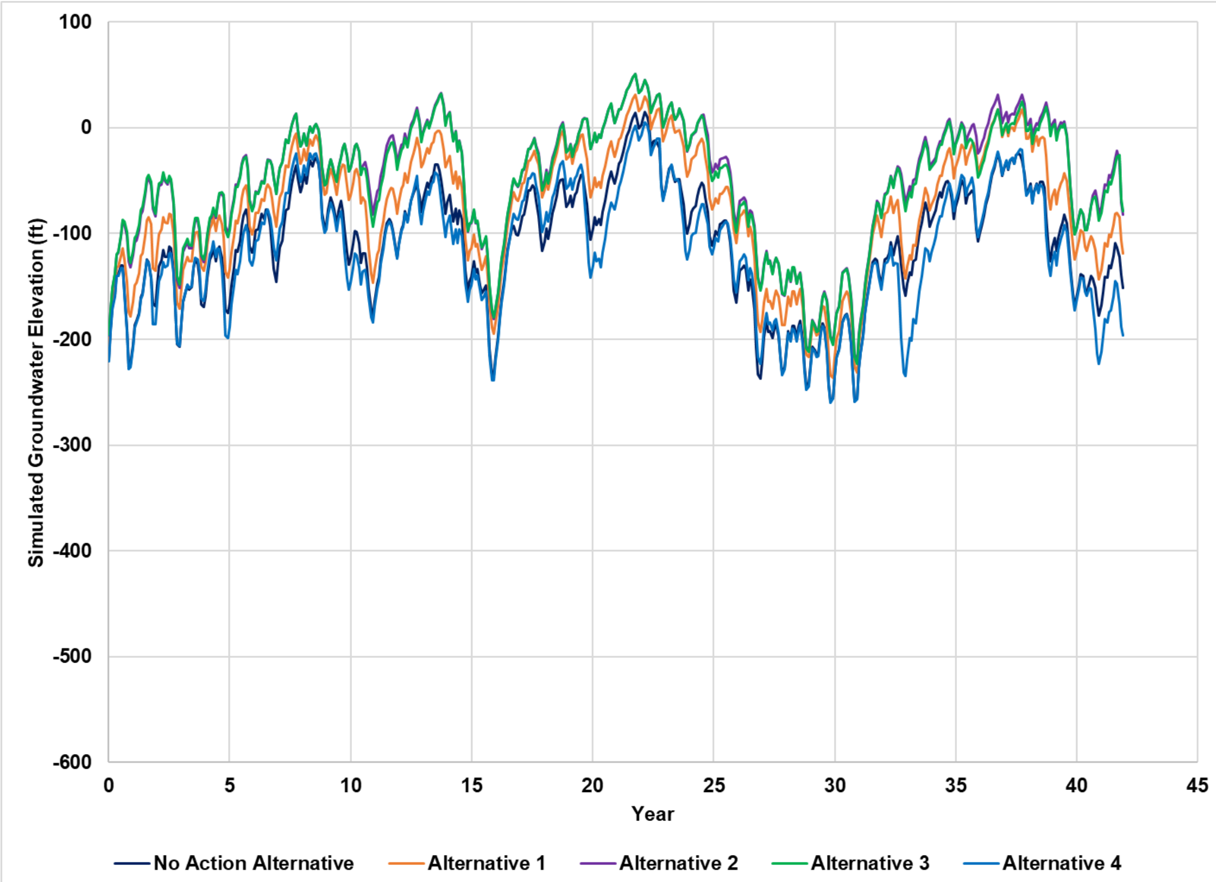


Figure 5.4-3. Simulated Groundwater Elevation in CVHM Area 14, No Action Alternative and Alternatives 1 through 4

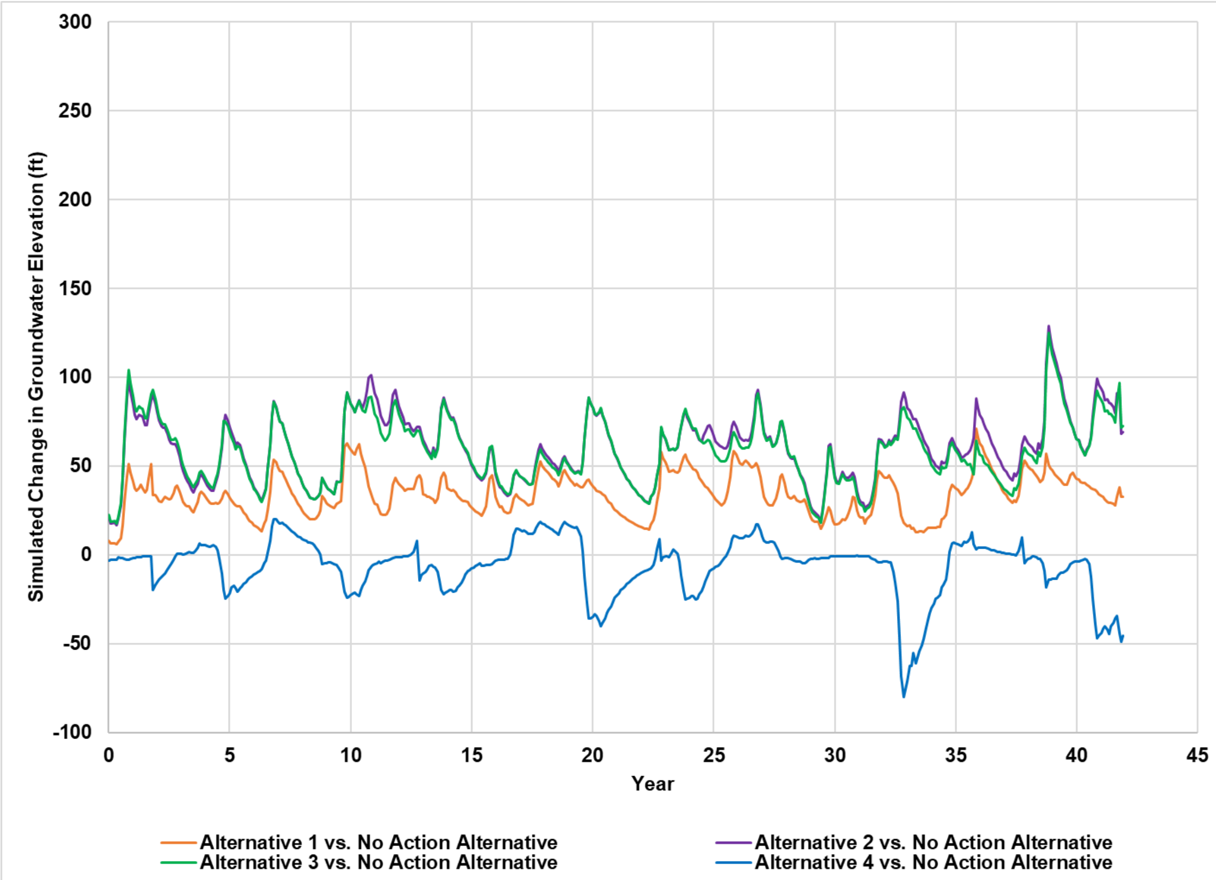


Figure 5.4-4. Simulated Change in Groundwater Level in CVHM Area 14, Alternatives 1 through 4 versus No Action Alternative

Potential changes in groundwater-surface water interaction

Surface water features such as rivers and streams are typically classified as being either "gaining" or "losing." These terms described the movement of water between the stream itself and the groundwater system under the stream. The bed of most streams is permeable and allows water to move back and forth through this material. The direction that water moves depends on the relative elevation of the water surface in the stream and the elevation of the underlying groundwater.

If the surface water elevation is higher than the groundwater elevation at the stream, water will flow from the stream into the groundwater, adding water to the groundwater system. Conversely, if the groundwater elevation surrounding the stream is higher than the surface water, groundwater will flow into the stream from the groundwater, increasing the amount of water in the stream.

Figure 5.4-5, Change in Groundwater-Surface Water Interaction Flow for Alternatives 1 through 4 Compared to the No Action Alternative shows the annual change in the groundwater-surface water interaction flow for Alternatives 1 through 4 compared to the No Action Alternative. Table 5.4-2, Average Annual Change in Groundwater-Surface Water Interaction Compared to the No Action Alternative shows the average change in the groundwater-surface water interaction flow. As noted above, average groundwater levels increase because of the action alternatives. When groundwater levels increase, there are more areas and times when the groundwater would be able to discharge from the subsurface to the surface water system (a "gaining" surface water system). The higher groundwater water levels also may reduce the amount of surface water that discharges from rivers and streams to groundwater (a "losing" surface water system).

As discussed above, the interaction between surface water and groundwater is a component of the GSPs that will be developed for this area. The average increase in discharge of groundwater to surface water will be incorporated in the GSPs that will be developed for this region under SGMA.

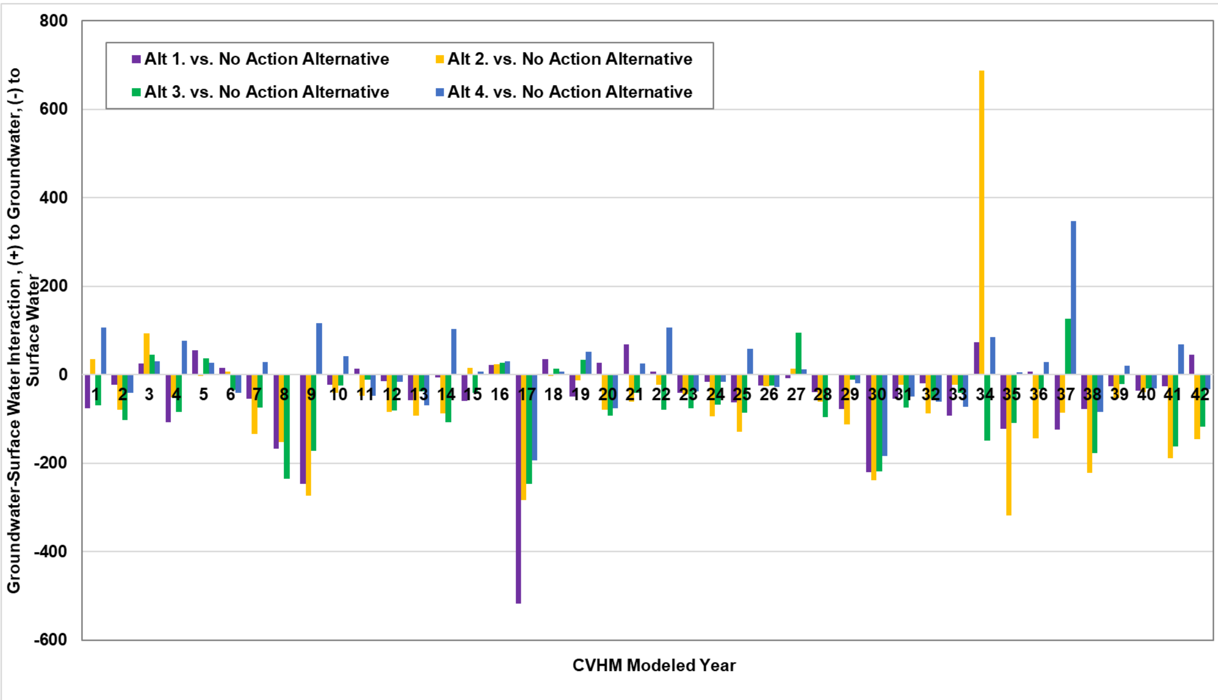


Figure 5.4-5. Change in Groundwater-Surface Water Interaction Flow for Alternatives 1 through 4 Compared to the No Action Alternative

Table 5.4-2. Average Annual Change in Groundwater-Surface Water Interaction Compared to the No Action Alternative

Alternative	Average Annual Change in Groundwater-Surface Water Interaction Compared to the No Action Alternative[1] (TAF)
Alternative 1	-50 (-10.3%)
Alternative 2	-64 (-113.2%)
Alternative 3	-65 (-13.4%)
Alternative 4	7 (1.4%)

[1] Positive is gain to groundwater; negative is gain to surface water
TAF = thousand acre-feet

Potential changes to land subsidence

Land subsidence is a process where the grains of the aquifer may rearrange and compact, making the layers of the subsurface thinner and causing the elevation of the ground surface to drop. Compaction requires the material be susceptible to compaction (typically clays). In these materials, when the water pressure within the material is reduced beyond the historical low value, the grains of the clay reorient and compact. Therefore, both appropriate material and lower water pressure, typically caused by pumping, need to exist for subsidence to occur. Areas of both the Sacramento Valley and the San Joaquin Valley have recent shown signs of land subsidence in recent years. Given that Alternatives 1 through 3 would likely increase groundwater levels and result in decreased groundwater pumping, the likelihood of subsidence resulting from the action alternatives is low. Alternative 4 has the potential to decrease groundwater levels under some conditions. In these conditions, the decreased groundwater elevations could increase the amount of land subsidence that is currently occurring in the San Joaquin Valley. Land subsidence is a component of the GSPs that will be developed and adopted as required by the SGMA. Stable or increased groundwater levels will aid in the sustainable management of each groundwater as it pertains to the subsidence component of GSPs.

5.4.1.2 *CVP and SWP Service Areas*

Potential changes in groundwater pumping and groundwater levels

Overall, surface water supplies to the CVP and SWP service areas are expected to increase. Given an increase in the supply of surface water, the amount of groundwater pumping would likely remain unchanged or decrease compared to the No Action Alternative. Groundwater levels would tend to remain stable or even rise in areas where groundwater pumping may decrease. Similar to the discussion for the Central Valley, the stable or increased groundwater levels would be incorporated in the GSPs that will be developed for this region under SGMA. These results would aid in attempts to sustainably manage groundwater basins. An increased reliance on groundwater due to a reduction in surface water supply could cause a reduction in groundwater levels. These changes would need to be part of the process of managing the groundwater sustainably under a GSP and would need to consider when the GSA develops the GSP.

Potential changes in groundwater-surface water interaction

As noted above, groundwater levels are expected to remain the same or increase under Alternatives 1 through 3 and decrease under Alternative 4 compared to the No Action Alternative. When groundwater levels increase, there are more areas and times when the groundwater would be able to discharge from the subsurface to the surface water system (a "gaining" surface water system). The higher groundwater water levels also may reduce the amount of surface water that discharges from rivers and streams to groundwater (a "losing" surface water system). As discussed above, the interaction between surface water and groundwater is a component of the GSPs that will be developed for this area. The average change in discharge of groundwater to surface water will be incorporated in the GSPs that will be developed for this region under SGMA.

Potential changes to land subsidence

Similar to the discussion for groundwater pumping and levels, the management of groundwater pumping and levels will be governed under SGMA by a GSA. The GSP that each GSA will develop will include groundwater related concerns including subsidence. Stable or increased groundwater levels will aid in the sustainable management of each groundwater as it pertains to the subsidence component of GSPs. Stable or increased groundwater levels will aid in the sustainable management of each groundwater as it pertains to the subsidence component of GSPs.

5.4.2 Program-Level Analysis

Construction-related actions analyzed at a program level would not affect groundwater resources. Short-term construction dewatering may be required in certain areas; however, groundwater resources would likely return to a preconstruction status following construction and cessation of dewatering pumping.

5.5 Indian Trust Resources

5.5.1 Project-Level Effects

Potential changes in erosion or quality of land or sites of religious or cultural importance to a federally recognized Indian tribe

Project-level components of Alternatives 1 through 4 are primarily operations based and would not involve the use of any land or sites of religious or cultural importance to Native Americans. As described in Appendix X, *Geology and Soils Technical Appendix*, no changes in peak flows are expected under Alternatives 1 and 2. Small changes (approximately 4% during the month of January) in peak flows are anticipated under Alternative 3. Therefore, stream channel erosion under Alternatives 1 and 2 would be the same as under the No Action Alternative. Stream channel erosion under Alternative 3 would not be substantial.

Increased releases and reduced water deliveries would occur in the Sacramento River, Clear Creek, Feather River, and American River under Alternative 4. No changes are expected in peak flow for the San Joaquin or Stanislaus Rivers under Alternative 4. Under Alternative 4, an almost 10% increase in outflow could occur and would result in greater levels of water moving through the Delta; however, the area miles of shoreline in the Delta are significant and the increase in outflow would likely not be sufficient enough for notable erosion to occur.

Therefore, under Alternative 4, an increase in releases from Sacramento Valley tributaries will occur, but these releases would be well within the standard bounds of operational peak flows. Delta outflow will also increase, but overall the differences are expected to result in negligible differences in the potential for increased erosion from outflow. There may be an increase in erosion under Alternative 4; however, erosion may occur primarily due to crop reduction as a result of reduced water deliveries and would not affect land or sites of religious or cultural importance.

There would not be subsequent degradation of land or sites of religious or cultural importance as a result of increases in erosion due to project-level activities.

Potential changes in quality of water utilized by a federally recognized Indian tribe

As described in Appendix G, changes in flow in the study area rivers due to changes in the operation of CVP/SWP under Alternatives 1 and 4 relative to the No Action Alternative would not result in increased frequency of exceedances of water quality standards. Changes in flow in Clear Creek and the Stanislaus River due to changes in the operation of CVP/SWP under Alternatives 2 and 3 would result in increased frequency of exceedances of water quality standards. However, there are no Indian Trust Assets (ITAs) identified in the vicinity of Clear Creek and the Stanislaus River. Therefore, there would be no degradation of water quality and subsequent effects on federally recognized tribes.

Potential changes to salmonid populations

Effects to salmonid populations, which are an important resource to ITAs, would result in an adverse effect to federally recognized Indian tribes that have fishing rights. Effects to salmonids vary in each river in the study area and are summarized by region below. For detailed analysis please refer to Appendix O:

5.5.1.1 *Trinity River*

Although the modeled maximum water temperatures in September and October under all alternatives would exceed the 55°F USEPA (2003) criteria for spawning, egg incubation, and fry emergence and could compromise salmonid reproductive success, there would be little or no potential for adverse effects relative to the No Action Alternative. While modeled maximum September temperatures under Alternatives 1–3 would exceed the No Action Alternative, little salmonid spawning occurs in September and the monthly model results may not accurately represent the daily maxima upon which the USEPA (2003) criteria are based. Spawning by Spring-Run Chinook Salmon in the Trinity River commences in late September and peaks in October, while spawning by Fall-Run Chinook Salmon commences in October and peaks in November. Trinity River Coho Salmon primarily spawn in November and December, while Steelhead and Coastal Cutthroat Trout spawn from January–April and September – April respectively.

Modeled maximum water temperatures under the action alternatives would be at or below the recommended 55°F criterion for spawning, egg incubation, and fry emergence (USEPA 2003) from December through May (Figure 5.9-4), which would provide substantial protection for these life stages of Coho Salmon, which begin spawning in November, and Steelhead and Coastal Cutthroat Trout, which begin spawning in January and September respectively. While water temperatures under the action alternatives would equal or exceed the No Action Alternative in some months during this period, no adverse effects are expected.

Modeled maximum water temperatures during November, however, would slightly exceed the 55°F criterion under Alternative 1 (55.2°F), Alternative 2 (55.1°F), and Alternative 4 (55.1°F) and would substantially exceed the criterion under Alternative 3 (59.3°F), which could compromise spawning success for Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, Coho Salmon, and Coastal Cutthroat Trout during November. The modeled water temperature exceedances under Alternatives 1, 2, and 4 are negligible relative to both the USEPA (2003) criteria and the No Action Alternative (54.8°F) and are likely much less than the uncertainty associated with model results. Consequently, no adverse effects are expected. Under Alternative 3, however, modeled maximum November water temperatures would substantially exceed both the USEPA (2003) criterion and the No Action Alternative, likely resulting in adverse effects on Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, Coho Salmon, and Coastal Cutthroat Trout. The magnitude of the November water temperature exceedance under Alternative 3 could substantially reduce spawning success and year-class recruitment, but the expected frequency of occurrence cannot be determined using available modeling data and the likelihood of population-level effects is therefore uncertain. Spawning Steelhead would not be affected by the November water temperatures, as they begin spawning in January.

5.5.1.2 *Clear Creek*

In Clear Creek below Whiskeytown Dam, CalSim II modeling results indicate that average flows in most water year types under Alternative 1 would be similar or the same as under the No Action Alternative, and average flows in all water year types under Alternatives 2 and 3 would be less than the No Action Alternative. Average flows in all water year types under Alternative 4 would be higher than under the No Action Alternative from November to May and would be similar or the same as under the No Action Alternative from June to October.

In all water year types, Alternative 1 and 4 would improve instream habitat conditions throughout the year compared to Alternative 2 and Alternative 3, but Alternative 1 would be similar to the No Action Alternative.

Modeled maximum water temperatures under Alternative 1 would be nearly identical to the No Action Alternative in most months but would be substantially less than the No Action Alternative in October, slightly less in August, and slightly greater in September. Modeled maximum water temperatures under Alternative 4 would be nearly identical to the No Action Alternative in most months but would be slightly less than the No Action Alternative in September and substantially less in October. Increases in water temperature under Alternatives 2 and 3 relative to the No Action Alternative and the NMFS (2009) criteria could compromise Spring-Run Chinook Salmon holding and rearing success and potentially lead to increased incidence of disease and physiological stress in holding adults and reduced survival of rearing juveniles, reduced juvenile production, and reduced spawning success of adults. These effects would be most likely to occur in June to August, when water temperatures are predicted to be highest.

5.5.1.3 *Sacramento River*

Changes in summer/fall water temperature management operations under Alternative 1, especially with respect to the Shasta temperature control device (TCD), are expected to improve temperature and dissolved oxygen conditions experienced by incubating Winter-Run Chinook Salmon eggs and alevins.

Alternatives 2 and 3 would likely not result in reduced temperature-related mortality of Winter-Run Chinook Salmon eggs and alevins relative to the No Action Alternative because these action alternatives protect no better than the No Action Alternative against a depleted coldwater pool (Appendix O, Figure SR-1). In contrast, Alternative 4 is expected to provide a similar level of protection to Alternative 1 (Appendix O, Figures SR-1 and SR-2).

The proposed improved TCD under Alternative 1, as well as Rice Decomposition Smoothing, Spring Management of Spawning Locations, Battle Creek Restoration, and Intake Lowering near Wilkins Slough, would further facilitate increased coldwater storage, resulting in greater protection of the Winter-Run and Spring-Run Chinook Salmon population.

5.5.1.4 *Feather River*

Average flows under Alternatives 1-3 are slightly greater than under the No Action Alternative from December to March, so the effects on eggs and rearing juveniles would be negligible and potentially beneficial because of the increased availability of habitat for these life stages. Increased flows under the action alternatives from May to June, during Spring-Run Chinook Salmon migration and holding, would provide potential temperature and fish passage benefits.

Modeled maximum water temperatures under the action alternatives and the No Action Alternative would exceed the recommended 55°F criterion for spawning, egg incubation, and rearing (USEPA 2003) from September to November, a period of Spring-Run Chinook Salmon egg incubation and juvenile rearing, which could reduce survival of these life stages.

Overall, simulated flows under the Alternative 4 and No Action Alternative scenarios are similar, but flows under the No Action Alternative are higher in September of wet and above normal years, and flows under Alternative 4 are higher in April and May of wet water years, from March through June of above normal water years, from January through May of below normal and dry water years, and in June of critically dry water years

Winter-Run Chinook are not likely to be affected by changes in flow under Alternative 4 compared to the No Action Alternative due to their limited distribution in the Feather River. Flow-related actions under Alternative 4 would have beneficial effects on Spring-Run Chinook Salmon and Fall-Run Chinook Salmon.

5.5.1.5 *Stanislaus River*

Alternative 1 and 4 flows would be slightly reduced but generally similar to the No Action Alternative. Flows under Alternatives 2 and 3 are the same and would be substantially reduced below Goodwin Dam from February through September, and at the mouth of the Stanislaus River from March through May compared to the No Action Alternative. Reduced flows under Alternatives 2 and 3 would likely result in reductions to suitable habitat area for juvenile salmonids.

Compared to the No Action Alternative, Alternatives 1 through 4 increase the annual storage and, therefore, the size of the coldwater pool in New Melones Reservoir, with the largest storage quantities occurring under Alternatives 2 and 3. Temperature modeling for the Stanislaus River at Ripon shows that there is a small increase in overall annual water temperature for Alternatives 1 through 4 relative to the No Action Alternative. Reduced flows in above normal water years and normal water years may increase water temperatures in these less critical hydrologic conditions, however, this promotes additional storage at New Melones Dam for potential future droughts and preserves the coldwater pool to benefit downstream salmonids.

Under Alternative 1, the proposed dissolved oxygen compliance point is protective of salmonids because the majority of salmonid eggs, alevin, and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L, although it reduces the area of suitable dissolved oxygen as compared to the No Action Alternative. However, based on the typical seasonal occurrence of the adult life stages in the river (July to October), adult migrating salmonids would potentially be exposed to the effects of relaxing dissolved oxygen requirements at Ripon.

5.5.1.6 *San Joaquin River*

Analyses of flow for Alternatives 1 through 4 compared to the No Action Alternative show that releases in the San Joaquin River below Millerton Reservoir would remain the same for all scenarios. Therefore, no change to salmonid populations is anticipated as a result in the upper San Joaquin River.

5.5.1.7 *Bay-Delta*

Under Alternatives 1, 2, and 3, CVP and SWP exports increase during the migration window for juvenile Winter-Run, Spring-Run, and Fall-Run Chinook Salmon as compared to the No Action Alternative whereas exports under Alternative 4 for are similar to the No Action Alternative. Salvage and loss of juvenile Winter-Run, Spring-Run, and Fall-Run Chinook have been shown to increase as exports increase. However, only a small proportion of the total population is lost at the export facilities. Increased flow in the Sacramento River mainstem would occur under all action alternatives, and higher flow has been shown to increase through-Delta survival of juvenile Chinook Salmon and reduce routing into the interior Delta at Georgiana Slough. The Sacramento River mainstem is the primary migration route for juvenile Winter-Run, Spring-Run, and Fall-Run Chinook Salmon, thus a much greater proportion of the population would be exposed to the positive effects of greater Sacramento River flows than would be exposed to the negative effects of increased exports. Under all action alternatives flows in the Sacramento River would be greater during the Winter-Run migration period which would increase survival and reduce routing into the interior Delta at Georgiana Slough (Perry et al 2015). San Joaquin River-origin juvenile Spring-Run Chinook Salmon are likely to be entrained at the salvage facilities at higher rates under Alternatives 1-3 and similar under Alternative 4 as compared to the No Action Alternative. San Joaquin River-origin juvenile Fall-Run Chinook Salmon are likely to be entrained at the salvage facilities at higher rates under all action alternatives as compared to the No Action Alternative.

5.5.2 Program-Level Effects

Potential changes in erosion or quality of land or sites of religious or cultural importance to federally recognized Indian tribe

As described in Appendix X, no changes in peak flows are expected as a result of program-level actions for Alternatives 1, 3, and 4. Therefore, stream channel erosion under Alternatives 1, 3, and 4 would be the same as under the No Action Alternative. Proposed restoration components have the potential to be implemented on land or sites of religious or cultural importance. The magnitude of effect would depend upon the size, location, and type of restoration implemented at the land or site and will be examined and evaluated in subsequent analyses. Alternative 3 has the greatest potential to affect ITAs as a result of habitat restoration of 25,000. There are no program-level components proposed for Alternative 2.

Potential changes in quality of water utilized by a federally recognized Indian tribe

As described in Appendix G, program-level actions and construction activities under Alternatives 1, 3, and 4 could have water quality implications. These include increased turbidity, mercury and selenium bioaccumulation, dissolved organic carbon, and increased sedimentation. However, adverse effects on water quality and violations to water quality standards are not expected from the Alternatives 1, 3 and 4 program-level activities. There are no program-level components proposed for Alternative 2

Potential to change salmonid populations.

Alternative 4 proposes to implement program-level water use efficiency measures that would improve agricultural and municipal and industrial water use efficiency. Implementation of these measures could reduce reliance upon water supply deliveries, which would reduce need for exports and provide more water for salmonids in the rivers that supply water to the CVP and SWP. This benefit is as yet undefined, however, and would be quantified in subsequent analysis. It is not anticipated that there would be any construction-related effects to salmonids as a result of implementation of Alternative 4. There are no program-level components proposed for Alternative 2

5.5.3 Mitigation Measures

Implementation of habitat restoration in the study area under Alternative 1 and Alternative 3 could affect ITAs, which are not identifiable at this time in the programmatic action phase. Tidal habitat design and location considerations could minimize effects on ITAs. The following mitigation measures have been identified as potential measures to avoid and minimize potential effects on ITAs:

- Mitigation Measure ITA-1: Consult with Tribal Entities Consistent with Secretarial Order 3175
- Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan
- Mitigation Measure WQ-2: Implement a Stormwater Pollution and Prevention Plan
- Mitigation Measure WQ-3: Develop a Turbidity Monitoring Program
- Mitigation Measure WQ-4: Develop a Water Quality Mitigation and Monitoring Program

5.6 Air Quality

5.6.1 Project-Level Effects

Potential changes in emissions from fossil-fueled powerplants

The action alternatives would change operations of the CVP and SWP, which could change river flows and reservoir levels. These changes could affect the amount hydroelectric generation at the CVP and SWP facilities. As discussed in Appendix U, *Power and Energy Technical Appendix*, Alternatives 1, 2, and 3 would increase both power generation and energy use for the CVP compared to the No Action Alternative. In contrast, Alternative 4 would decrease both power generation and energy use for the CVP compared to the No Action Alternative.

Under all of the action alternatives, the CVP would generate more power than it uses. For the SWP, Alternatives 1, 2, and 3 would also increase both power generation and energy use compared to the No Action Alternative, whereas Alternative 4 would decrease both power generation and energy use. Under all of the action alternatives, the SWP would use more power than it produces. Under Alternatives 1, 2, and 3, although the CVP by itself would produce more power than it uses, the CVP and SWP combined would use more power than they produce. The SWP would purchase power from the regional electric system (the grid) to meet demand for power. To the extent that the additional purchased power would be generated by fossil-fueled powerplants, emissions from these plants would increase. Under Alternative 4, the CVP and SWP combined would produce more power than they use. To the extent that the power sold to the grid would have been generated by fossil-fueled powerplants, emissions from these plants would decrease. Although the specific power purchases and sales that the CVP and SVP may make in the future are not known, approximately 50% of the grid electricity in California was generated by fossil-fueled plants in 2016 (USEPA 2018). Air quality effects associated with changes in hydropower generation, and consequently in grid power, were evaluated on a project-wide basis in terms of air pollutant emissions from fossil-fueled powerplants. For the details of the power modeling on which the air quality analysis was based, see Appendix U, Attachment 1. For the details of the air quality analysis see Appendix L, *Air Quality Technical Appendix*. Table 5.6-1, Emissions Associated with Grid Energy Generation, presents the estimated emissions associated with grid power generation for an average year. Figure 5.6-1, Emissions from Grid Power Generation, and Figure 5.6-2, Emissions from Grid Power Generation Compared to the No Action Alternative, show the emissions of each pollutant and the changes compared to the No Action Alternative for grid power generation, respectively. Table 5.6-1 and Figure 5.6-1 show that emissions of all pollutants would be greatest under Alternative 2, less under Alternative 3, followed by Alternative 1 and the No Action Alternative, and least under Alternative 4. Figure 5.6-2 shows that the emissions increase under the action alternatives compared to the No Action Alternative would be greatest for all pollutants under Alternative 2, less under Alternative 3, and least for Alternative 1. In contrast, emissions would decrease under Alternative 4 compared to the No Action Alternative.

Table 5.6-1. Emissions Associated with Grid Energy Generation

	Emissions (U.S. tons per average year)[1, 2]				
Pollutant	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
CO	-41	345	749	724	-158
NO_x	-23	192	418	405	-88
PM_{10}	-8.1	69	149	144	-31
$PM_{2.5}$	-7.3	62	134	130	-28
ROG	-3.5	30	65	63	-14
SO_2	-1.8	15	33	32	-6.9

[1] Additional information on calculations is provided in Appendix L.

[2] Values represent the emissions effects of net generation, that is, CVP/SWP hydropower generation minus CVP/SVP energy use. Emissions of zero would indicate that CVP/SWP hydropower generation exactly equals CVP/SWP energy use. Negative emission values indicate decreases in emissions because net generation is positive and displaces grid power; positive emission values indicate increases in emissions because net generation is negative and CVP/SWP purchases the needed power from the grid.

Alt = alternative
CO = carbon monoxide
NO_x = nitrogen oxides
PM_{10} = particulate matter of 10 microns diameter and smaller
$PM_{2.5}$ = particulate matter of 2.5 microns diameter and smaller
ROG = reactive organic gas
SO_2 = sulfur dioxide

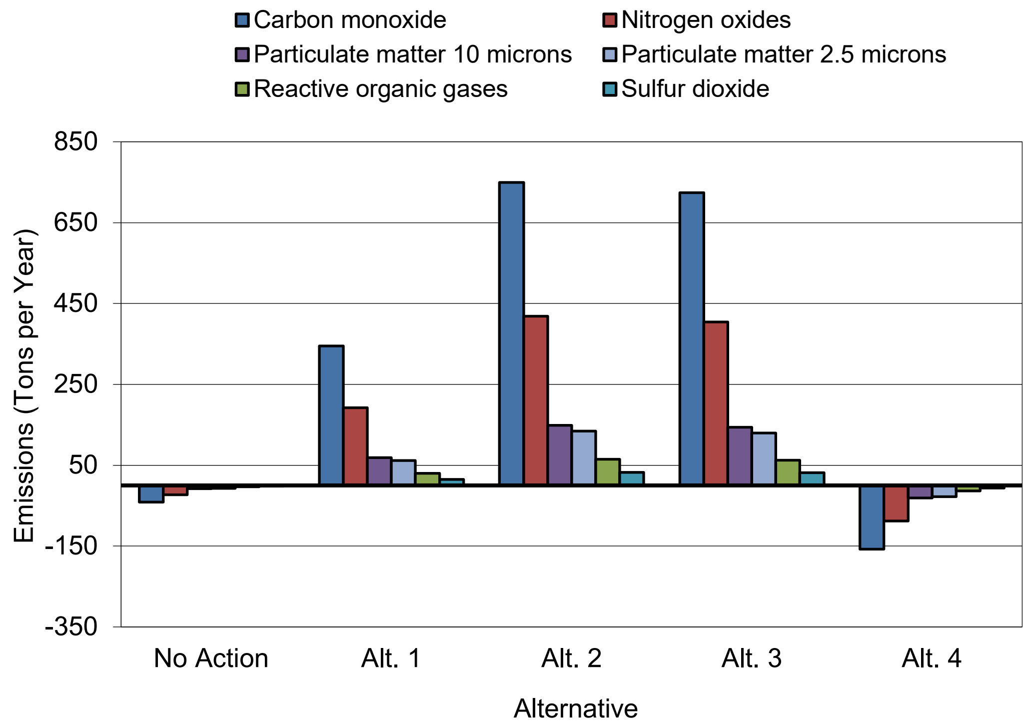


Figure 5.6-1. Emissions from Grid Power Generation

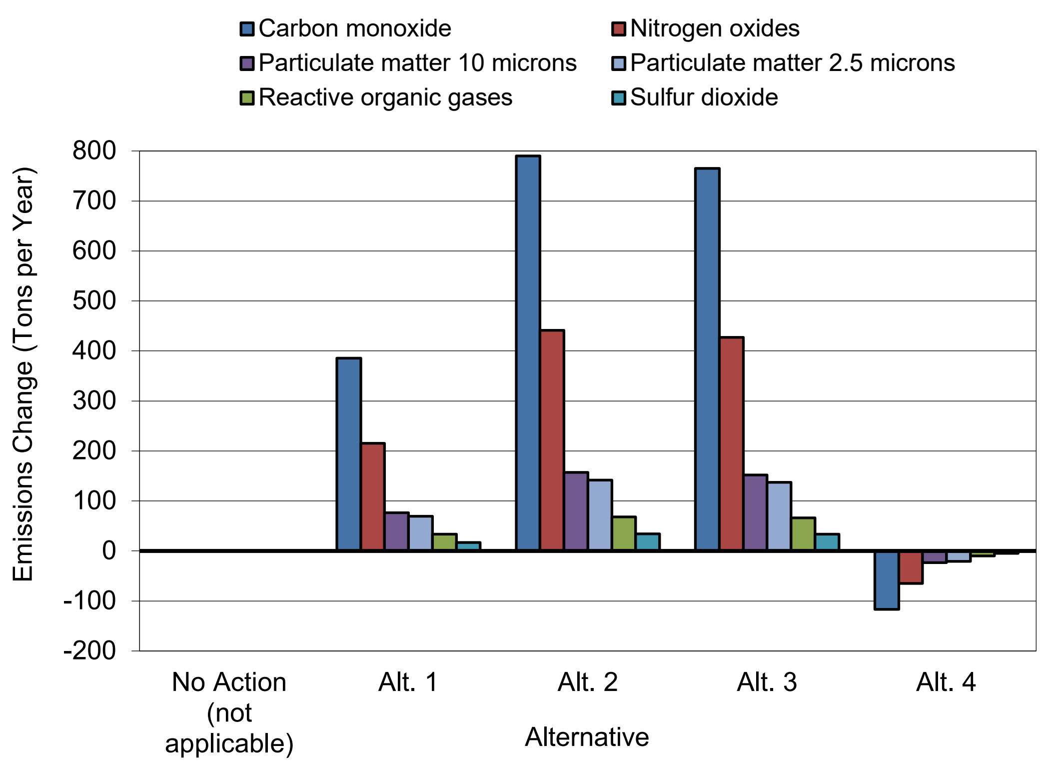


Figure 5.6-2. Emissions from Grid Power Generation Compared to the No Action Alternative

Potential changes in emissions from fossil-fueled powerplants (groundwater pumping)

Alternatives 1, 2, and 3 would increase CVP and SWP deliveries to water users and decrease groundwater pumping compared to the No Action Alternative. Most groundwater pumps are electric, so decreased pumping would decrease the demand for grid power. To the extent that the decreased grid power would have been generated by fossil-fueled powerplants, emissions from these plants would decrease. In contrast, Alternative 4 would decrease CVP and SWP deliveries to water users and increase groundwater pumping compared to the No Action Alternative. Increased groundwater pumping would increase the demand for grid power and associated emissions. Although the specific power purchases that water users may make in the future are not known, approximately 50% of the grid electricity in California was generated by fossil-fueled plants in 2016 (USEPA 2018). A small proportion of groundwater pumps is powered by engines that predominantly are diesel-fueled, so decreased use of these pumps would decrease diesel exhaust emissions, and increased use would increase diesel exhaust emissions.

Air quality effects resulting from changes in groundwater pumping were evaluated on a project-wide basis in terms of air pollutant emissions from the fossil-fueled powerplants (for electrically-powered pumps) and emissions from diesel engines (for engine-powered pumps). For the details of the groundwater modeling on which the air quality analysis was based, see Appendix I. For the details of the air quality analysis see Appendix L. Table 5.6-2, Emissions Associated with Groundwater Pumping, presents the estimated emissions associated with groundwater pumping for an average year. Figures 5.6-3, Emissions from Groundwater Pumping, and 5.6-4, Changes in Emissions from Groundwater Pumping Compared to the No Action Alternative, show the emissions of each pollutant and the changes compared to the No Action Alternative for groundwater pumping, respectively. Table 5.6-2 and Figure 5.6-3 show that emissions of all pollutants would be least under Alternative 2, greater under Alternative 3, followed by Alternative 1, the No Action Alternative, and greatest under Alternative 4. Figure 5.6-4 shows that the emissions decrease under the action alternatives compared to the No Action Alternative would be greatest for all pollutants under Alternative 2, less under Alternative 3, and least for Alternative 1. In contrast, emissions would increase under Alternative 4 compared to the No Action Alternative.

Table 5.6-2. Emissions Associated with Groundwater Pumping

	Emissions (U.S. tons per average year)[1]				
Pollutant	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
CO	6,493	6,252	6,005	6,025	6,517
NO_x	5,608	5,400	5,187	5,203	5,629
PM_{10}	700	674	647	650	703
$PM_{2.5}$	658	633	608	610	660
ROG	726	699	672	674	729
SO_2	101	97	93	94	101

Source: Appendix L.

[1] Values represent the sum of emissions from fossil-fueled powerplants (for electrically-powered pumps) and emissions from diesel engines (for engine-powered pumps).

Alt = alternative

CO = carbon monoxide

NO_x = nitrogen oxides

PM_{10} = particulate matter of 10 microns diameter and smaller

$PM_{2.5}$ = particulate matter of 2.5 microns diameter and smaller

ROG = reactive organic gas

SO_2 = sulfur dioxide

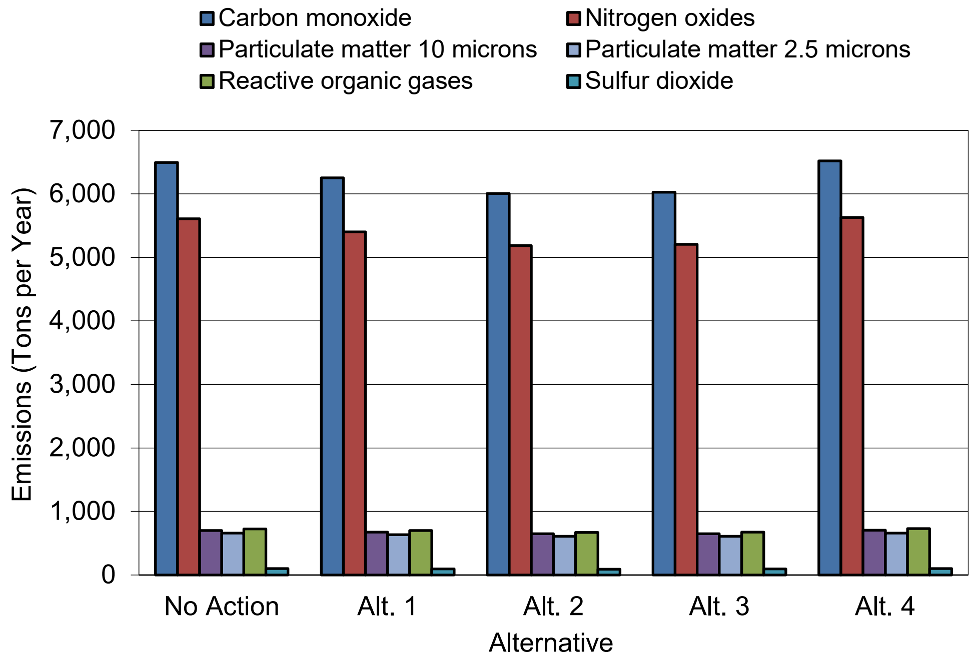


Figure 5.6-3. Emissions from Groundwater Pumping

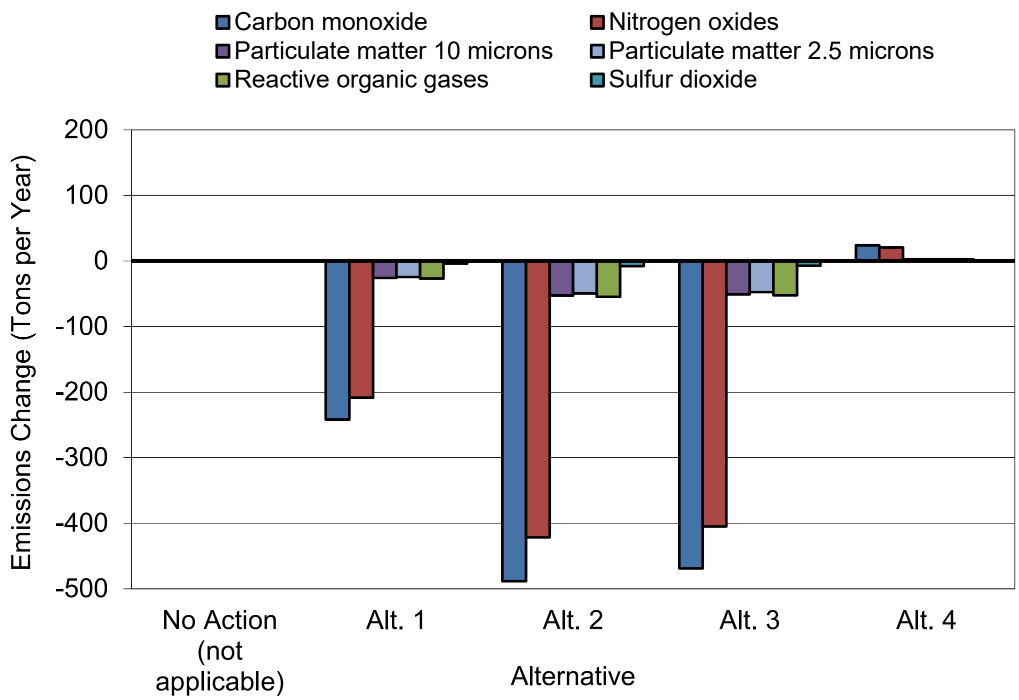


Figure 5.6-4. Changes in Emissions from Groundwater Pumping Compared to the No Action Alternative

The overall impact of the action alternatives on emissions is the sum of the changes associated with grid power generation and the changes associated with groundwater pumping. Table 5.6-3, Emissions from All Sources Associated with the Action Alternatives, presents the estimated overall emissions associated with project actions for an average year. Table 5.6-3 and Figure 5.6-5, Emissions from All Sources, show that emissions of all pollutants would be greatest under Alternative 2, less under Alternative 3, followed by Alternative 1, the No Action Alternative, and least under Alternative 4. Figure 5.6-6, Changes in Emissions from All Sources Compared to the No Action Alternative, shows that the emissions increases under the action alternatives compared to the No Action Alternative would be greatest for all pollutants under Alternative 2, less under Alternative 3, and least for Alternative 1. In contrast, emissions would decrease under Alternative 4 compared to the No Action Alternative.

Table 5.6-3. Emissions from All Sources Associated with the Action Alternatives

	Emissions (U.S. tons per average year)[1]				
Pollutant	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
CO	6,452	6,597	6,754	6,749	6,360
NO_x	5,585	5,592	5,605	5,608	5,541
PM_{10}	692	743	796	794	671
$PM_{2.5}$	650	695	743	740	632
ROG	723	729	736	736	715
SO_2	99	112	126	125	94

Source: Appendix L.

[1] Values represent the sum of emissions from fossil-fueled powerplants (for CVP/SWP purchases of grid power and for electrically-powered groundwater pumps) and emissions from diesel engines (for engine-powered groundwater pumps).

Alt = alternative
CO = carbon monoxide
NO_x = nitrogen oxides
PM_{10} = particulate matter of 10 microns diameter and smaller
$PM_{2.5}$ = particulate matter of 2.5 microns diameter and smaller
ROG = reactive organic gas
SO_2 = sulfur dioxide

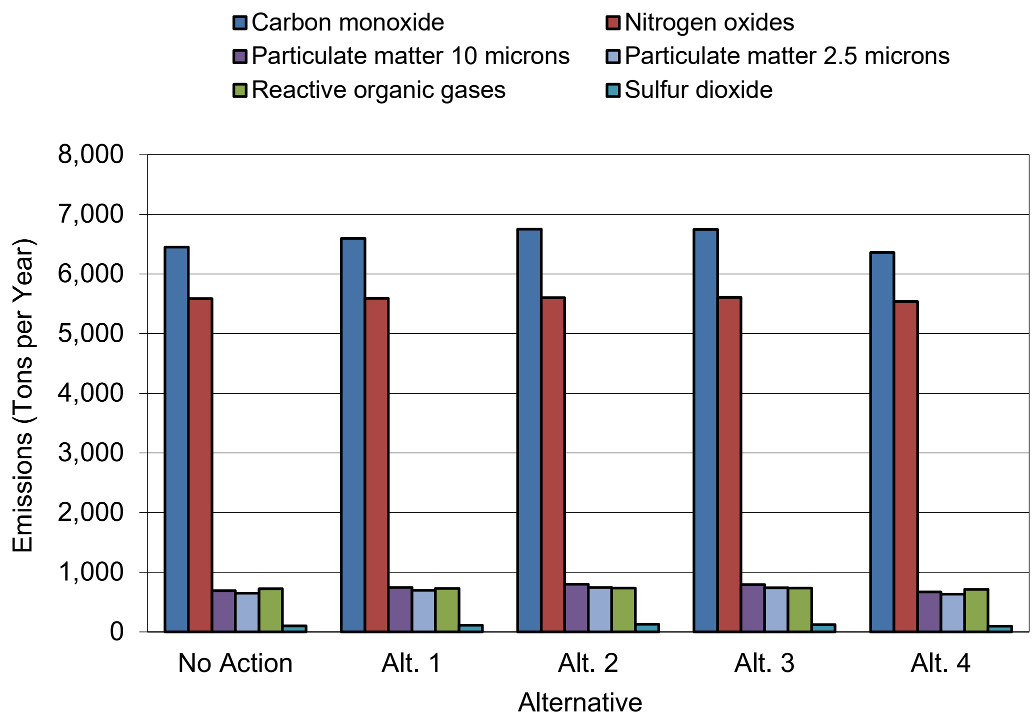


Figure 5.6-5. Emissions from All Sources

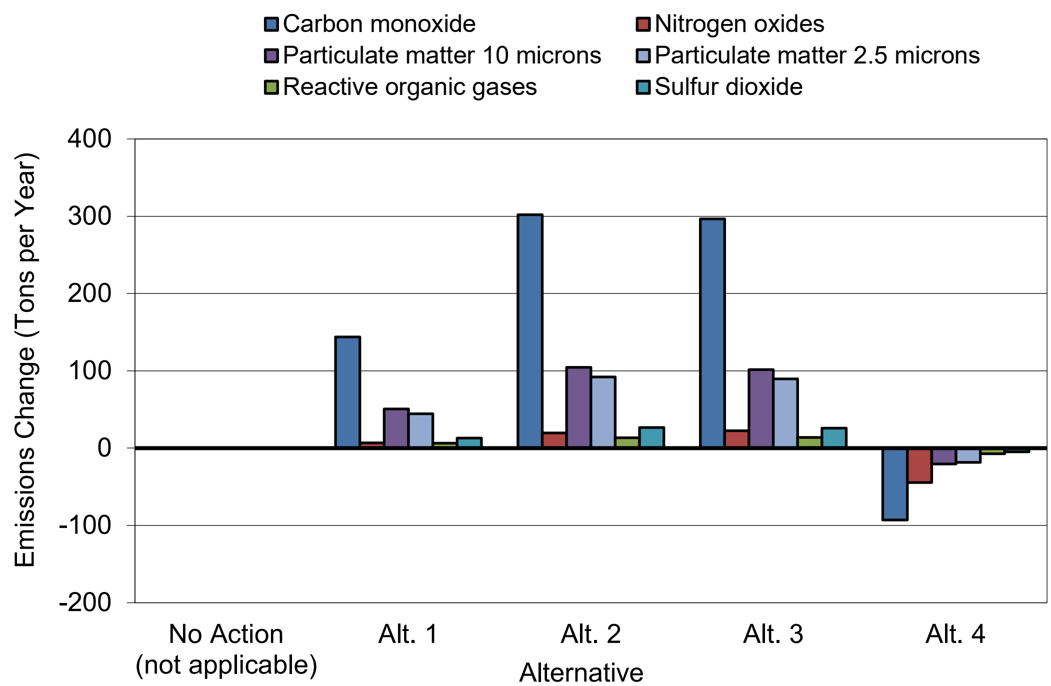


Figure 5.6-6. Changes in Emissions from All Sources Compared to the No Action Alternative

5.6.2 Program-Level Effects

Potential for exhaust and fugitive dust emissions from construction equipment and vehicles

Under Alternatives 1, 3, and 4, program-level actions that include construction or repair of facilities or the transport of fish or materials are proposed in the upper Sacramento River, American River, Stanislaus River, San Joaquin River, Bay-Delta, and south-of-Delta (Alternative 4 only) regions. The details of construction currently are not known in sufficient detail to estimate emissions, but construction equipment and vehicular use have the potential to increase emissions. Potential construction impacts would not be expected to lead to exceedance of the California Ambient Air Quality Standards (CAAQS) or National Ambient Air Quality Standards (NAAQS) if Mitigation Measures are implemented. Appendix E, *Mitigation Measures,* provides a list of typical mitigation measures that could be implemented to reduce emissions from construction.

Under Alternative 2, there would be no construction associated with program-level actions, and therefore, no construction-related air quality effects.

5.6.3 Mitigation Measures

Grid-generated electric power comprises the output of numerous powerplants across California and in other states, and no specific powerplant can be associated with power purchased by CVP/SVP. Fossil-fueled powerplants are subject to the air quality permitting requirements of the air quality management district in which they are located. To obtain a permit, the plant must demonstrate to the satisfaction of the district that its maximum air quality impacts will not exceed the CAAQS or NAAQS. The plant also may be required to comply with USEPA requirements for Best Available Control Technology or Lowest Achievable Emissions Rate, or mitigation measures specified by the air quality management district. Therefore, no additional mitigation is proposed for electric power-related air quality impacts.

Groundwater pump engines produce exhaust pollutants that potentially can affect air quality in the local area around the pump. Pump engines are subject to CARB and USEPA emissions standards. Most pump engines are relatively small (less powerful than a typical automobile engine) and usually are located in agricultural areas without dense development in the vicinity. Therefore, human exposure to pump engine exhaust is expected to be low, and no mitigation is proposed.

The following mitigation measures have been identified as potential measures to avoid and minimize potential construction air quality impacts:

- Mitigation Measure AQ-1: Develop and Implement a Fugitive Dust Control Plan
- Mitigation Measure AQ-2: Pave, Apply Gravel, or Otherwise Stabilize the Surfaces of Access Roads
- Mitigation Measure AQ-3: Apply Water or Dust Palliatives to Access Roads as Necessary during High Wind Conditions.
- Mitigation Measure AQ-4: Post and Enforce Speed Limits on Unpaved Access Roads
- Mitigation Measure AQ-5: Stage Activities to Limit the Area of Disturbed Soils Exposed at Any One Time
- Mitigation Measure AQ-6: Water, Stabilize, or Cover Disturbed or Exposed Earth Surfaces and Stockpiles of Dust-Producing Materials, as Necessary

- Mitigation Measure AQ-7: Install Wind Fences Around Disturbed Earth Areas if Windborne Dust Is Likely to Affect Sensitive Areas beyond the Site Boundaries (e.g., Nearby Residences)
- Mitigation Measure AQ-8: Cover the Cargo Areas of Vehicles Transporting Loose Materials
- Mitigation Measure AQ-9: Inspect and Clean Dirt from Vehicles, as Necessary, at Access Road Exits to Public Roadways
- Mitigation Measure AQ-10: Remove from Public Roadways Visible Trackout or Runoff Dirt from the Activity Site (e.g., Using Street Vacuum Sweeping)
- Mitigation Measure GHG-1: Minimize Potential Increases in GHG Emissions from Exhaust Associated with Construction Activities

5.7 Greenhouse Gas Emissions

5.7.1 Project-Level Effects

Potential changes in GHG emissions from fossil-fueled powerplants (hydropower generation)

As described in Section 5.6.1., *Air Quality*, operational changes under Alternatives 1, 2, 3, and 4 could affect the amount hydroelectric generation and energy use at CVP and SWP facilities. As discussed in Section 5.15, *Power*, Alternatives 1, 2, and 3 would increase both power generation and energy use for the CVP and SWP. In contrast, Alternative 4 would decrease both power generation and energy use at CVP and SWP facilities. The CVP by itself generates more power than it uses (net generation) under the No Action Alternative. The net generation would be reduced under Alternatives 1, 2, and 3, and increased under Alternative 4. Under all action alternatives, the SWP by itself uses more power than it generates (net energy use). The net energy use would increase under Alternatives 1, 2, and 3, and decrease under Alternative 4. Less net power generation results in the need for the CVP and SWP to purchase power from the grid to meet demand for power. To the extent that the purchased power would be generated by fossil-fueled powerplants, GHG emissions from these plants would increase. Greater net generation would reduce the amount of power purchased and would result in decreased GHG emissions. Although the specific power purchases that the CVP and SVP may make in the future are not known, approximately 50% of the grid electricity in California was generated by fossil-fueled plants in 2016 (USEPA 2018).

GHG emissions from fossil-fueled powerplants resulting from changes in hydropower generation, and consequently in grid power, were evaluated on a project-wide basis and reported as emissions of carbon dioxide equivalent (CO_2e) consistent with the USEPA GHG inventory. For the details of the power modeling on which the GHG emission analysis was based, see Appendix U, Attachment 1. For the details of the GHG emission analysis see Appendix M, *Greenhouse Gas Emissions Technical Appendix*.

Potential changes in emissions from fossil-fueled powerplants (groundwater pumping)

As described in Section 5.6, *Air Quality*, changes in water deliveries could affect groundwater pumping, which would change GHG emissions depending on the power source for the groundwater well. GHG emissions from the fossil-fueled powerplants (for electrically-powered pumps) and GHG emissions from diesel engines (for engine-powered pumps) resulting from changes in groundwater pumping were evaluated and reported as CO_2e. For the details of the groundwater modeling on which the GHG emission analysis was based, see Appendix I. For the details of the GHG emission analysis see Appendix M.

Alternatives 1, 2, and 3 would increase CVP and SWP deliveries to water users and decrease groundwater pumping. As a result, the associated GHG emissions also would decrease. Alternative 4 would decrease CVP and SWP deliveries to water users and increase groundwater pumping and the associated GHG emissions. The overall impact of the action alternatives on GHG emissions is the sum of the changes associated with grid power generation and with groundwater pumping. Table 5.7-1, Estimated GHG Emissions Associated with the Action Alternatives, presents the estimated overall CO_{2e} emissions associated with project actions for an average year. Figure 5.7-1, GHG Emissions Associated with the Action Alternatives, also summarizes this information. Although GHG emissions from groundwater pumping would decrease under Alternatives 1, 2, and 3, the increased GHG emissions from grid power generation would more than offset this decrease. In contrast, Alternative 4 would increase GHG emissions from groundwater pumping, but the decreased GHG emissions from grid power generation would offset the increase. As a result, Alternatives 1, 2, and 3 would increase GHG emissions compared to the No Action Alternative and Alternative 4 would decrease GHG emissions compared to the No Action Alternative (Table 5.7-1 and Figure 5.7-1).

Table 5.7-1. Estimated GHG Emissions Associated with the Action Alternatives

	CO_2e Emissions (Metric tons per average year)				
Source of Emissions	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Grid Energy Generation[1]	-19,841	166,916	362,840	350,809	-76,373
Groundwater Pumping[2]	1,690,787	1,627,909	1,563,685	1,568,749	1,697,001
Total Emissions[3]	1,670,946	1,794,826	1,926,525	1,919,558	1,620,629

Additional information on calculations is provided in Appendix M.

[1] Values represent GHG emissions from net generation, that is, CVP/SWP hydropower generation minus CVP/SWP energy use. Emissions of zero would indicate that CVP/SWP hydropower generation equals CVP/SWP energy use. Negative emission values indicate decreases in GHG emissions because net generation is positive and displaces grid power; positive emission values indicate increases in GHG emissions because net generation is negative and CVP/SWP purchases the needed power from the grid.

[2] Values represent the sum of GHG emissions from fossil fueled powerplants (for electrically powered pumps) and GHG emissions from diesel engines (for engine powered pumps).

[3] Values represent the sum of GHG emissions from fossil fueled powerplants (for CVP/SWP purchases of grid power and for electrically-powered groundwater pumps) and GHG emissions from diesel engines (for engine-powered groundwater pumps).

Alt = alternative

CO_2e = carbon dioxide equivalent

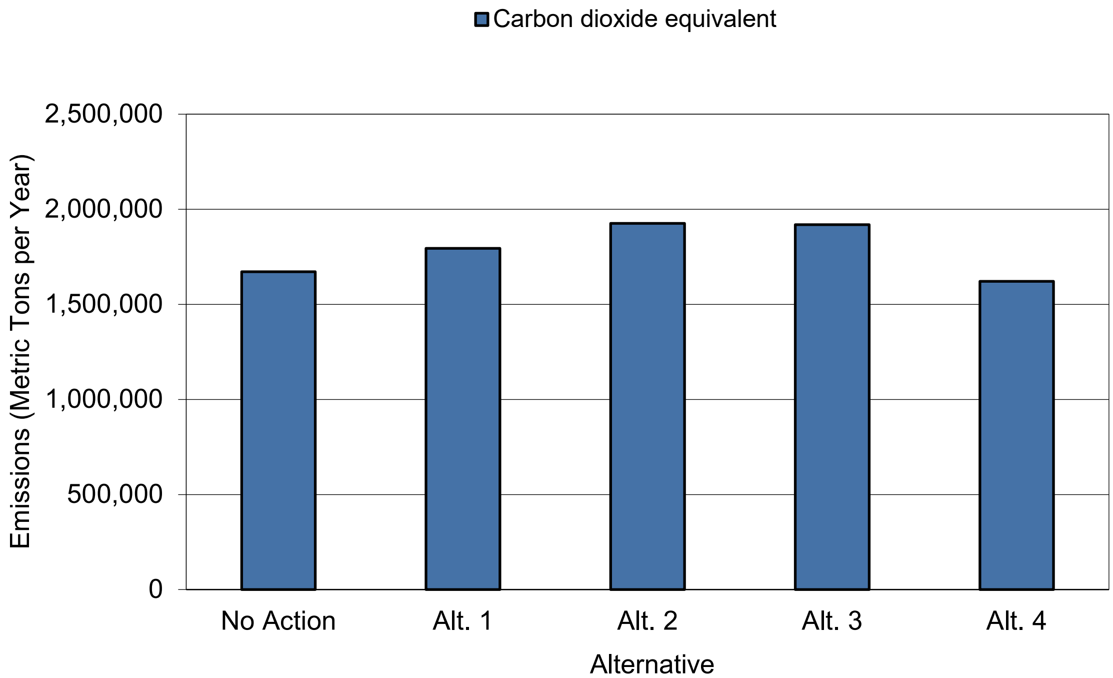


Figure 5.7-1. GHG Emissions Associated with the Action Alternatives

5.7.2 Program-Level Effects

Potential for exhaust GHG emissions from engines of construction equipment and vehicles

Under Alternatives 1, 3, and 4, program-level actions that include construction or repair of facilities or the transport of fish or materials are proposed in the upper Sacramento River, American River, Stanislaus River, San Joaquin River, Bay-Delta (Alternative 3 only), and south-of-Delta (Alternative 4 only) regions, as well as for habitat restoration, facility improvements, and fish intervention actions. The details of construction currently are not known in sufficient detail to estimate GHG emissions, but construction equipment and vehicular use have the potential to increase GHG emissions from engine exhaust. Mitigation Measure GHG-1 includes BMPs to lessen the potential temporary increases in GHG emissions. Appendix M provides a list of typical BMPs that could be implemented to reduce GHG emissions from construction.

Under Alternative 2, there would be no construction associated with program-level actions, and therefore, no construction-related effects on GHG emissions.

5.7.3 Mitigation Measures

Grid-generated electric power comprises the output of numerous powerplants across California and in other states, and no specific powerplant can be associated with power purchased by CVP/SVP. Fossil-fueled powerplants are subject to the air quality permitting requirements of the air quality management district in which they are located. Permit conditions may include requirements to reduce or minimize GHG emissions. Under Assembly Bill 32, California regulations require utility companies to ensure that one-third of their electricity comes from the sun, wind, and other renewable sources by 2030, a portion that will rise to 50% by 2050. Therefore, no project-specific mitigation is proposed for energy-related GHG emissions.

Groundwater pump engines produce GHGs as part of their exhaust. Pump engines are subject to CARB and USEPA emissions standards for criteria pollutants but these standards do not regulate GHGs. Agricultural pump engines are eligible for funding under the CARB Carl Moyer Program to replace older engines with newer, lower-emitting engines or electric motors. To the extent that new engines are more fuel-efficient they are expected to have lower GHG emissions than the engines they replace. Replacement of engines with electric motors also would result in a net reduction in GHG emissions.

Mitigation Measure GHG-1 includes BMPs to minimize GHG emissions from construction. Appendix E provides further information on Mitigation Measure GHG-1 and recommended BMPs.

5.8 Visual Resources

5.8.1 Project-Level Effects

Project-level effects on visual resources were evaluated and determined to not be substantial changes resulting from implementation of Alternatives 1, 2, 3, and 4. These effects are discussed further in Appendix N, *Visual Resources Technical Appendix*.

5.8.2 Program-Level Effects

Potential changes in visual resources at Delta Fish Species Conservation Hatchery

Under Alternatives 1 and 3, Reclamation would partner with DWR to construct and operate a new conservation hatchery for Delta Smelt. Potential changes to visual resources could occur in the Delta region related to short-term, temporary construction activities, including truck hauling, construction vehicle use and storage, and equipment and materials storage.

Potential changes in visual resources from habitat restoration

Alternatives 1 and 3 both include programmatic actions that have the potential to affect visual resources and views temporarily. Alternative 3 involves approximately 25,000 more acres of habitat restoration than Alternative 1. While restoration efforts (such as creation or rehabilitation of spawning and rearing habitat, adult fish rescue, juvenile trap and haul, and small screen programs) would have no visual effects once operational, there could be short-term construction effects on visual resources. Construction vehicles, trucks, and other construction equipment and activities could temporary effect the quality of visual resources and views during habitat restoration activities at the Sacramento, American, Stanislaus, and San Joaquin Rivers, and in the Bay-Delta region. Water efficiency use measures under Alternative 4 would have no visual effects. Program-level visual effects under Alternative 4 would therefore be similar to the No Action Alternative.

Other program-level changes and project-level actions under Alternatives 1, 3, and 4 would be the same regarding visual resources effects and range from negligible to beneficial compared to the No Action Alternative. Alternative 2 includes no programmatic actions and therefore it would have no program-level effects.

5.9 Aquatic Resources

This impact assessment is based on the technical analysis documented in Appendix O, *Aquatic Resources Technical Appendix*, which includes additional information on aquatic resource conditions and technical analysis of the effects of each alternative.

The action alternatives would change operations of the CVP and SWP, altering reservoir storage and releases and changing flow and temperature regimes in downstream waterways. These changes have the potential to affect special-status fishes, critical habitat for listed fish species, and fishes with commercial or recreational importance, as well as resources and important ecological processes on which the fish community depends. Flow-related habitat changes could include increases or decreases in the quantity and quality of riverine aquatic habitats, altered frequency or magnitude of ecologically important geomorphic processes (channel maintenance), and altered frequency and duration of inundated floodplains that support salmonid rearing and conditions for other native fish species. If river flows and water temperatures decrease or increase in locations or seasonal periods that coincide with use by sensitive life stages of anadromous fish, the flows and water temperatures could influence the amount and suitability of habitat and the success of adult upstream migration, spawning and incubation, rearing, or juvenile/smolt out-migration. Additionally, direct effects on fishes could result from stranding or dewatering, which can occur when flows are reduced rapidly.

5.9.1 Project-Level Effects

5.9.1.1 *Trinity River and Clear Creek*

Potential changes to aquatic resources from variation in river flows and water temperatures

5.9.1.1.1 Trinity River below Lewiston

Model results illustrating the average flow in the Trinity River below Lewiston Dam for all water year types show no discernible difference among the action alternatives during any time of the year, and a relatively small difference between the No Action Alternative and the action alternatives from December through March (Figure 5.9-1, Average Trinity River Flow below Lewiston Dam for the Period October–September, Average of All Water Year Types). Average flow under the action alternatives would be greater than average flow under the No Action Alternative from December through March, which coincides with a large portion of the egg incubation periods of Coho Salmon, Spring-Run Chinook Salmon, Fall-Run Chinook Salmon, and Klamath Mountains Province DPS (Steelhead) in the Trinity River. The differences would be greatest during February of above normal water years, when the average flow under the action alternatives would be 273 to 365 cfs greater than flow under the No Action Alternative (Figure 5.9-2). Average Trinity River Flow below Lewiston Dam during February in Above Normal Water Years).

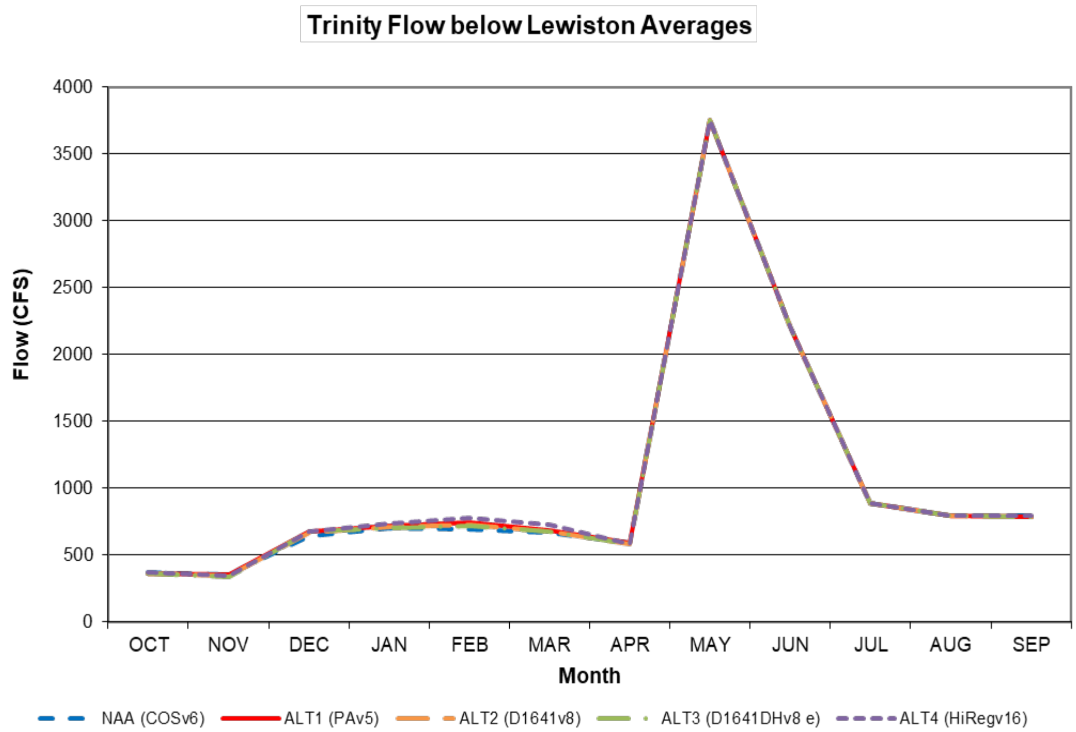


Figure 5.9-1. Average Trinity River Flow below Lewiston Dam for the Period October–September, Average of All Water Year Types

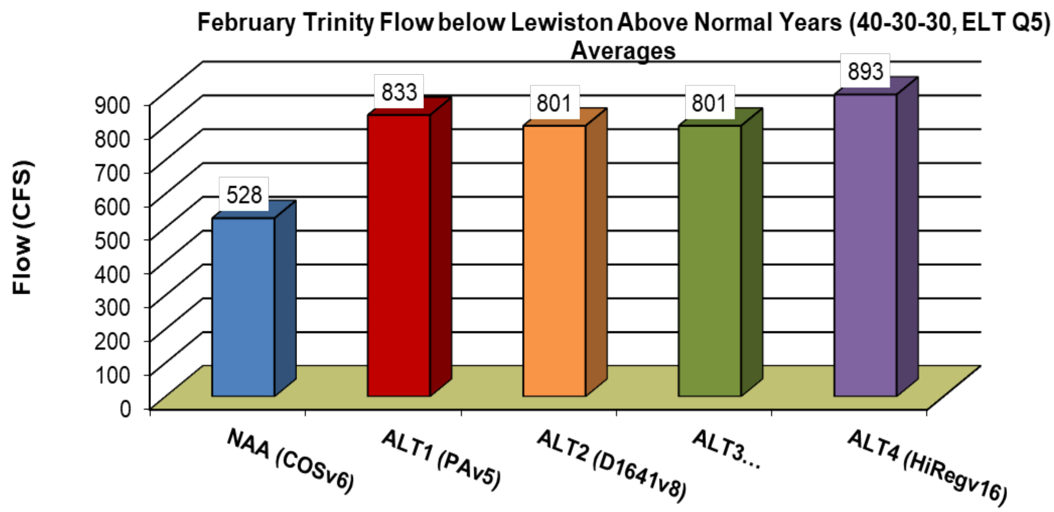


Figure 5.9-2. Average Trinity River Flow below Lewiston Dam during February in Above Normal Water Years

The increased February flows in above normal water years under the action alternatives would not overlap substantially with the spawning and incubation period of other fish species of concern in the Trinity River below Lewiston Dam, so any effects would be negligible and potentially beneficial for migrating and holding steelhead because of increased habitat availability. These same increases in flow could result in potential adverse effects on fry and juvenile Coho and Chinook salmon due to reduced habitat availability, however, the percent change in total WUA in this flow range is negligible (USFWS and Hoopa Valley Tribe 1999: 123).

Modeled average water temperatures under the action alternatives and the No Action Alternative (Figure 5.9-3, Average Monthly Trinity River Water Temperatures below Lewiston Dam, Average of All Water Year Types) would be maintained well below the daily average water temperature objectives set by the Regional Water Quality Control Board, North Coast Region (SWRCB 1990) for the Trinity River below Lewiston Dam, which stipulate a maximum of 60°F from July 1 to September 14 and a maximum of 56°F from September 15 to December 31.

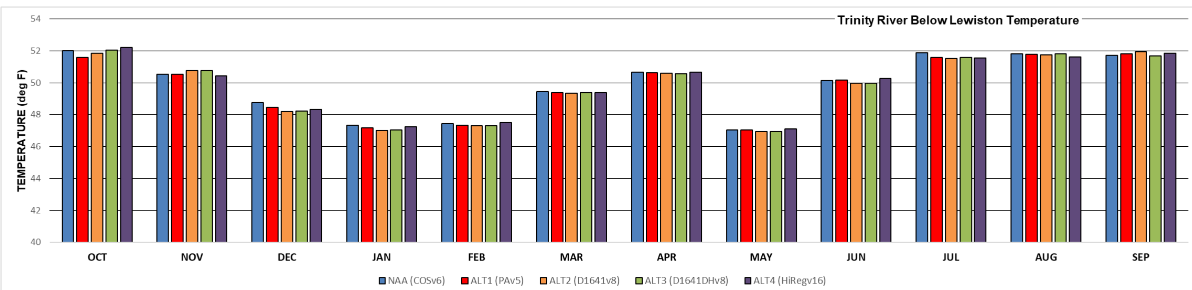


Figure 5.9-3. Average Monthly Trinity River Water Temperatures below Lewiston Dam, Average of All Water Year Types

The USEPA (2003) recommends use of the maximum 7-day average of the daily maxima (7DADM) as the metric for comparison of water temperature conditions against protective criteria for salmonid uses. While the HEC5Q output used in this assessment is based on a monthly time step and does not provide daily water temperature predictions, maximum monthly water temperatures from HEC5Q provide the closest available approximation to the values recommended by USEPA (2003) and are therefore used herein to provide a coarse-level comparative analysis for each alternative. Modeled maximum water temperatures under the action alternatives would remain at or below the USEPA's (2003) recommended criteria to protect salmonid life stages during the entirety of the adult and juvenile migration periods (64°F to 68°F), the majority of the core (moderate to high density, summertime) juvenile rearing period (61°F), and a portion of the spawning, egg incubation, and fry emergence period (55°F) (Figure 5.9-4, Maximum Trinity River Water Temperatures below Lewiston Dam for the Period October–September, Average of All Water Year Types).

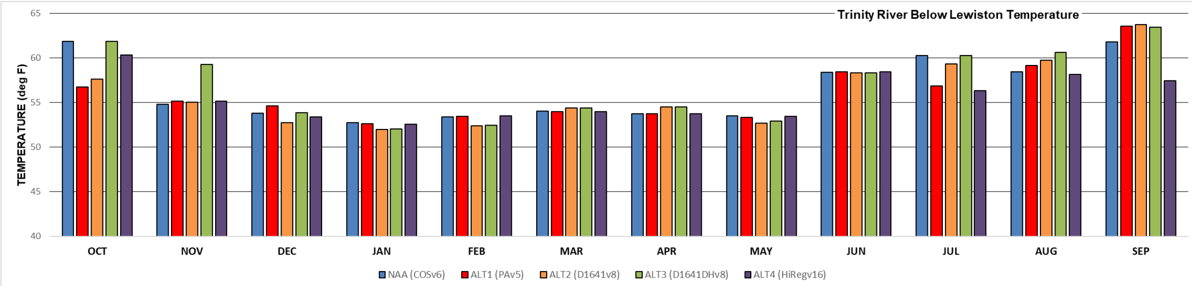


Figure 5.9-4. Maximum Trinity River Water Temperatures below Lewiston Dam for the Period October–September, Average of All Water Year Types

Based on modeled maximum water temperatures the following effects were observed:

- Modeling results show that maximum water temperatures in September under Alternative 1 (63.5°F), Alternative 2 (63.8°F), and Alternative 3 (63.4°F) would exceed those under the No Action Alternative (61.8°F). However, modeled maximum water temperatures in September under Alternative 4 (57.4°F) would be 4.4°F less than under the No Action Alternative. Modeled maximum October water temperatures under Alternative 1 (56.7°F), Alternative 2 (57.6°F), and Alternative 4 (60.3°F) would be less than under the No Action Alternative. Modeled maximum October water temperatures under Alternative 3 (61.9°F) would be slightly higher than the No Action Alternative (61.8°F); however, the 0.1°F difference in temperature would be negligible and likely much less than the uncertainty associated with model results. Although the modeled maximum water temperatures in September and October under all alternatives would exceed the 55°F USEPA (2003) criteria for spawning, egg incubation, and fry emergence and could compromise salmonid reproductive success, there would be little or no potential for adverse effects relative to the No Action Alternative. While modeled maximum September temperatures under Alternatives 1–3 would exceed the No Action Alternative, little salmonid spawning occurs in September and the monthly model results may not accurately represent the daily maxima upon which the USEPA (2003) criteria are based. Spawning by Spring-Run Chinook Salmon in the Trinity River commences in late September and peaks in October, while spawning by Fall-Run Chinook Salmon commences in October and peaks in November. Trinity River Coho Salmon primarily spawn in November and December, while Steelhead and Coastal Cutthroat Trout spawn from January–April and September – April respectively.
- Modeled maximum water temperatures under the action alternatives would be at or below the recommended 55°F criterion for spawning, egg incubation, and fry emergence (USEPA 2003) from December through May (Figure 5.9-4), which would provide substantial protection for these life stages of Coho Salmon, which begin spawning in November, and Steelhead and Coastal Cutthroat Trout, which begin spawning in January and September respectively. While water temperatures under the action alternatives would equal or exceed the No Action Alternative in some months during this period, no adverse effects are expected.
- Modeled maximum water temperatures during November, however, would slightly exceed the 55°F criterion under Alternative 1 (55.2°F), Alternative 2 (55.1°F), and Alternative 4 (55.1°F) and would substantially exceed the criterion under Alternative 3 (59.3°F), which could compromise spawning success for Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, Coho Salmon, and Coastal Cutthroat Trout during November. The modeled water temperature exceedances under Alternatives 1, 2, and 4 are negligible relative to both the USEPA (2003) criteria and the No Action Alternative

(54.8°F) and are likely much less than the uncertainty associated with model results. Consequently, no adverse effects are expected. Under Alternative 3, however, modeled maximum November water temperatures would substantially exceed both the USEPA (2003) criterion and the No Action Alternative, likely resulting in adverse effects on Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, Coho Salmon, and Coastal Cutthroat Trout. The magnitude of the November water temperature exceedance under Alternative 3 could substantially reduce spawning success and year-class recruitment, but the expected frequency of occurrence cannot be determined using available modeling data and the likelihood of population-level effects is therefore uncertain. Spawning Steelhead would not be affected by the November water temperatures, as they begin spawning in January.

5.9.1.1.2 Clear Creek below Whiskeytown

In Clear Creek below Whiskeytown Dam, CalSim II modeling results indicate that average flows in most water year types under Alternative 1 would be similar or the same as under the No Action Alternative, and average flows in all water year types under Alternatives 2 and 3 would be less than the No Action Alternative (Figure 5.9-5). , Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Average of all Water Year Types). Flows under Alternatives 2 and 3 would include base flows of 50 cfs to 100 cfs but would not include scheduled channel maintenance flows or spring pulse flows. Average flows in all water year types under Alternative 4 would be higher than under the No Action Alternative from November to May and would be similar or the same as under the No Action Alternative from June to October. In all water year types, Alternative 1 and Alternative 4 would improve instream habitat conditions throughout the year compared to Alternative 2 and Alternative 3, but Alternative 1 would be similar to the No Action Alternative.

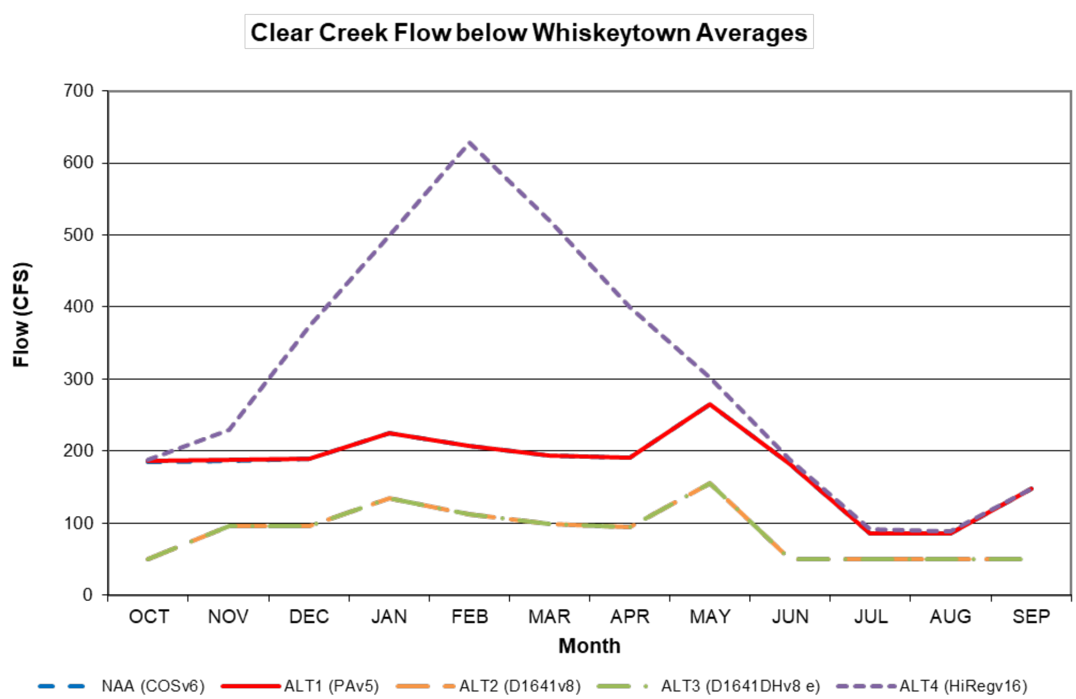


Figure 5.9-5. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Average of all Water Year Types

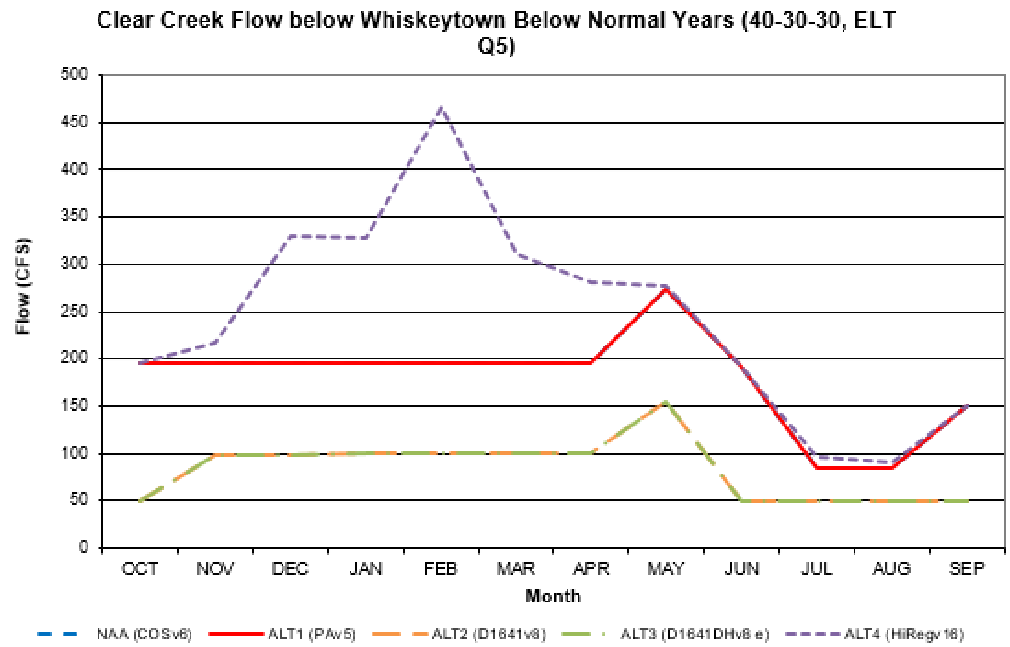


Figure 5.9-6. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Below Normal Water Years

Minimum flow objectives for Clear Creek below Whiskeytown Dam have been established for specific seasonal periods, pursuant to previous agreements. The following flow effects of the action alternatives were observed from model results.

- Under Alternatives 2 and 3, modeled average flows from November 1 to December 31 would be substantially lower than the No Action Alternative, but in wet, above normal, and dry years would still meet or exceed the 100 cfs minimum flow objective specified in the aforementioned agreements. In critically dry (80 cfs) years, however, modeled average flows under Alternatives 2 and 3 would be less than the 100 cfs minimum November 1 to December 31 flow specified for all water year types by the 1960 Memorandum of Agreement with CDFW (Figure 5.9-7, Modeled Average November Flows in Clear Creek below Whiskeytown Dam in Below Normal Years [left] and Critically Dry Years [right]). As a result, habitat quality and quantity for anadromous salmonids under Alternative 2 and Alternative 3 in critically dry water years could be reduced during the November to December spawning and egg incubation period for Spring-Run Chinook Salmon, Fall-Run/Late Fall-Run Chinook Salmon, and Steelhead relative to the No Action Alternative.
- Under Alternative 4, modeled average flows would be substantially higher than the No Action Alternative from December through April, and similar to slightly higher than the No Action Alternative from May through November (Figure 5.9-5). Increased flows during the months of December through April would benefit Spring-Run Chinook Salmon, Fall-Run/Late-Fall Run Chinook Salmon, and Steelhead migrating and holding adults and rearing and outmigrating juveniles by increasing pool connectivity and available habitat, and eggs and fry by lowering water temperatures and increasing DO, as these months overlap with the occurrences of portions of these life stages for all three species within Clear Creek. Increases in modeled average flows from January–March under Alternative 4 during wet years increase by 528 cfs to 665 cfs relative to the No Action Alternative, which may increase the likelihood of salmonid egg mortality due to redd scour.

- Pacific Lamprey occur in Clear Creek. Pacific Lamprey have similar habitat requirements to salmonids but spawn in late spring. Pacific lamprey spawning and egg incubation would be unaffected by flow-related habitat conditions in November and December under Alternatives 2 and 3. Compared with flows under the No Action Alternative, the lower flows under Alternatives 2 and 3 throughout the year and lack of channel maintenance flows and spring pulse flows may result in reduced habitat quantity and quality for salmonids, Pacific Lamprey, and other native fishes in Clear Creek. Pacific Lamprey would benefit from increased flows under Alternative 4 through increased pool connectivity, reduced water temperatures, and increased foraging habitat and shelter.

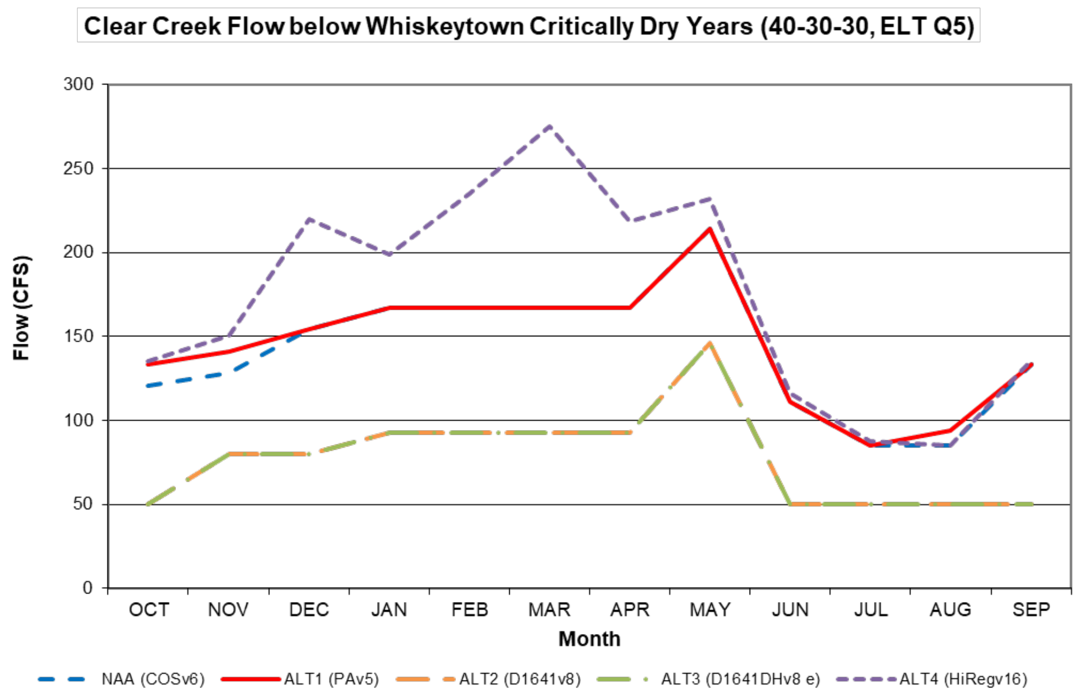


Figure 5.9-7. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Critically Dry Water Years.

Under the No Action Alternative, releases to Clear Creek from Whiskeytown Dam would be managed to meet seasonal water temperature objectives established by the 2009 NMFS BO in all water year types. Under Alternative 1, Whiskeytown releases would be managed to meet the NMFS (2009) water temperature objectives only in below normal, above normal, normal, and wet years. In dry and critically dry years, Whiskeytown operations under Alternative 1 would be managed to meet these objectives as closely as possible. Under Alternatives 2 and 3, Whiskeytown releases would not be managed to meet water temperature objectives in Clear Creek. The following results were observed for average water temperature in Clear Creek below Whiskeytown Dam.

- Modeled average water temperatures would be similar under Alternative 1 and Alternative 4 relative to the No Action Alternative. Average water temperatures under Alternative 1 and Alternative 4 would slightly exceed the NMFS (2009) objectives (by less than 1°F) during July, August, and September. Due to the imprecise nature of the water temperature model output and the very small apparent exceedance of the NMFS (2009) objectives, water temperatures under Alternative 1 and

Alternative 4 would be unlikely to cause substantial reduction in Spring-Run or Fall-Run Chinook Salmon spawning or egg incubation success compared with the No Action Alternative.

Modeled average water temperatures in Clear Creek below Whiskeytown Dam from June to October in all water year types would be substantially greater under Alternatives 2 and 3 than under the No Action Alternative (Figure 5.9-8, Modeled Average Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of All Water Year Types). From June to September, average temperatures under Alternatives 2 and 3 would range from 61.6°F to 65.7°F, exceeding the 60°F objective for June 1 to September 15 established by the NMFS (2009) BO to protect Spring-Run Chinook Salmon holding and rearing. In September and October, average temperatures under Alternatives 2 and 3 would range from 57°F to 61.6°F and would exceed the 56°F NMFS (2009) objective for September 15 to October 31 meant to protect Spring-Run and Fall-Run Chinook Salmon spawning and egg incubation (Figure 5.9-8). The substantial increases relative to the No Action Alternative and the NMFS (2009) criteria could compromise Spring-Run Chinook Salmon holding and rearing success and potentially lead to increased incidence of disease and physiological stress in holding adults and reduced survival of rearing juveniles, reduced juvenile production, and reduced spawning success by adults. These effects would be most likely to occur in June to August, when water temperatures are predicted to be highest.

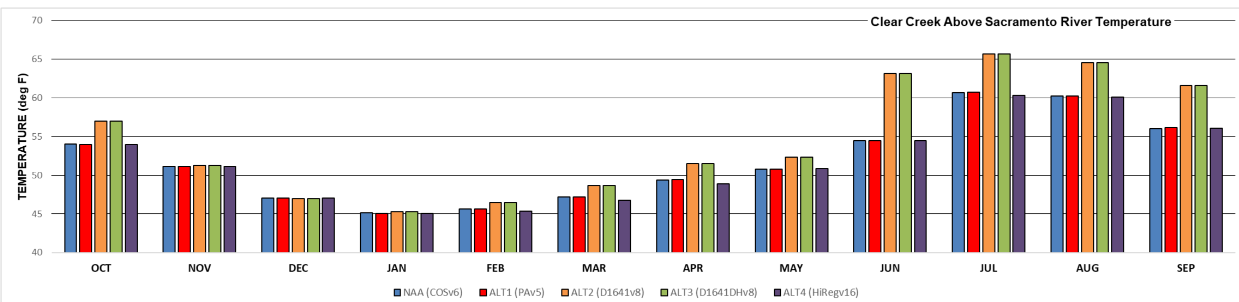


Figure 5.9-8. Modeled Average Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of All Water Year Types

The following results were observed for average water temperature in Clear Creek below Whiskeytown Dam (Figure 5.9-9, Modeled Maximum Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of all Water Year Types).

- Modeled maximum water temperatures in Clear Creek under Alternative 1 and Alternative 4 would remain at or below the USEPA's (2003) recommended criteria to protect salmonid life stages during the entirety of the adult and juvenile migration periods (64°F to 68°F), a substantial portion of the core (moderate to high density, summertime) juvenile rearing period (61°F), and the latter portion of the spawning, egg incubation, and fry emergence period (55°F).
- Modeled maximum water temperatures under Alternative 1 would be nearly identical to the No Action Alternative in most months but would be substantially less than the No Action Alternative in October, slightly less in August, and slightly greater in September. Elevated water temperatures under Alternative 1 could reduce Spring-Run Chinook Salmon and California Central Valley Steelhead juvenile rearing success from July to October and Spring-Run Chinook Salmon spawning/incubation success during September and October. Fall-Run Chinook Salmon typically out-migrate prior to summer and are unlikely to be affected by elevated summer water temperatures under Alternative 1. Spawning and egg incubation success by Fall-Run Chinook Salmon and California Central Valley

Steelhead, which typically spawn later in the fall (Fall-Run Chinook Salmon) and in winter/spring (Central Valley Steelhead) would not be compromised under Alternative 1.

- Modeled maximum water temperatures under Alternatives 2 and 3 would be greater than under the No Action Alternative from spring through early fall but less than under the No Action Alternative in October and roughly equal to under the No Action Alternative during winter. Compared with the No Action Alternative, the elevated temperatures under Alternative 3 would likely reduce Spring-Run Chinook Salmon and Central Valley Steelhead juvenile rearing success from June to October and Spring-Run Chinook Salmon spawning/incubation success during September and October. From June to August, the potential for compromised Spring-Run Chinook Salmon and Central Valley Steelhead juvenile rearing success would be greater under Alternatives 2 and 3 because of the higher water temperatures.
- Modeled maximum water temperatures under Alternative 4 would be nearly identical to the No Action Alternative in most months but would be slightly less than the No Action Alternative in September and substantially less in October (Figure 5.9-9). Reduced water temperatures under Alternative 4 could enhance Spring-Run Chinook Salmon and Steelhead juvenile rearing success from July to October and Spring-Run Chinook Salmon spawning/incubation success during September and October. Fall-Run Chinook Salmon outmigration is unlikely to be affected by reduced water temperatures under Alternative 4 as outmigration occurs prior to summer. Spawning and egg incubation success by Fall-Run Chinook Salmon would likely be enhanced by reduced water temperatures in the October.

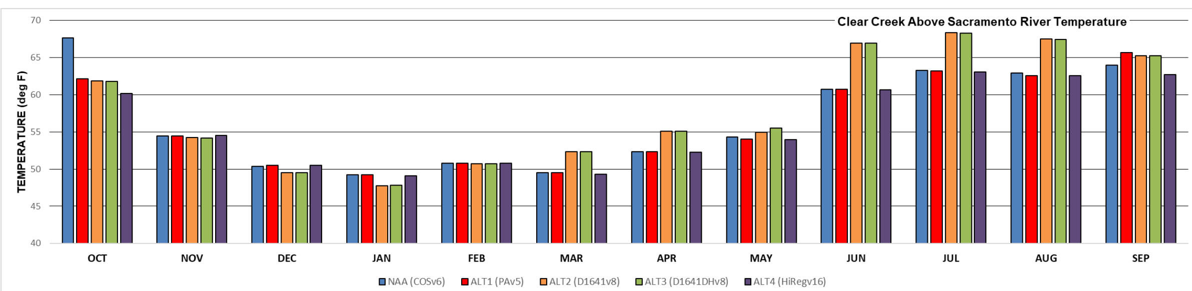


Figure 5.9-9. Modeled Maximum Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of all Water Year Types

5.9.1.2 *Sacramento River*

Potential changes in survival of Winter-Run Chinook Salmon incubating eggs and alevins and rearing juveniles in the upper Sacramento River

Potential changes in survival of Winter-Run Chinook Salmon early life stages from reduced risk of dewatering redds and stranding juveniles

High water temperature in the spawning habitat of Winter-Run Chinook Salmon during summer and fall is currently a major stressor on the Winter-Run Chinook Salmon population. Changes in summer/fall water temperature management operations under Alternative 1, especially with respect to the Shasta temperature control device (TCD), are expected to improve temperature and dissolved oxygen conditions experienced by incubating Winter-Run Chinook Salmon eggs and alevins. The proposed changes in operations have three principal objectives: (1) provide enough coldwater to optimize survival of the current year's Winter-Run Chinook Salmon eggs and alevins, (2) stabilize water levels through the fall to avoid dewatering redds and stranding juveniles of Winter-Run Chinook Salmon and other salmonids, and (3) conserve and rebuild Shasta Lake storage in the fall and winter to provide the coldwater pool resources needed to optimize survival of the next year's Winter-Run Chinook Salmon eggs and alevins. Reduced water temperatures would also increase survival of Winter-Run Chinook Salmon juveniles. Under Alternative 1, changes in Sacramento River compliance temperatures and locations, real-time seasonal monitoring of the Winter-Run Chinook Salmon population's behavior with respect to spawning and related activities, and increased flexibility in Shasta Dam TCD operations and flow releases are expected to improve success in meeting the objectives relative to the No Action Alternative. The improved TCD operations under Alternative 1, as well as a number of other proposed actions, would further facilitate increased coldwater storage, resulting in greater protection of Winter-Run Chinook Salmon early life stages relative to the No Action Alternative. Water temperatures downstream of Keswick Dam are expected to be higher under Alternative 1 relative to the No Action Alternative in September of wetter years (Table 5.9-1), but the higher Alternative 1 temperatures remain low enough to be tolerated by the early life stages. It should be noted that this temperature difference results from the major modification of Fall X2 flow releases under Alternative 1, rather than from the proposed water temperature management measures.

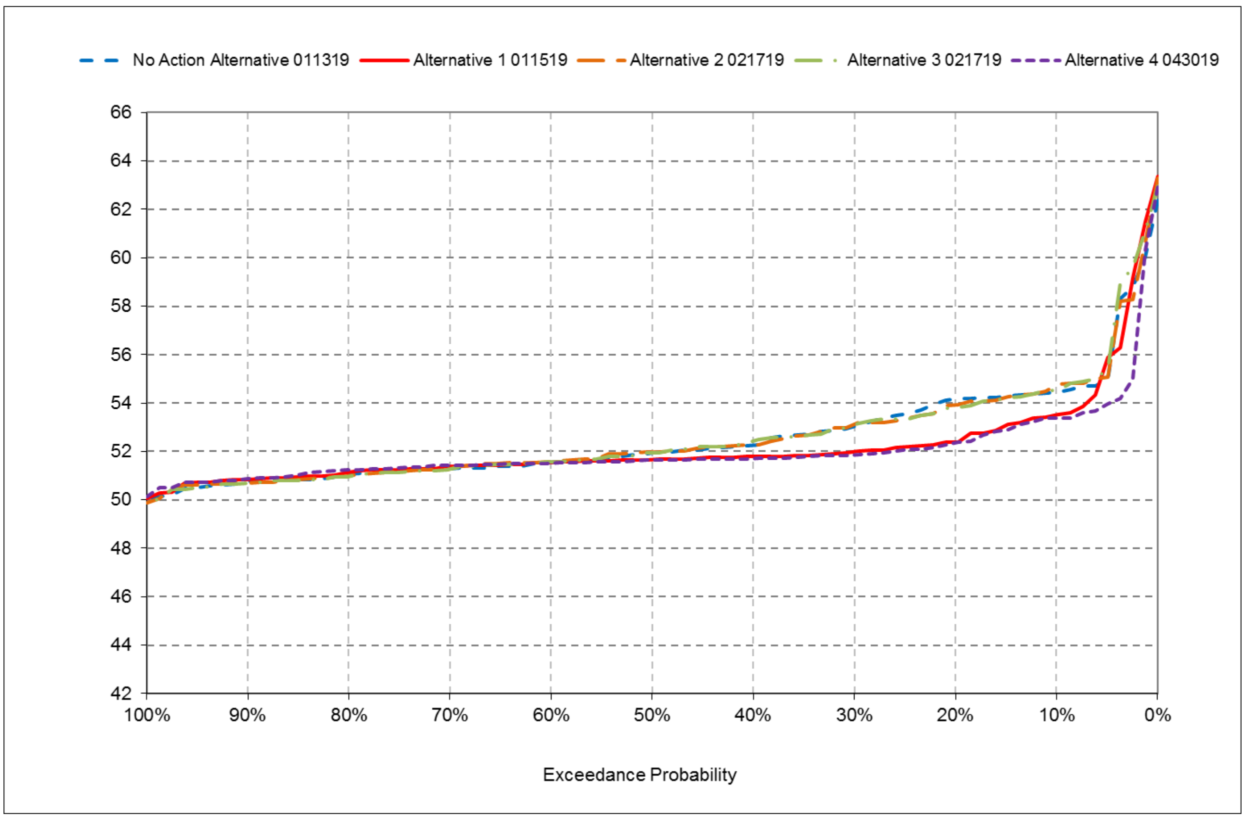


Figure 5.9-10. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the No Action Alternative, Alternative 1, Alternative 2, Alternative 3 and Alternative 4; August

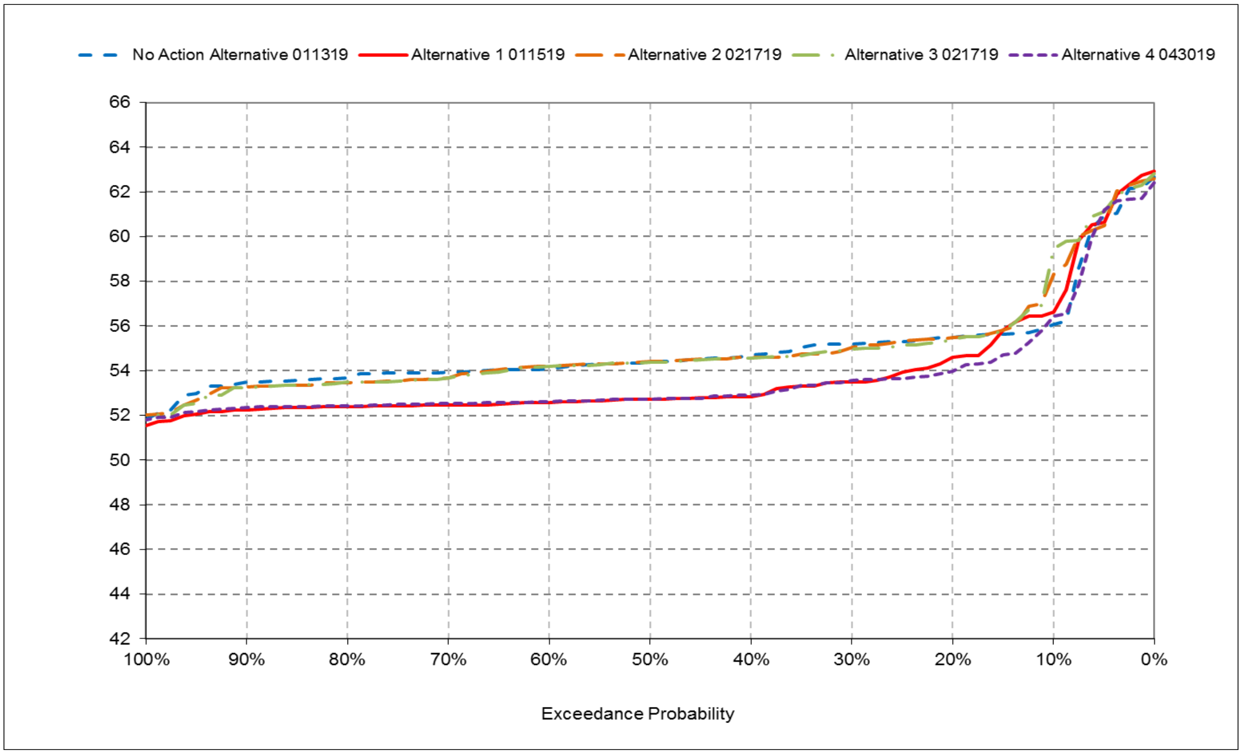


Figure 5.9-11. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the No Action Alternative, Alternative 1, Alternative 2, Alternative 3 and Alternative 4; October

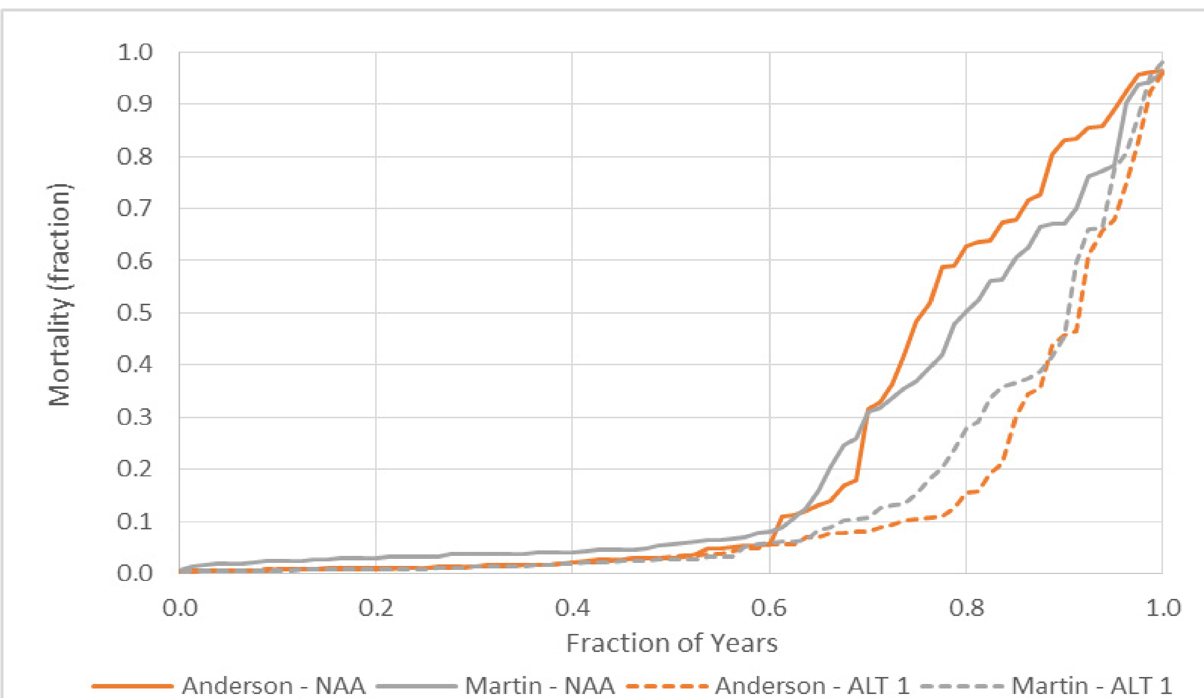


Figure 5.9-12. Exceedances of Winter-run Chinook Salmon Temperature-Dependent Egg Mortality, Alternative 1 vs. No Action Alternative; All Water Year Types.

Table 5.9-1. HEC-5Q Monthly Average Water Temperature (degrees Fahrenheit) by Water Year Type and Month at Clear Creek Confluence for No Action Alternative, Alternative 1 and Differences between Them.

Alternative[a,b,c]	Monthly Temperature (degrees Fahrenheit)											
Water Year Type[d]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action Alternative												
Wet (32%)[e]	54.7	55.3	51.6	47.3	46.2	47.0	49.2	50.3	51.4	51.9	52.9	51.9
Above Normal (16%)	54.4	54.7	51.0	47.7	46.4	47.4	49.9	50.3	51.0	51.3	52.6	52.1
Below Normal (13%)	54.7	54.2	51.0	48.1	47.4	49.0	51.1	51.0	51.3	52.1	53.5	54.5
Dry (24%)	55.2	54.3	50.6	48.3	47.9	49.1	51.0	51.2	51.7	52.8	54.6	55.0
Critical (15%)	59.4	56.1	51.2	48.2	47.8	49.5	51.4	52.4	54.0	55.5	57.8	59.8
Alternative 1												
Wet (32%)	53.3	54.6	51.4	47.5	46.3	47.1	49.2	50.2	51.5	52.0	52.8	52.9
Above Normal (16%)	53.1	53.9	50.8	47.7	46.4	47.4	49.9	50.3	51.0	51.4	52.8	53.7
Below Normal (13%)	54.3	54.7	51.5	48.2	47.4	49.0	51.1	50.6	51.2	52.1	53.0	54.2
Dry (24%)	54.0	54.6	51.1	48.4	48.0	49.0	51.2	51.1	51.5	52.7	53.6	54.4
Critical (15%)	59.5	56.3	51.4	48.6	48.2	49.6	51.6	52.2	53.4	55.0	57.4	60.5
Alternative 1 minus No Action Alternative[f]												
Wet (32%)	-1.4	-0.7	-0.2	0.1	0.1	0.1	0.0	-0.1	0.0	0.1	-0.1	1.0
Above Normal (16%)	-1.4	-0.8	-0.3	0.0	0.0	0.0	0.1	-0.1	0.0	0.1	0.2	1.7
Below Normal (13%)	-0.4	0.5	0.5	0.1	0.0	0.0	0.0	-0.4	-0.1	-0.1	-0.4	-0.3
Dry (24%)	-1.2	0.3	0.5	0.1	0.1	0.0	0.1	-0.2	-0.2	-0.1	-1.0	-0.6
Critical (15%)	0.1	0.2	0.2	0.4	0.3	0.2	0.2	-0.2	-0.6	-0.5	-0.4	0.8

a Results based on the 82-year simulation period.

b Results displayed with calendar year - year type sorting.

c All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

d Water year types as defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

e Percent of years of each type given in parentheses.

f Bold green font indicates greater than 1oF reduction in temperature, bold red font indicates greater than 1oF increase in temperature.

Alternatives 2 and 3 would likely not result in reduced temperature-related mortality of Winter-Run Chinook Salmon eggs and alevins relative to the No Action Alternative because these action alternatives protect no better than the No Action Alternative against a depleted coldwater pool (Figure 5.9-10). In contrast, Alternative 4 is expected to provide a similar level of protection to Alternative 1 (Figures 5.9-10 and 5.9-11).

Potential changes in availability of suitable physical habitat for Winter-Run Chinook Salmon redd construction, spawning, and egg and alevin incubation

Construction of Shasta Dam blocked recruitment of coarse gravel from upstream sources, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the upper Sacramento River. The resulting depletion of coarse gravel suitable for Winter-Run Chinook Salmon spawning is a potentially limiting factor for restoration of the Winter-Run Chinook Salmon population (NMFS 2014a).). Alternative 1 and Alternative 3 propose to create additional spawning habitat by injecting 15,000 to 40,000 tons of gravel between Keswick Dam and RBDD, which would potentially increase Winter-Run Chinook Salmon production relative to the No Action Alternative, thereby benefiting the Winter-Run Chinook Salmon population.

Potential changes in availability of suitable physical habitat for Winter-Run Chinook Salmon *redd construction, spawning, and egg and alevin incubation*

The upper Sacramento River has poor rearing habitat. The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment. Some complex, productive habitats with floodplains remain in the system and flood bypasses (i.e., Yolo and Sutter Bypasses), but the overall condition of riparian habitat for rearing juvenile salmonid is degraded (NMFS 2009). Alternative 1 and Alternative 3 propose to create 40 to 60 acres of side channel and floodplain habitat at approximately 10 sites in the Sacramento River by 2030, which would potentially increase Winter-Run Chinook Salmon production relative to the No Action Alternative, thereby benefiting the Winter-Run Chinook Salmon population.

Alternative 2 provides no spawning habitat restoration measures beyond those currently existing under the No Action Alternative, and therefore has no effect on the Winter-Run Chinook Salmon population with regard to spawning habitat.

Potential changes in the survival of incubating eggs and alevins and rearing juveniles in the upper Sacramento River

Potential changes in the risk of dewatering Spring-Run Chinook Salmon redds and stranding juveniles

High water temperature in the spawning habitat of Spring-Run Chinook Salmon during summer and fall is currently a major stressor on the Spring-Run Chinook Salmon population, as described above for Winter-Run Chinook Salmon. For Winter-Run Chinook Salmon, changes in summer/fall water temperature management operations under Alternative 1, especially with respect to the Shasta temperature control device (TCD), are expected to improve temperature and dissolved oxygen conditions experienced by incubating eggs and alevins, resulting in reduced egg mortality (Figures 5.9-10 through 5.9-12). Spring-Run Chinook Salmon, which have very similar water temperature and dissolved oxygen requirements to those of Winter-run Chinook Salmon, are expected to similarly respond to the improved water temperature conditions with reductions in egg and alevin mortalities. Reduced water temperatures would also increase survival of Spring-Run Chinook Salmon fry. Under Alternative 1, changes in Sacramento River compliance temperatures and locations, real-time seasonal monitoring of the Spring-Run Chinook Salmon population's behavior with respect to spawning and related activities, and increased flexibility in Shasta Dam TCD operations and flow releases are expected to improve success in meeting the objectives relative to the No Action Alternative. The improved TCD operations under Alternative 1, as well as a number of other proposed actions, would further facilitate increased coldwater storage, resulting in greater protection of Spring-Run Chinook Salmon early life stages relative to the No Action Alternative. Water temperatures downstream of Keswick Dam are expected to be higher under Alternative 1 relative to the No Action Alternative in September of wetter years (Table 5.9-1), but the higher Alternative 1 temperatures remain low enough to be tolerated by the early life stages. It should be noted that this temperature difference results from the major modification of Fall X2 flow releases under Alternative 1, rather than from the proposed water temperature management measures.

Spring-Run Chinook Salmon spawn about three months later in the year than Winter-Run Chinook Salmon, when water temperatures in the upper Sacramento River typically reach their annual peak and when the coldwater pool in Lake Shasta is most likely depleted. Because Spring-Run and Winter-Run Chinook Salmon have similar water temperature requirements for incubating eggs and alevins, it is likely that water temperature is as important a stressor for the Spring-Run population in the Sacramento River as it is for the Winter-Run Chinook Salmon population. Changes in summer/fall water temperature management operations under Alternative 1, especially with respect to the Shasta TCD, are expected to improve temperature and dissolved oxygen conditions experienced by incubating Spring-Run eggs and alevins. These proposed changes are described above at the beginning of the Sacramento River section. Operations under the No Action Alternative include the same objectives, but new information on the temperature requirements of incubating Winter-Run Chinook Salmon eggs and alevins, changes in Sacramento River compliance temperatures and locations, real-time seasonal monitoring of the Winter-Run Chinook Salmon population's behavior with respect to spawning and related activities, and increased flexibility in Shasta Dam TCD operations and flow releases are expected to improve success in meeting the objectives under Alternative 1 and, thereby, increase survival of the Sacramento River Spring-Run Chinook Salmon population. The improved TCD operations under Alternative 1, as well as Rice Decomposition Smoothing, Spring Management of Spawning Locations (adaptive management experiments to test effects of release temperatures on time of spawning), Battle Creek Restoration, and Intake Lowering near Wilkins Slough, would further facilitate increased coldwater storage, resulting in greater protection of the Spring-Run Chinook Salmon population.

Alternatives 2 and 3 would likely not result in reduced temperature-related mortality of Spring-Run Chinook Salmon eggs and alevins relative to the No Action Alternative because these action alternatives protect no better than the No Action Alternative against a depleted coldwater pool (Figure 5.9-10). In contrast, Alternative 4 is expected to provide a similar level of protection to Alternative 1 (Figures 5.9-10 and 5.9-11).

Potential spawning habitat restoration changes in the availability of suitable physical habitat for Spring-Run Chinook Salmon redd construction, spawning, and egg and alevin incubation

Construction of Shasta Dam blocked recruitment of coarse gravel from upstream sources, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the upper Sacramento River. The resulting depletion of coarse gravel suitable for Spring-Run Chinook Salmon spawning is a potentially limiting factor for restoration of the Sacramento River Spring-Run Chinook Salmon population (NMFS 2014a). Alternative 1 proposes to create additional spawning habitat by injecting 15,000 to 40,000 tons of gravel between Keswick Dam and RBDD, which would potentially increase Sacramento River Spring-Run Chinook Salmon production relative to the No Action Alternative, thereby benefiting the Spring-Run Chinook Salmon population.

Alternative 2 provides no spawning habitat restoration measures beyond those currently existing under the No Action Alternative, and therefore has no effect on the Spring-Run Chinook Salmon population with regard to spawning habitat. Alternative 3 proposes the same spawning habitat restoration measures that are included in Alternative 1 and, therefore, is expected to have a potential benefit on Spring-Run Chinook Salmon relative to the No Action Alternative.

Potential changes in side channel and floodplain rearing habitat for aquatic resources

As mentioned previously, the upper Sacramento River has poor rearing habitat. The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment. Some complex, productive habitats with floodplains remain in the system and flood bypasses (i.e., Yolo and Sutter Bypasses), but the overall condition of riparian habitat for rearing juvenile salmonid is degraded (NMFS 2009). Alternative 1 and Alternative 3 propose to create 40 to 60 acres of side channel and floodplain habitat at approximately 10 sites in the Sacramento River by

2030, which would potentially increase Winter-Run Chinook Salmon production relative to the No Action Alternative, thereby benefiting the Winter-Run Chinook Salmon population.

Fall-Run Chinook Salmon does not begin spawning until about October, so incubating fall-run eggs and alevins are less vulnerable to water temperature stress than those of winter-run and spring-run. However, October and November water temperatures are frequently above the threshold for egg and alevin mortality, so the October temperature reductions expected under Alternative 1 relative to the No Action Alternative (Appendix O, Figure SR-2) would likely benefit the Fall-Run Chinook Salmon population in the Sacramento River. Fall-Run Chinook Salmon are major prey of Southern Resident Killer Whale, so any benefit from Alternative 1 would potentially benefit the killer whale population.

Alternatives 2 and 3 would likely not result in reduced temperature-related mortality of Fall-Run Chinook Salmon eggs and alevins relative to the No Action Alternative because these action alternatives protect no better than the No Action Alternative against a depleted coldwater pool (Figure 5.9-10). In contrast, Alternative 4 is expected to provide a similar level of protection to Alternative 1 (Figures 5.9-10 and 5.9-11).

California Central Valley Steelhead spawn from about November through April. Except in November, water temperatures during this period are cold enough for incubating steelhead eggs and alevins, and water temperatures are expected to be similar in all months under Alternative 1 and the No Action Alternative (Table 5.9-1). Therefore, Alternative 1 would have no impact on California Central Valley Steelhead with respect to survival of eggs and alevins. Alternative 1 would have a less-than-significant impact on steelhead juveniles and adults as well.

Southern DPS Green Sturgeon primarily spawn from April through July. Alternative 1 would potentially reduce availability of suitable spawning habitat for the Green Sturgeon relative to the No Action Alternative because Alternative 1 reductions in water temperature to protect salmonids could impinge on the upstream limit of Green Sturgeon spawning, although confidence in this conclusion is low because of uncertainty about the effects of other potentially important effects on Green Sturgeon spawning distribution. In contrast, increased water temperatures near the upstream spawning location in September of some years may benefit Green Sturgeon larvae (Table 5.9-1). As previously noted, the increased September water temperatures result from the major modification of Fall X2 flow releases. These flow reductions have a potentially significant impact on Green Sturgeon Spawning habitat.

As previously indicated, Alternatives 2 and 3 would likely not result in reduced water temperatures relative to the No Action Alternative, and therefore would have no temperature-related impact with respect to upstream spawning habitat for Green Sturgeon. However, these alternatives would also have no Fall X2 flow releases and therefore would have a potentially significant flow-related impact on spawning habitat in comparison to the No Action Alternative. The impacts on Green Sturgeon under Alternative 4 are expected to be similar level to those of Alternative 1.

5.9.1.3 *Feather River*

Potential changes in egg mortality and migrating salmonid survival due to flow and water temperatures

Model results illustrating the average flow in the Feather River below the Thermalito Afterbay for all water year types show modest differences among the action alternatives from May to August, when migrating and holding Spring-Run Chinook Salmon and Green Sturgeon are present in the Feather River HFC. Projected differences between the No Action Alternative and the action alternatives occur from December to March, with more substantial differences occurring in April under Alternative 4, overlapping a substantial portion of the egg incubation and juvenile rearing periods of Spring-Run Chinook Salmon and Central Valley Steelhead. Similarly, differences are shown from May to September coinciding with migration and holding of Spring-Run Chinook Salmon (Figure 5.9-13, Average Feather River Flow below Thermalito Afterbay for the Period October–September, Average of All Water Year Types).

Average flows under the action alternatives are slightly greater than under the No Action Alternative from December to March, so the effects on eggs and rearing juveniles would be negligible and potentially beneficial because of increased availability of habitat for these life stages. Increased flows under the action alternatives from May to June, during Spring-Run Chinook Salmon migration and holding and Green Sturgeon spawning, rearing, migration and holding, would provide potential temperature and fish passage benefits. The differences would be greatest during September of wet water years, when the average flow under the action alternatives would be 6,049 cfs to 6,256 cfs lower than flow under the No Action Alternative (Figure 5.9-14, Average Feather River Flow below Thermalito Afterbay during September in Wet Water Years).

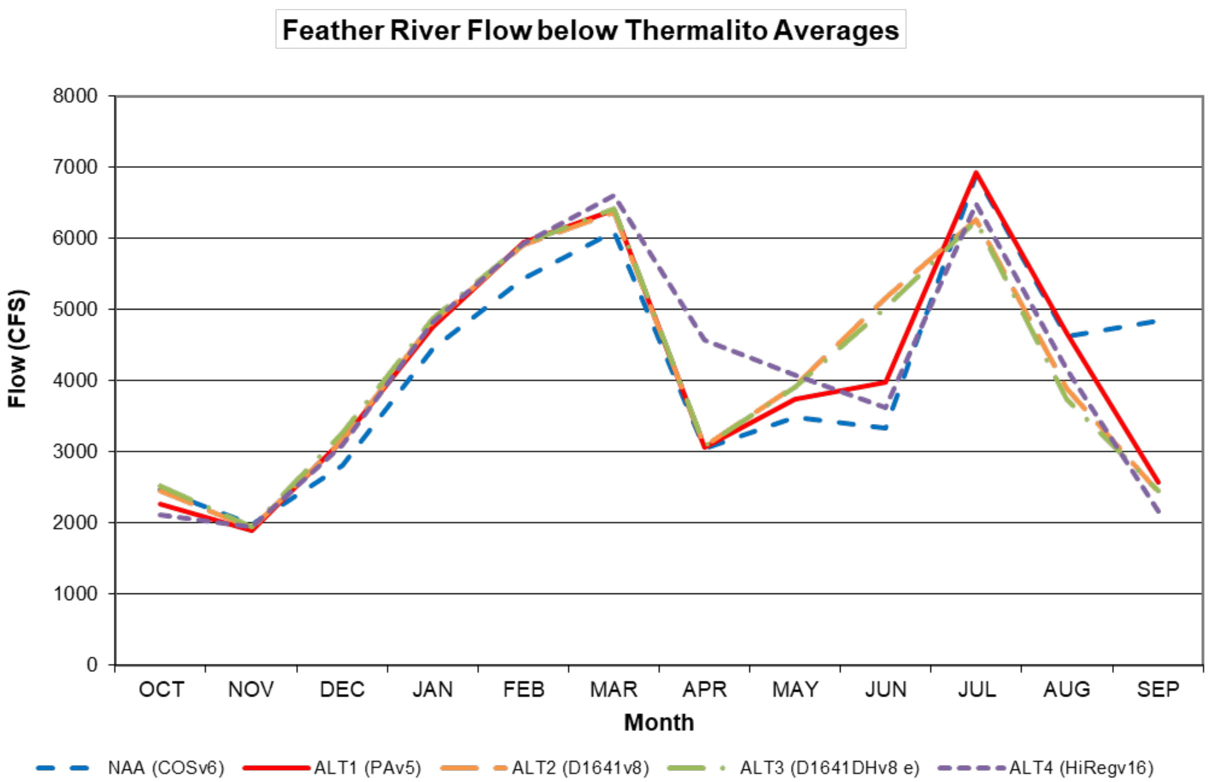


Figure 5.9-13. Average Feather River Flow below Thermalito Afterbay for the Period October–September, Average of All Water Year Types

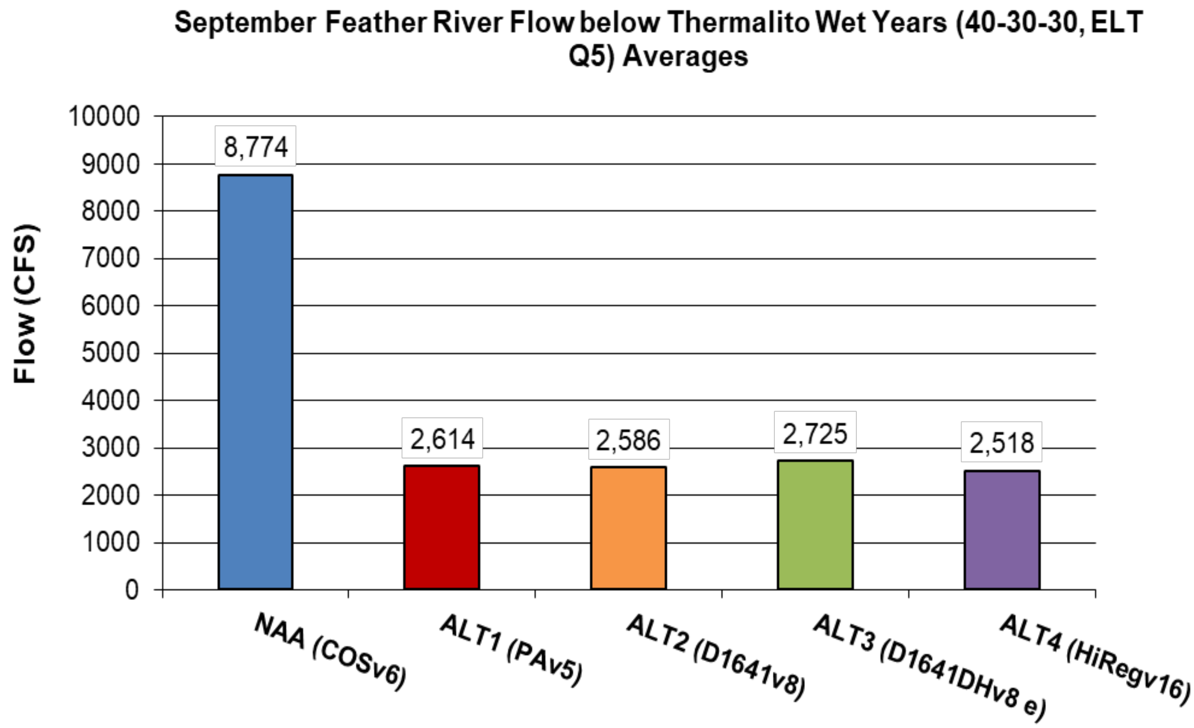


Figure 5.9-14. Average Feather River Flow below Thermalito Afterbay during September in Wet Water Years

Modeled average water temperatures from June to September under the action alternatives and the No Action Alternative (Figure 5.9-15, Average Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types) would exceed the daily average water temperature targets for the Feather River HFC, which stipulate a maximum of 64°F from June 1 to August 31 and a maximum of 61°F from September 1 to 30. During June, average modeled water temperatures under the action alternatives would be equal to or less than the No Action Alternative, but during September, average modeled water temperatures under the action alternatives would exceed those under the No Action Alternative by up to 2°F.

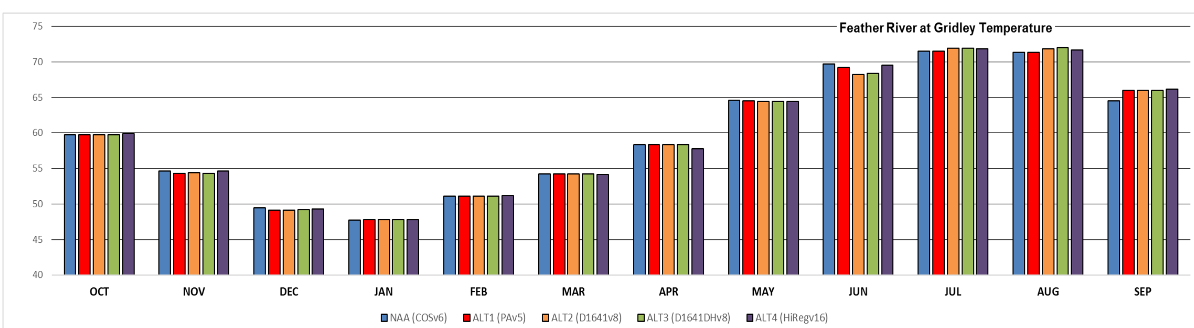


Figure 5.9-15. Average Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types

Modeled maximum water temperatures under the action alternatives and the No Action Alternative would exceed the USEPA's (2003) recommended criteria to protect salmonid life stages during a portion of the adult migration period (64°F to 68°F) for Spring-Run Chinook Salmon (June to August), and Central Valley Steelhead (September) (Figure 5.9-16, Maximum Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types). Migrating salmonid survival could be reduced from June to September due to elevated water temperatures. During these months, maximum modeled water temperatures under the action alternatives would be slightly less than the No Action Alternative. Modeled maximum water temperatures during the months of May and June would also fall into the impaired fitness or likely lethal categories for spawning, egg, and larvae life stages of Green Sturgeon.

Modeled maximum water temperatures under the action alternatives and the No Action Alternative would exceed the recommended 55°F criterion for spawning, egg incubation, and rearing (USEPA 2003) from September to November, a period of Spring-Run Chinook Salmon egg incubation and juvenile rearing, which could reduce survival of these life stages.

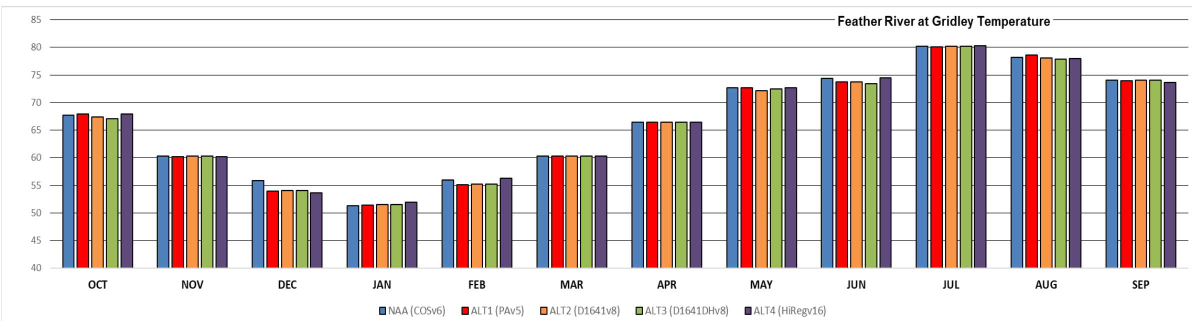


Figure 5.9-16. Maximum Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types

5.9.1.4 *American River*

Potential changes in fisheries resources due to flows and water temperatures on the American River

Flows in the American River below Nimbus Dam would be similar throughout the year in average and in wet years under the action alternatives relative to the No Action Alternative. Changes to flows would occur in dry and critically dry years under Alternative 1 with some increased flows in late winter/early spring months and in the late summer months (Figure 5.9-17, Flows in the American River below Nimbus Dam in Dry and Critically Dry Years). Increased flows in January through March would benefit steelhead by providing additional spawning habitat in dry years when the available habitat is reduced.

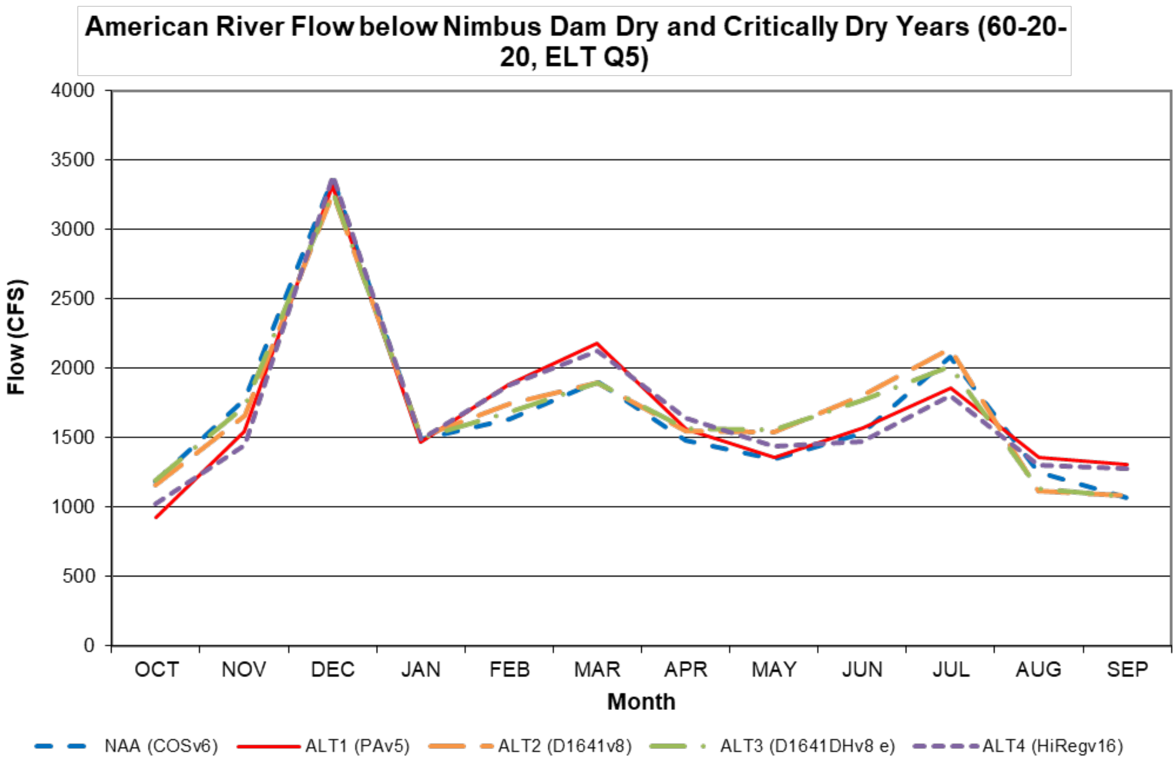


Figure 5.9-17. Flows in the American River below Nimbus Dam in Dry and Critically Dry Years

Differences in water temperatures are more a function of hydrologic conditions than operations to meet objectives, with cooler summer maximum temperatures in wet years than in dry years. Water temperatures are similar throughout the year in the lower American River under the action alternatives relative to the No Action Alternative (Figure 5.9-18, Average Temperatures at Watt Avenue on the American River) and follow the same pattern in dry years (Figure 5.9-19, Average Temperatures at Watt Avenue on the American River in Dry and Critically Dry Years), and thus the action alternatives would result in minimal if any water temperature related effects on fishery resources.

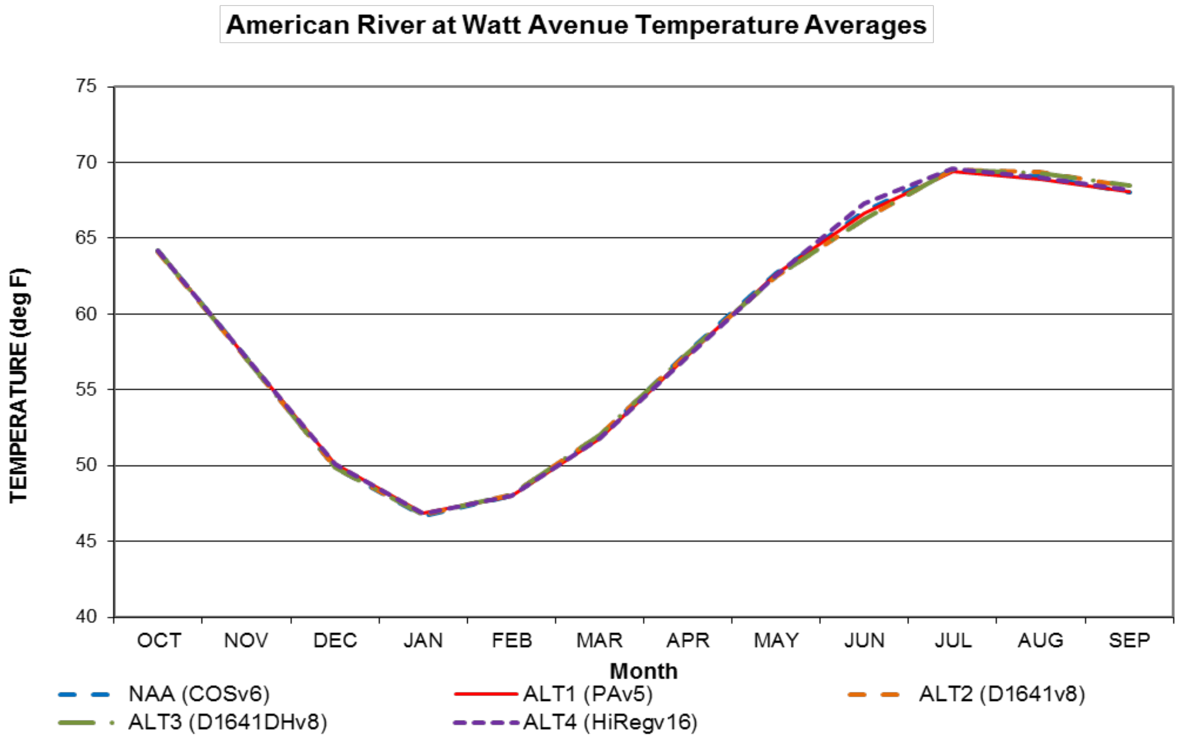


Figure 5.9-18. Average Temperatures at Watt Avenue on the American River

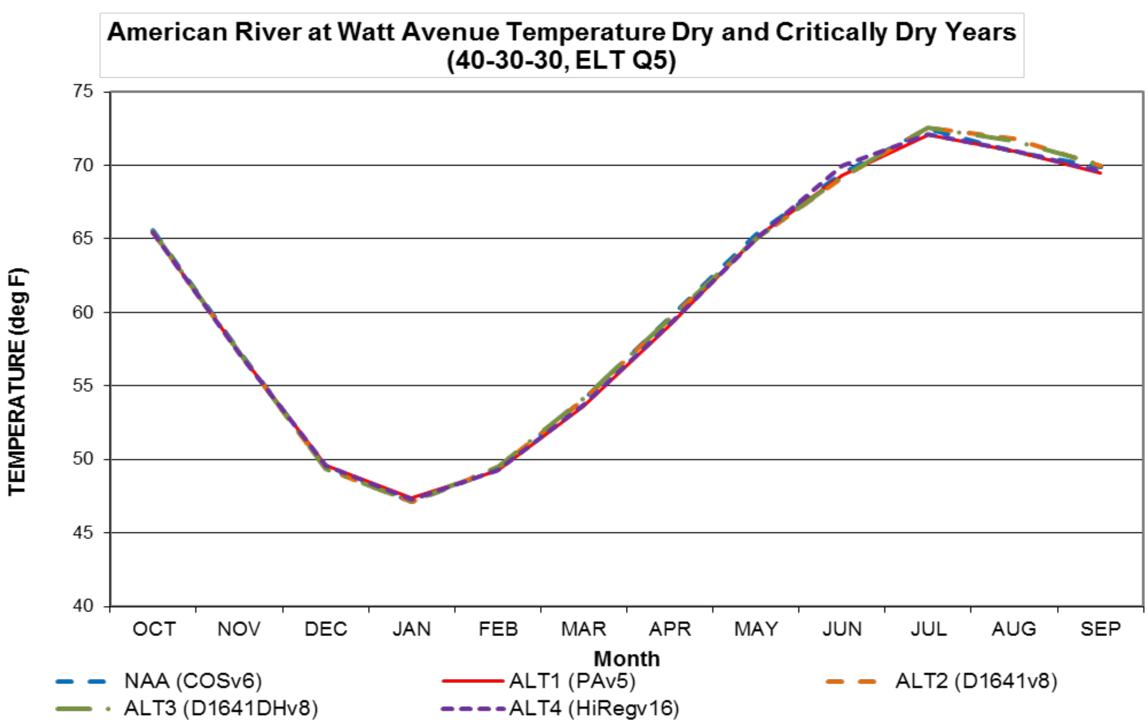


Figure 5.9-19. Average Temperatures at Watt Avenue on the American River in Dry and Critically Dry Years

5.9.1.5 *Stanislaus River*

Potential changes in suitable habitat area for juvenile salmon due to water operations on the Stanislaus River

Reclamation currently manages releases from New Melones Reservoir and flow in the Stanislaus River to meet the New Melones Reservoir year-type specific minimum flow schedule to the best of their ability, and to provide habitat for all life stages of steelhead while incorporating habitat-maintaining geomorphic flows in a pattern that provides smolts with migratory cues and facilitates out-migrant movement. Stanislaus River flows below Goodwin Dam and at the mouth under the SRP under Alternative 1 would be slightly reduced but generally similar to the No Action Alternative (Figures 5.9-20, Stanislaus River Average Minimum Flow below Goodwin Dam, and 5.9-21, Average Monthly Flow at the Mouth of the Stanislaus River). Spawning and rearing habitat restoration activities proposed under Alternative 1 are anticipated to beneficially affect fish populations in these reaches. Flows under Alternatives 2 and 3 are the same and would be substantially reduced below Goodwin Dam from February through September, and at the mouth of the Stanislaus River from March through May, compared to the No Action Alternative. Reduced flows under Alternatives 2 and 3 would likely result in reductions to suitable habitat area for juvenile salmonids.

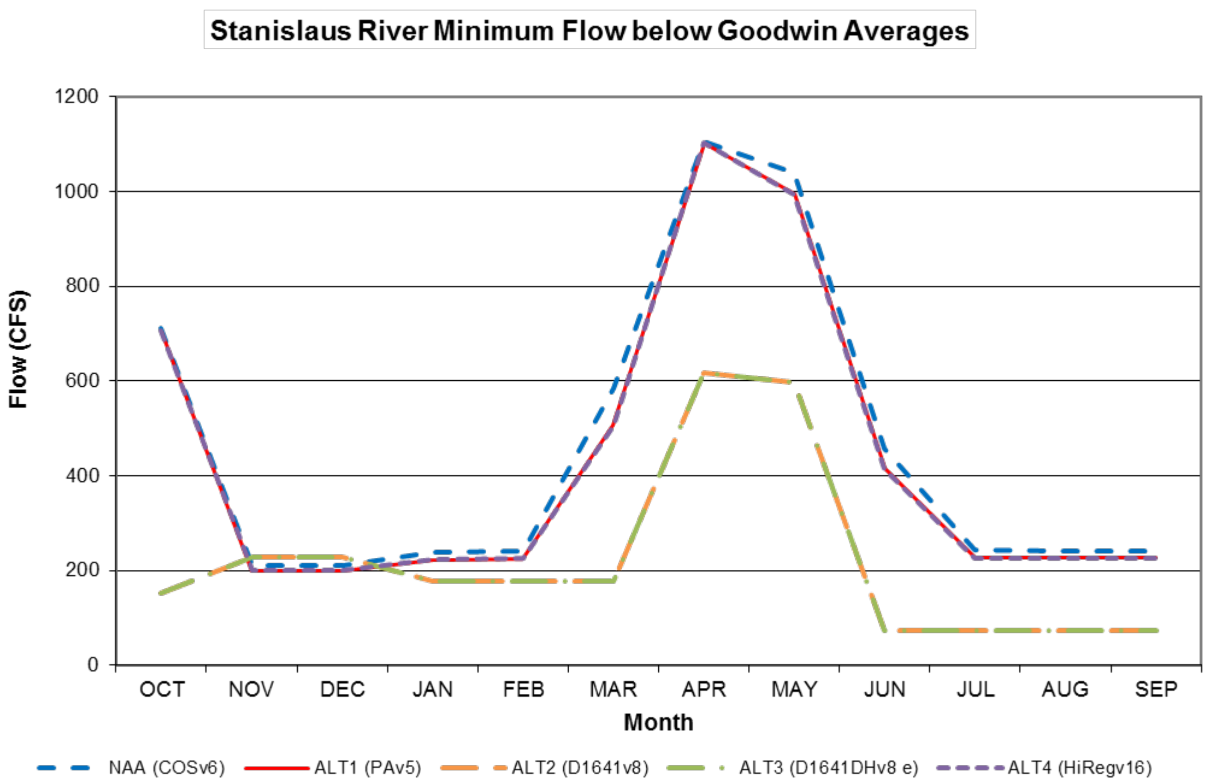


Figure 5.9-20. Stanislaus River Average Minimum Flow below Goodwin Dam.

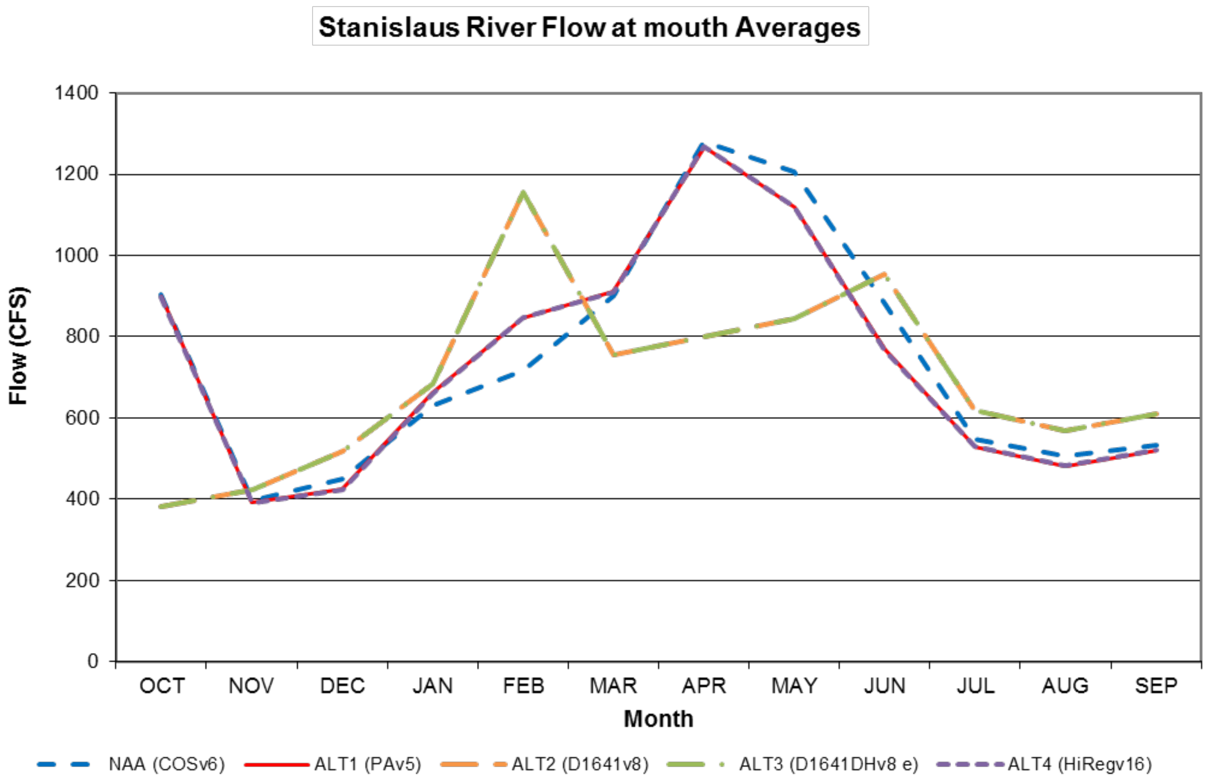


Figure 5.9-21. Average Monthly Flow at the Mouth of the Stanislaus River.

Potential changes in the amount of suitable habitat due to water operations on the Stanislaus River and temperature conditions

Water temperatures in the Stanislaus River are affected by maintenance of the coldwater pool in New Melones Reservoir and air temperatures. The release intake structure at New Melones Dam is static, so the only means to increase the coldwater pool in the reservoir is by increasing storage. Compared to the No Action Alternative, Alternatives 1 through 3 increase the annual storage and, therefore, the size of the coldwater pool in New Melones Reservoir, with the largest storage quantities occurring under Alternatives 2 and 3. Temperature modeling for the Stanislaus River at Ripon shows that there is a small increase in overall annual water temperature for Alternatives 1 through 3 relative to the No Action Alternative. Reduced flows in above normal water years and normal water years may increase water temperatures in these less critical hydrologic conditions, however, this promotes additional storage at New Melones Dam for potential future droughts and preserving the coldwater pool to benefit downstream salmonids. The increased storage at New Melones Dam for Alternatives 1 through 3 increases the coldwater pool available for downstream salmonids through warmer months and may lower water temperatures downstream of Godwin Dam, in more critical lower water year types. Monthly average water temperature modeling shows that Alternatives 2 and 3 are warmer at Ripon from March through May, but cooler from July through September relative to the No Action Alternative. Alternative 1 is slightly warmer than the No Action Alternative from May through September and results in the highest relative water temperature in July (Figure 5.9-22, Average Monthly Temperature at Ripon on the Stanislaus River). Juvenile salmonids rear and out-migrate during the February through May period and may be exposed to warmer conditions during a more sensitive life stage. During July through September, Central Valley Steelhead and possibly Spring-Run Chinook Salmon adults may hold in the river, and warmer conditions may incrementally reduce the amount of suitable holding habitat available.

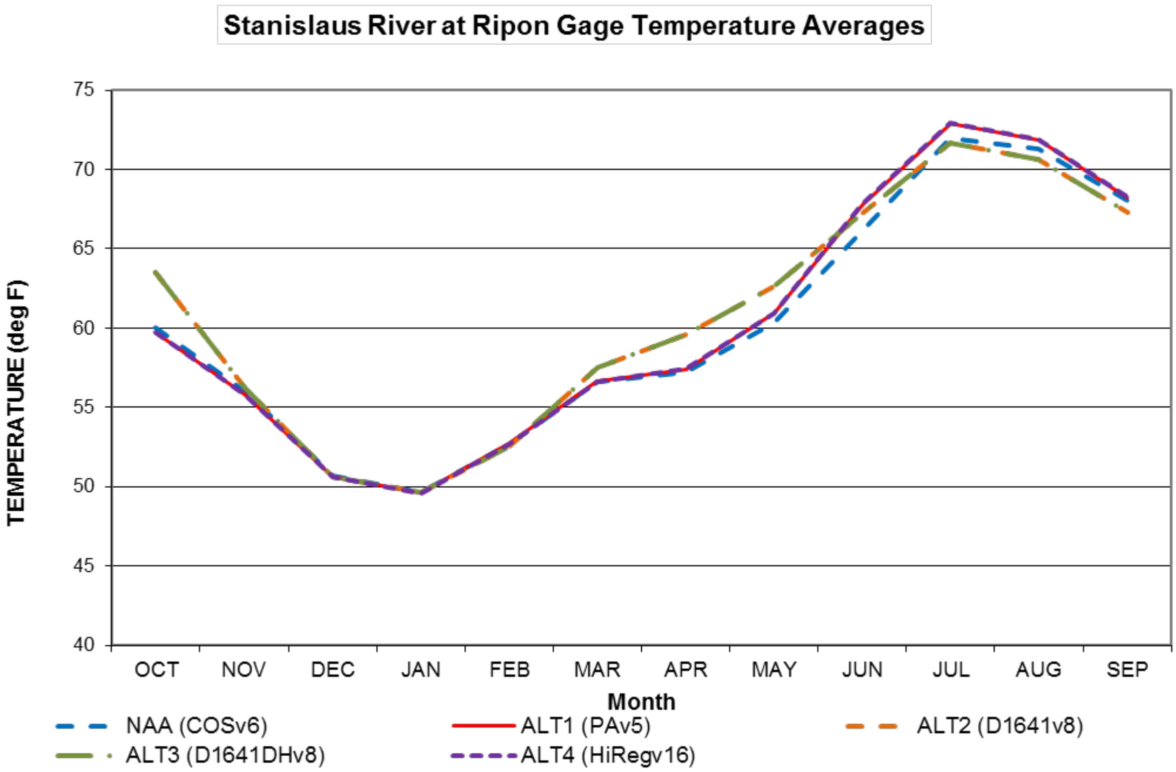


Figure 5.9-22. Average Monthly Temperature at Ripon on the Stanislaus River

Potential changes to aquatic resources due to changes to the compliance point and changes to temperature and dissolved oxygen

Current operations are required to meet a year-round dissolved oxygen minimum of 7 mg/L, from June 1 to September 30 in the Stanislaus River at Ripon to protect salmon, steelhead, and trout in the river (CDFW 2018). Under existing conditions, it is challenging to maintain dissolved oxygen concentrations above 7 mg/L during drought conditions, and based on recent studies, does not appear to be warranted to protect salmonids in the river (Kennedy and Cannon 2005; Kennedy 2008). Alternatives 2 and 3 maintain this requirement, so no changes to dissolved oxygen management would occur under those scenarios relative to the No Action Alternative. Alternative 1 maintains the minimum of 7 mg/L from June 1 to September 30, but proposes moving the compliance point location to Orange Blossom Bridge. The proposed temperature compliance point is protective of salmonids because the majority of salmonid eggs, alevin, and/or fry are found in locations where summer dissolved oxygen levels would be expected to be maintained at or near 7 mg/L. However, based on the typical seasonal occurrence of the adult life stages in the river (July to October), adult migrating salmonids would potentially be exposed to the effects of relaxing dissolved oxygen requirements at Ripon.

Potential changes to salmonid habitat from habitat restoration

The No Action Alternative and Alternative 2 do not include habitat restoration activities, so there would be no changes to habitat in the Stanislaus River under these scenarios. Alternatives 1 and 3 include spawning and habitat restoration activities in the Stanislaus River that would result in construction-related temporary disturbance to habitat and may expose nearby fish to stressful conditions. However, through coordination with the regulatory agencies and implementation of avoidance and minimization measures, including the implementation of an in-water work window from July 15 through October 15, effects on the particular life stages would be minimized or avoided. Although construction may temporarily affect certain fish species and their habitat, restoration of spawning and rearing habitat would result in long-term improvements to the habitat and aquatic inhabitants, including an increase in riparian vegetation providing instream objects and overhanging object cover, new shaded riverine habitat, and additional areas for food sources.

5.9.1.6 *San Joaquin River*

Potential changes to aquatic resources from water project operations

Analyses of flow for Alternatives 1 through 3 compared to the No Action Alternative show that releases in the San Joaquin River below Millerton Reservoir would remain the same for all scenarios. Therefore, no change is anticipated as a result in the upper San Joaquin River. Flow at Vernalis in the San Joaquin River represents all contributions from the upper San Joaquin, Merced, Tuolumne, and Stanislaus Rivers combined. However, overall, Alternatives 1 through 3 would not result in a substantial change in flow at Vernalis relative to the No Action Alternative. Average flows would follow the same general trend, rising early in the year to peak in spring and then generally decreasing. The differences in annual average flow between each alternative is within 50 cfs, representing no greater than 1.1% variation between all action alternatives (Figure 5.9-23, January–December San Joaquin River Flow at Vernalis Averages). By water year type, analysis of the action alternatives are again very similar, therefore substantial variation between all action alternatives is not expected.

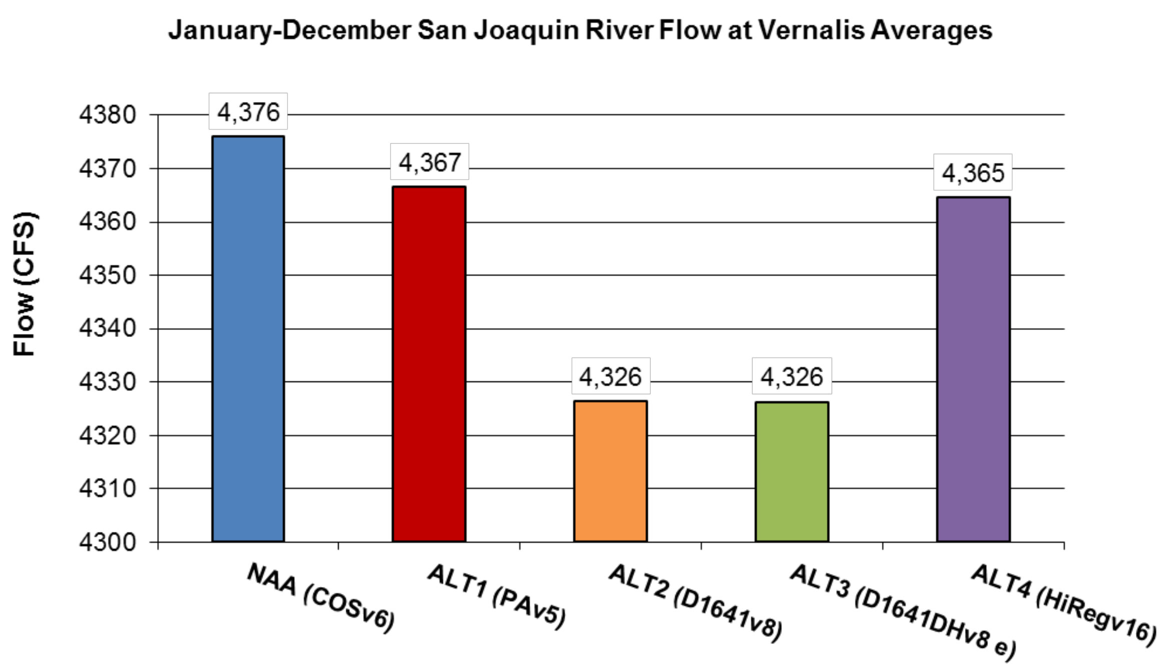


Figure 5.9-23. January–December San Joaquin River Flow at Vernalis Averages.

There would be no changes in outflow release from Friant Dam at Millerton Lake under any of the action alternatives. Therefore, temperature changes as a result of flow or storage are not expected in the upper San Joaquin River. Additionally, given the low variation in flow in the San Joaquin River at Vernalis between the action alternatives, modeled temperatures there are not substantially different under any of the action alternatives (Figure 5.9-24, Average Monthly Water Temperature at Vernalis by Project Alternative).

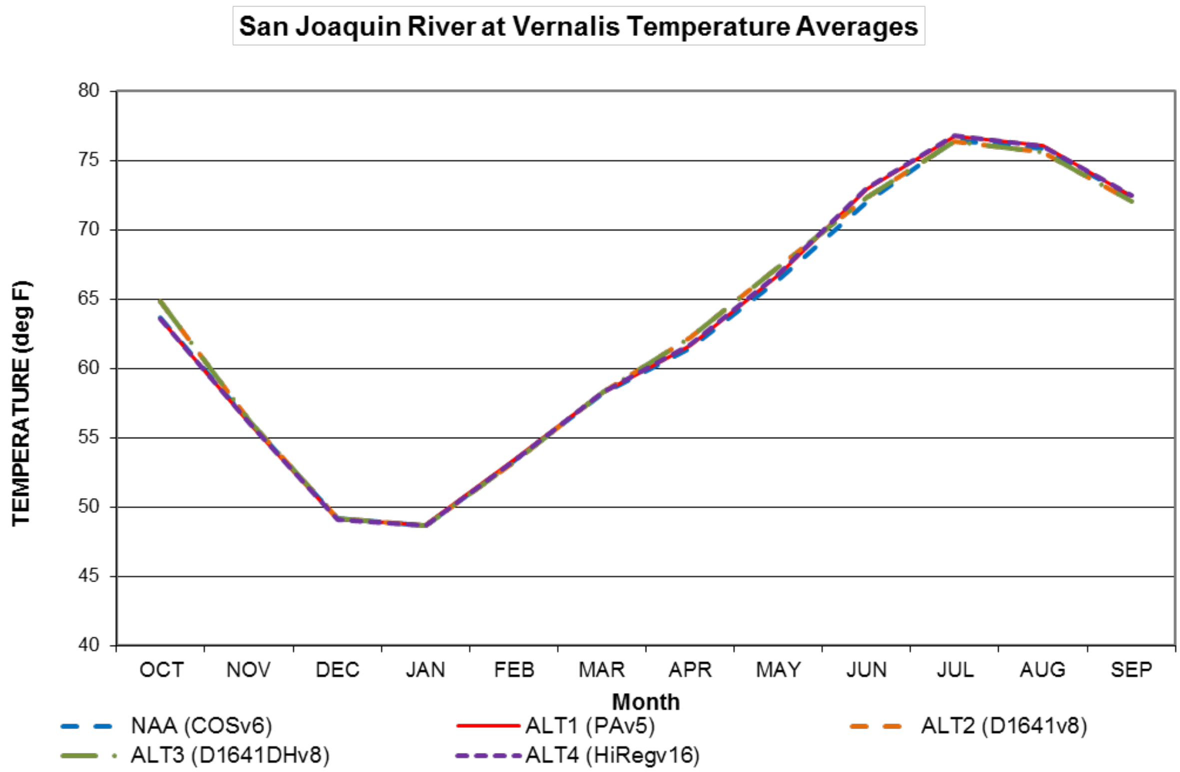


Figure 5.9-24. Average Monthly Water Temperature at Vernalis by Project Alternative.

No habitat restoration activities are included in the No Action Alternative or Alternative 2; therefore, no changes in habitat in the lower San Joaquin River would occur under those alternatives. Alternatives 1 and 3 include a provision for rearing habitat restoration in the lower San Joaquin River. The timing and temporary nature and of restoration activities would limit the potential for lasting impacts on the surrounding aquatic community, and the benefit of the restoration would likely result in long-term improvements to the habitat and aquatic inhabitants.

5.9.1.7 *Bay-Delta*

5.9.1.7.1 Sacramento Winter-Run Chinook Salmon

Potential changes to risk of entrainment at the export facilities from water project operations

*N*egative effects from increased entrainment probability in the spring would likely be offset by increased flow in the Sacramento River mainstem during spring, which would increase survival and reduce routing into the interior Delta where survival is lower regardless of flows.

Under Alternatives 1, 2 and 3, CVP and SWP exports increase during the migration window for juvenile Winter-Run Chinook Salmon whereas exports under Alternative 4 for are similar to the No Action Alternative. Salvage and loss of juvenile Winter-Run Chinook have been shown to increase as exports increase. However, only a small proportion of the total population is lost at the export facilities. Increased flow in the Sacramento River mainstem would occur under all action alternatives and higher flow has been shown to increase through-Delta survival of juvenile Chinook Salmon and reduce routing into the interior Delta at Georgiana Slough. The Sacramento River mainstem is the primary migration route for juvenile Winter-Run Chinook Salmon, thus a much greater proportion of the population would be exposed to the positive effects of greater Sacramento River flows than would be exposed to the negative effects of increased exports. Under all action alternatives flows in the Sacramento River would be greater during the Winter-Run migration period which would increase survival and reduce routing into the interior Delta at Georgiana Slough (Perry et al 2015)

5.9.1.7.2 Central Valley Spring-Run Chinook Salmon

Potential changes to juvenile Spring-Run Chinook Salmon entrainment at export facilities from water project operations

For Sacramento River-origin Spring-Run Chinook Salmon, negative effects from increased entrainment probability in the spring would likely be offset by increased flow in the Sacramento River mainstem during spring, which would increase survival and reduce routing into the interior Delta where survival is lower regardless of flows. For San Joaquin River-origin Spring-Run Chinook Salmon, salvage, and thus entrainment, is likely to be higher with greater exports. However, salvage at the TFCF has been shown to be a relatively high survival route compared to the San Joaquin River when the Head of Old River Barrier is out (Buchanan et al. 2018).

Under action alternatives 1-3, exports increase during the migration window for juvenile Spring-Run Chinook Salmon whereas exports under Alternative 4 are similar to the No Action Alternative. Salvage and loss of juvenile Chinook Salmon has been shown to increase as exports increase. However, only a small proportion of the total Sacramento River-origin population is lost at the export facilities. Increased flow in the Sacramento River mainstem would occur under all action alternative and higher flow has been shown to increase through-Delta survival of juvenile Chinook Salmon and reduce routing into the interior Delta at Georgiana Slough. The Sacramento River mainstem is the primary migration route for juvenile Sacramento River-origin Spring-Run Chinook Salmon thus, many more individuals would be exposed to the positive effects of greater Sacramento River flows than would be exposed to the negative effects of increased exports. San Joaquin River-origin juvenile Spring-Run Chinook Salmon are likely to be entrained at the salvage facilities at higher rates under Alternatives 1-3 and similar under Alternative 4. Acoustic tagging studies indicate that when the Head of Old River Barrier is out, greater than 60% of fish that successfully migrate through the Delta do so via the . TFCF (Buchanan et al. 2018).

5.9.1.7.3 Central Valley Fall-Run Chinook Salmon

Potential changes to juvenile Fall-Run Chinook Salmon entrainment at export facilities from water project operations

For Sacramento River-origin Fall-Run Chinook Salmon, negative effects from increased entrainment probability in the spring would likely be offset by increased flow in the Sacramento River mainstem during spring, which would increase survival and reduce routing into the interior Delta where survival is lower regardless of flows. For San Joaquin River-origin Fall-Run Chinook Salmon, salvage is likely to be higher with greater exports. Additionally, lower velocities in the south Delta may reduce migration rates, which may also reduce survival. However, salvage at the TFCF has been shown to be a relatively high survival route compared to the San Joaquin River or Old River.

Under action alternatives 1-3 , exports increase during the migration window for juvenile Fall-Run Chinook Salmon whereas exports under Alternative 4 are similar to the No Action Alternative. Salvage and loss of juvenile Chinook Salmon has been shown increase as exports increase. However, only a small proportion of the total Sacramento River-origin population is lost at the export facilities. Increased flow in the Sacramento River mainstem would occur under all action alternatives and higher flow has been shown to increase through-Delta survival of juvenile Chinook Salmon and reduce routing into the interior Delta at Georgiana Slough. The Sacramento River mainstem is the primary migration route for juvenile Sacramento River-origin Fall-Run Chinook Salmon, thus a much great proportion of the population would be exposed to the positive effects of greater Sacramento River flows than would be exposed to the negative effects of increased exports. San Joaquin River-origin juvenile Fall-Run Chinook Salmon are likely to be entrained at the salvage facilities at higher rates under all action alternatives. Acoustic tagging studies indicate that when the Head of Old River Barrier is out, greater than 60% of fish that successfully migrate through the Delta have been salvaged at the TFCF and trucked to the western Delta (Buchanan et al. 2018).

5.9.1.7.4 California Central Valley Steelhead

Potential changes to juvenile California Central Valley Steelhead entrainment at export facilities from water project operations

For Sacramento River-origin fish, negative effects from increased entrainment probability during their migration period would likely be offset by increased flow in the Sacramento River mainstem, which would increase survival and reduce routing into the interior Delta where survival is lower regardless of flows. For San Joaquin River-origin California Central Valley Steelhead, salvage is likely to be higher with greater exports. Additionally, lower velocities in the south Delta may reduce migration rates, which may also reduce survival. However, salvage and trucking of juvenile steelhead from the TFCF has been shown to result in relatively higher survival than volitional migration in some years (Buchanan et al. 2018).

Under all of the action alternatives, exports increase during the migration window for juvenile California Central Valley Steelhead. Salvage of steelhead has been shown to increase as exports increase. Increased flow in the Sacramento River mainstem would occur under Alternatives 1, 2, and 3 and higher flow has been shown to increase through-Delta survival of juvenile Chinook Salmon and reduce routing into the interior Delta at Georgiana Slough. We assume that survival of Central Valley Steelhead would also increase because of increased flow and reduced routing into the interior Delta at Georgiana Slough. The Sacramento River mainstem is the primary migration route for juvenile Sacramento River-origin Central Valley Steelhead, thus a much greater proportion of the population would be exposed to the positive effects of greater Sacramento River flows than would be exposed to the negative effects of increased exports. San Joaquin River-origin juvenile Central Valley Steelhead are likely to be entrained at the salvage facility at higher rates under all of the action alternatives relative to the No Action Alternative. Acoustic tagging studies indicate that under certain conditions, salvage at the TFCF and trucking to the western Delta can result in survival similar to volitional migration.

5.9.1.7.5 North American Green Sturgeon Southern DPS

Potential changes in juvenile North American Green Sturgeon from water project operations

Higher exports may increase entrainment risk for Alternative 1-3; however, few Green Sturgeon are salvaged at the CVP and the south Delta is not predicted to be preferred habitat for this species. Potentially negative effects could be offset by tidal habitat restoration in the Delta where Green Sturgeon reside for multiple years prior to ocean entry.

There is a large amount of uncertainty regarding potential effects of operational changes on Green Sturgeon. Little is known about linkages between Green Sturgeon ecology, habitat conditions, and project operations. Green Sturgeon use the Delta for rearing over multiple years and only rarely appear at the salvage facilities. Increasing exports under the three alternatives may increase salvage but without information on the total number of Green Sturgeon potentially available for salvage, the proportion of the population potentially affected cannot be estimated.

Green Sturgeon juveniles reside in the Delta for 1 to 3 years, suggesting they encounter a variety of daily, seasonal, and annual hydrological conditions. The majority of Green Sturgeon likely use habitats in the Delta for rearing and foraging rather than solely migrating through. NMFS (2009:338) suggested Green Sturgeon are more likely to be found in the main channels and interconnecting sloughs of the western Delta relative to the south Delta, where the export facilities are located. Velocity overlap between the three alternatives and the No Action Alternative was high in the western Delta, which suggests hydrology within the region Green Sturgeon are thought to inhabit would change very little under any of the Alternatives.

5.9.1.7.6 Delta Smelt

Potential changes to Delta Smelt entrainment risk, food availability, low salinity zone habitat extent, and population abundance from water operations and introduction of captive-bred Delta Smelt

Changes in winter/spring water operations could change entrainment risk for Delta Smelt at the south Delta water export facilities. Under Alternative 1, potentially lower Old and Middle River (OMR) flows would be managed through protective criteria such as real-time adjustments to operations in response to physical and biological criteria in order to limit entrainment risk. Under Alternatives 2 and 3, seasonal operations to D-1641 criteria may appreciably increase entrainment risk. Under Alternative 4, greater OMR flow may reduce entrainment risk.

Reductions in Delta outflow during spring, summer, and fall could negatively affect Delta Smelt food availability in the Suisun Bay and Marsh region although there is some uncertainty in the extent to which outflow changes of the magnitude predicted under Alternatives 1, 2, and 3, relative to the No Action Alternative would change food availability relative to outflow changes attributable to hydrological conditions (i.e., wetter vs. drier years). Reductions in Delta outflow during spring, summer and fall could also reduce the surface area of low salinity zone water (i.e., salinities between 1 and 6) under Alternatives 1, 2, and 3, relative to the No Action Alternative. Alternative 1 includes a Delta Smelt summer-fall habitat action to manage summer-fall habitat elements that contribute to the recovery of the species. Alternative 4's water operations have the potential to increase food availability in the Suisun Bay and Marsh region in spring and summer although there is some uncertainty in the extent to which outflow changes of the magnitude predicted under Alternatives 4 relative to the No Action Alternative would change food availability relative to outflow changes attributable to hydrological conditions (i.e., wetter vs. drier years). Alternative 4's water operations also have the potential to decrease the surface area of low salinity zone water in fall relative to the No Action Alternative.

Reintroduction of captive-bred Delta Smelt from the existing Fish Conservation and Culture Laboratory under Alternatives 1 and 3 would potentially subsidize the population increasing population abundance. All appropriate mitigation measures will be taken to minimize risks of potential negative effects such as propagation and spread of nuisance species.

5.9.1.7.7 Longfin Smelt

Potential changes to Longfin Smelt abundance and south Delta entrainment risk

Reductions in winter/spring Delta outflow under Alternatives 1 through 3 have the potential to negatively affect the population abundance of Longfin Smelt given observed outflow-abundance relationships, although there is some uncertainty in the extent to which outflow changes of the magnitude possible with water operations would change abundance relative to outflow changes attributable to hydrological conditions (i.e., wetter vs. drier years). Changes in OMR management under Alternatives 1 through 3 could increase Longfin Smelt south Delta entrainment risk, although historical observations suggest that proportional losses would be limited Greater spring OMR flow and Delta outflow under Alternative 4 could reduce Longfin Smelt entrainment risk and positively affect population abundance, with the same uncertainty as described above for potential negative effects from the other alternatives.

5.9.1.8 *Nearshore Pacific Ocean of the California Coast*

5.9.1.8.1 Southern Resident Killer Whale

Potential changes in Southern Resident Killer Whale's Chinook Salmon prey

Changes in water operations under the alternatives could have the potential to affect Chinook Salmon prey of Southern Resident Killer Whale. Such effects generally would be expected to be limited because of the medium priority of Central Valley Chinook Salmon stocks in the diet of Southern Resident Killer Whale, plus the relatively high representation in the stocks by hatchery-origin fish, many which are released downstream of the Delta and therefore downstream of the influence of water operations. Alternatives 2 and 3 may have more potential for negative effects than the other alternatives because of water operations criteria that largely focus on measures such as D-1641 without additional features such as the OMR operations included in Alternative 1 and percentage of unimpaired flow included in Alternative 4, although in general there is uncertainty in the potential for effect.

5.9.2 Program-Level Effects

5.9.2.1 *Sacramento River*

Potential changes in rearing and emigrating Winter-Run Chinook Salmon juveniles from restoration by changing food production and protection from predators, high velocity flow, and other potential stressors

Potential changes to emigrating juvenile salmonids in the Sacramento River by entrainment

Potential change in migration habitat for emigrating Winter-Run Chinook Salmon during summer and fall

Alternative 1 includes two programmatic components that would potentially improve rearing habitat for juvenile salmonids rearing and migrating in the upper Sacramento River. These include creation of 40 to 60 acres of side channel habitat at no fewer than 10 sites, and a small diversion screen program to install fish screens on unscreened or poorly screened diversions. The increased side channel habitat would provide rearing and emigrating juvenile salmonids with increased diversity of habitat elements, greater and more diverse food resources, cover from predators, and bioenergetic benefits from reduced flow velocities. Potential adverse effects of the increased channel habitat are greater risks of stranding with reductions in water level and rapid changes water temperature and dissolved oxygen level. The potential benefits of the increased side-channel habitat are expected to outweigh the potential adverse effects.

The small screen program would improve juvenile habitat by reducing mortality and injury from unscreened and poorly screened diversions. Most large diversions on the Sacramento River have already been screened. However, there are many small diversions that are unscreened and potentially entrain juvenile salmon or have screens that perform poorly and may entrain or injure the fish. Installing screens that meet NMFS and CDFW criteria on these diversions would potentially reduce mortality of the juveniles and thereby benefit the Winter-Run population

The two habitat restoration components, increased side channel habitat and screening of small diversions, are expected to benefit the Winter-Run population. Therefore, Alternative 1 potentially benefits the Winter-Run Chinook Salmon population relative to the No Action Alternative. Alternative 3 also includes these two components, so this alternative would also benefit the Winter-Run Chinook Salmon population relative to the No Action Alternative, but Alternative 2 does not include these components and is not expected to affect Winter-run juvenile rearing and migration habitat relative to the No Action Alternative.

Potential changes in rearing and emigrating Spring-Run juveniles from rearing habitat restoration

Alternative 1 includes a programmatic component to create 40 to 60 acres of side channel habitat at no fewer than 10 sites in the upper Sacramento River. The increased side channel habitat would provide rearing and emigrating juvenile salmonids with increased diversity of habitat elements, greater and more diverse food resources, refuge from predators, and bioenergetic benefits from reduced flow velocities. Potential adverse effects of the increased channel habitat are greater risks of stranding with reductions in water level, and rapid changes in water temperature and dissolved oxygen level. The potential benefits of the increased side-channel habitat are expected to outweigh the potential adverse effects. The restored side-channel habitat would also benefit juvenile Spring-Run from streams tributary to the upper Sacramento River (e.g., Clear Creek) that use the Sacramento River mainstem during their emigration to the Delta.

Alternative 1 potentially benefits the Sacramento River Spring-Run Chinook Salmon population, as well as tributary Spring-Run populations, relative to the No Action Alternative. Alternative 3 also includes the side-channel habitat restoration component, so this alternative would also benefit the Spring-Run Chinook Salmon population relative to the No Action Alternative, but Alternative 2 does not include this component and is not expected to affect Spring-Run Chinook Salmon juvenile rearing and migration habitat relative to the No Action Alternative.

Note that the small diversion screen program of Alternative 1, which was previously identified as a major migration habitat improvement for juvenile Winter-Run Chinook Salmon, is not expected to substantially affect Spring-Run Chinook Salmon migration habitat because Sacramento River Spring-Run Chinook Salmon juveniles typically emigrate from the Sacramento River during late fall through mid-spring; during most of that time the unscreened diversions do not operate.

5.9.2.2 *American River*

Potential changes to salmonid habitat from habitat restoration

No additional habitat restoration is proposed under the No Action Alternative or Alternative 2, therefore, there would be no changes to habitat in the lower American River for these alternatives. Alternatives 1 and 3 include implementation of spawning and rearing habitat projects in the American River and its tributaries. These habitat projects would result in improved habitat conditions in the American River, including increased total spawning habitat area, increased and improved side channel habitat, improved intragravel incubation conditions, increased and improved total rearing habitat area, improved overall habitat complexity, and cover and refugia.

5.9.2.3 *Bay-Delta*

5.9.2.3.1 Sacramento Winter-Run Chinook Salmon

Potential changes to juvenile Winter-Run Chinook Salmon rearing in the Delta from tidal habitat restoration

The proposed 8,000 acres of tidal habitat restoration of the No Action Alternative and 25,000 acres of Alternatives 1 and 3 may provide enhanced availability and quality of rearing habitat for Winter-Run Chinook Salmon rearing in the Delta. Variable fractions of each juvenile cohort leave their natal habitat as fry and rear in the Delta for weeks to months prior to entering the ocean. Enhanced food production in restored habitat may increase growth rates of these fish and physical habitat improvements can provide refuge from predators in the Delta.

Potential changes in survival of migrating juvenile Winter-Run Chinook Salmon from removal of predator hot spots

Measures proposed as components of Alternative 1 have the potential to reduce predation. A reduction in predation at key locations identified as predation hot spots has the potential to increase through-Delta survival for juvenile Winter-Run Chinook Salmon during their migration. There is considerable uncertainty about the efficacy of predator management for increasing salmonid survival and potential benefits from this action.

5.9.2.3.2 Central Valley Spring-Run Chinook Salmon

Potential changes in juvenile Spring-Run Chinook Salmon rearing in the Delta from tidal habitat restoration

The proposed 8,000 acres of tidal habitat restoration in the No Action Alternative and 25,000 acres Alternatives 1 and 3 may provide enhanced availability and quality of rearing habitat for Spring-Run Chinook Salmon rearing in the Delta. Variable fractions of each juvenile cohort leave their natal habitat as fry and rear in the Delta for weeks to months prior to entering the ocean. Enhanced food production in restored habitat may increase growth rates of these fish and physical habitat improvements can provide refuge from predators in the Delta.

Potential removal of predator hot spots changing the survival of migrating juvenile Spring-Run Chinook Salmon

A reduction in predation at key locations identified as predation hot spots has the potential to increase through-Delta survival for juvenile Spring-Run Chinook Salmon during their migration. There is considerable uncertainty about the efficacy of predator management for increasing salmonid survival and potential benefits from this action.

5.9.2.3.3 Central Valley Fall-Run Chinook Salmon

Potential changes in juvenile Fall-Run Chinook Salmon rearing in the Delta from tidal habitat restoration

The proposed 8000 acres of tidal habitat restoration in Alternative 1 and additional 25,000 acres in Alternative 3 may provide enhanced availability and quality of rearing habitat for Fall-Run Chinook Salmon rearing in the Delta. Variable fractions of each juvenile cohort leave their natal habitat as fry and rear in the Delta for weeks to months prior to entering the ocean. Enhanced food production in restored habitat may increase growth rates of these fish and physical habitat improvements can provide refuge from predators in the Delta.

Potential changes in survival of migrating juvenile Fall-Run Chinook Salmon from removal of predator hot spots

A reduction in predation at key locations identified as predation hot spots has the potential to increase through-Delta survival for juvenile Fall-Run Chinook Salmon during their migration. There is considerable uncertainty about the efficacy of predator management for increasing salmonid survival and potential benefits from this action.

5.9.2.3.4 Central Valley Steelhead

Potential changes to the survival of migrating juvenile Central Valley Steelhead from removal of predator hot spots

A reduction in predation at key locations identified as predation hot spots has the potential to increase through-Delta survival for juvenile Central Valley Steelhead during their migration. There is considerable uncertainty about the efficacy of predator management for increasing salmonid survival and potential benefits from this action.

5.9.2.3.5 North American Green Sturgeon southern DPS

Potential changes in juvenile Green Sturgeon rearing in the Delta from tidal habitat restoration

Green Sturgeon reside in the Delta for one to three years before migrating to the ocean. The proposed 8,000 acres of tidal habitat restoration in Alternative 1 and the additional 25,000 acres in Alternative 3 has the potential to benefit these rearing Green Sturgeon by providing enhanced food production and physical habitat. The potential benefits likely depend on the location of restored habitat relative to the distribution of juvenile Green Sturgeon in the Delta.

5.9.2.3.6 Delta Smelt

Potential changes to Delta Smelt food availability, habitat extent, and population abundance from tidal habitat restoration, food subsidies, and reintroduction of captive-bred Delta Smelt

Completion of 8,000 acres of tidal habitat restoration under Alternative 1 potentially would contribute to offsetting negative operational effects, with additional offsetting provided by various programmatic food subsidy studies under Alternatives 1 and 3 (North Delta/Colusa Basin Drain; Sacramento Deep Water Ship Channel; Suisun Marsh Roaring River Distribution System). Alternative 3 would include an additional 25,000 acres of habitat that could provide additional positive effects on food availability and habitat extent, with all tidal habitat restoration requiring minimization of potential contaminant effects.

Reintroduction of Delta Smelt from the Delta Fish Species Conservation Hatchery could increase population abundance.

5.9.2.3.7 Longfin Smelt

Potential changes in food availability and habitat suitability for Longfin Smelt from tidal habitat restoration

Completion of 8,000 acres of tidal habitat restoration under Alternatives 1 through 3 potentially would contribute to offsetting negative operational effects on Longfin Smelt from reduced winter/spring Delta outflow and increased south Delta entrainment risk; Alternative 3 would include an additional 25,000 acres of habitat that could provide additional positive effects on food availability and habitat extent, with all tidal habitat restoration requiring minimization of potential contaminant effects. Alternative 4 also includes completion of the 8,000 acres of restoration, =as well as greater Delta outflow during the winter/spring, so Alternative 4 has the potential for positive effects for Longfin Smelt as compared to the No Action Alternative. The potential effects of tidal habitat restoration on Longfin Smelt in the Delta would be more limited than for Delta Smelt as Longfin Smelt have less spatial overlap with proposed restoration areas.

5.9.2.4 *Nearshore Pacific Ocean of the California Coast*

5.9.2.4.1 Southern Resident Killer Whale

Potential changes to Southern Resident Killer Whale’s Chinook Salmon prey

Effects of program-level actions such as tidal habitat restoration on Southern Resident Killer Whale’s Chinook Salmon prey generally would be expected to be limited because of the medium priority of Central Valley Chinook Salmon stocks in the diet of Southern Resident Killer Whale and the relatively high representation in the stocks by hatchery-origin fish, many which are released downstream of the Delta and therefore downstream of program-level actions. Alternative 3 has a considerably greater extent of tidal habitat restoration (25,000 acres) than proposed for other alternatives and therefore may have more potential for positive effects than the other alternatives, although in general there is uncertainty in the potential for effect.

5.9.3 Mitigation Measures

The following mitigation measures have been identified as appropriate to avoid or minimize effects on aquatic resources. Species-specific measures described below have been developed to avoid and minimize effects that could result from the proposed action on species addressed in Appendix O. For full descriptions of the proposed Mitigation Measures please see Appendix E.

- Mitigation Measure AQUA-1: Worker Awareness Training
- Mitigation Measure AQUA-2: Construction Best Management Practices and Monitoring
- Mitigation Measure AQUA-3: Develop and Implement Program to Expand Adult Holding, Spawning, Egg Incubation, and Fry/Juvenile Rearing Habitat.
- Mitigation Measure AQUA-4: Erosion and Sediment Control Plan
- Mitigation Measure AQUA-5: Spill Prevention, Containment, and Countermeasure Plan
- Mitigation Measure AQUA-6: Disposal of Spoils and Dredged Material
- Mitigation Measure AQUA-7: Fish Rescue and Salvage Plan
- Mitigation Measure AQUA-8: Underwater Sound Control and Abatement Plan
- Mitigation Measure AQUA-9: Methylmercury Management
- Mitigation Measure AQUA-10: Noise Abatement
- Mitigation Measure AQUA-11: Hazardous Material Management
- Mitigation Measure AQUA-12: Construction Site Security
- Mitigation Measure AQUA-13: Notification of Activities in Waterways
- Mitigation Measure AQUA-14: Fugitive Dust Control

5.10 Terrestrial Biological Resources

Most of the actions from the proposed action alternatives that would affect terrestrial species are programmatic. The only effects from project-specific actions are from flow changes, which are discussed in detail below.

With respect to terrestrial species, Alternative 2 is nearly the same as the No Action Alternative. No additional restoration activities are proposed that would affect terrestrial species and the existing UC Davis Fish Culture and Conservation Laboratory would be used to produce and release Delta Smelt instead of constructing the new Delta Fish Species Conservation Hatchery (Conservation Hatchery) in Rio Vista. The only effects on terrestrial species under Alternative 2 are from river flows and reservoir levels and inundation in the Yolo and Sutter Bypasses.

Alternative 4 will also have minimal effects on terrestrial species as compared to the No Action Alternative, as impacts are limited to disturbed agricultural areas. Alternative 4 will result in flow changes and impacts on giant garter snake and valley elderberry longhorn beetle from water use efficiency upgrades.

5.10.1 Project-Level Effects

Potential changes in wildlife and plant habitat on river banks

Operation of the CVP and SWP under Alternatives 1, 2, and 3 would change river flows and reservoir levels relative to the No Action Alternative. If river flows or reservoir levels have substantive declines or increases in areas with wildlife or plant habitat, the flows could adversely affect that habitat. However, Alternatives 1, 2, and 3 would cause only minor changes to the water levels in reservoirs and along rivers. The flow changes are relatively small during each water year type and would not result in substantive changes to riparian habitat.

Operation of the CVP and SWP under Alternative 4 would also change river flows and reservoir levels compared to the No Action Alternative, which would not change existing flow conditions. Increases in peak flows are expected in the affected stream reaches for the Sacramento River, Clear Creek, Feather River, and American River under Alternative 4 compared to the No Action Alternative. If peak river flows or reservoir levels have substantive increases beyond the No Action Alternative, it could kill or injure special-status species and remove their habitat along rivers and reservoirs. However, evaluation of changes in peak flow indicates that increases will maintain higher flows generally in the February through June period, where it is common for seasonal discharge to increase naturally. These flows are not expected to result in riverbank overtopping/flooding or increased inundation in the Yolo Bypass, therefore flow increases under Alternative 4 are not expected to affect wildlife and plant habitat on river banks in comparison to the No Action Alternative. Action.

For the purposes of the wildlife and plant species analyses, “flow changes” constitute the expected effects of implementing the action alternatives. Differences in flow management would have the potential to affect a special-status wildlife or plant species if flow changes were to directly alter habitat availability or quality, or result in vegetation changes that would alter habitat availability or quality. The great majority of stream channels within the study area are linear channels confined by levees or other engineered works that provide negligible habitat for special-status wildlife or plant species. There is, however, potential to affect such species at those sites where habitat has not been removed by channel alteration, where habitat has been restored, or where habitat is expected to be restored during the proposed term of the action alternative. In the first two of these cases, existing habitat shows evidence of adaptation to anthropogenic modifications to the ecosystem that date back decades, or, in many cases, over a century. These modifications include hydrologic changes associated with water manipulation; topographic changes associated with flood control, agriculture, restoration site construction, and other causes; and biological changes associated with the introduction of nonnative species. Implementation of the action alternatives would generally result in very minor potential changes and these changes are small relative to normal month-to-month and year-to-year variability in the system.

While Alternatives 1, 2, 3, and 4 are expected to have only minor effects on habitat along the banks of rivers and reservoirs, flow changes have the potential to affect the amount of yellow-billed cuckoo riparian habitat. The Action Alternatives may modify flows in a manner that will limit channel forming flows, which could result in less riparian habitat establishment and expansion over time. If hydrologic modifications lead to too little or too much water during different times of the year, existing riparian habitat could be affected (U.S. Fish and Wildlife Service 2014); higher flows could result in erosion and potential loss of riparian vegetation while lower flows, especially during the spring, could result in drought stress or less riparian vegetation recruitment, such as cottonwood seed dispersal. The hydrologic regime (stream flow pattern) and supply of (and interaction between) surface and subsurface water is a driving factor in the long-term maintenance, growth, recycling, and regeneration of western yellow-billed cuckoo habitat (U.S. Fish and Wildlife Service 2013). Higher flows could also result in higher sedimentation along the channel banks that similarly result in the inability of riparian vegetation to establish or regenerate. Alternatively, lower flows could diminish the water table, leading to reduced ground water availability and water stress in riparian trees. Physiological stress in native vegetation from prolonged lower flows or ground water results in reduced plant growth rate, morphological change, or mortality, and altered species composition dominated by more drought-tolerant vegetation, and conversion to habitat dominated by nonnative species (Poff et al. 1997). These effects reduce and degrade habitat for the western yellow-billed cuckoo for foraging, nesting, and cover.

Flow changes could adversely affect nesting habitat for bank swallows on the Sacramento and Feather Rivers. One of the primary threats to bank swallows is loss of nesting habitat from the placement of rock revetment for levee stabilization. Because of the resulting limited nesting habitat, and the reduction of natural river processes, the species is highly sensitive to (1) reductions in winter flows which are necessary to erode banks for habitat creation, and (2) high flows during the breeding season (generally April 1 to August 31). The potential impacts of changes in upstream flows during the breeding season on bank swallows are the flooding of active burrows and destruction of colonies from increased bank sloughing. Bank swallows arrive in California and begin to excavate their burrows in March, and the peak egg-laying occurs between April and May (Bank Swallow Technical Advisory Committee 2013). Therefore, high-flow events on the Sacramento and Feather Rivers that occur after March, when the swallows have nested and laid eggs in the burrows, could adversely affect bank swallows and result in the loss of nests. On the Sacramento River, breeding season flows between 14,000 and 30,000 cfs have been associated with localized bank collapses, which resulted in partial or complete colony failure (Stillwater Sciences 2007).

Additionally, flows above 50,000 cfs on the Sacramento River could lead to multiple colony failures during the breeding season, but may be beneficial during the nonbreeding season because erosion can create new breeding habitat in the form of cut banks (Stillwater Sciences 2007).

Relative to the No Action Alternative, model results illustrate flows on the Sacramento River would be slightly higher under Alternatives 1, 2, and 3 during the bank swallow breeding season. The modeled results illustrate the average flow on the Sacramento River as having modest differences among the action alternatives. Projected differences between the No Action Alternative and the action alternatives occur from mid-April to July; average flows under the action alternatives are slightly greater than under the No Action Alternative, with Alternatives 2 and 3 having slightly higher flows than Alternative 1 during this period.

Average flows on the Sacramento River downstream of Keswick Reservoir, at Bend Bridge, and below RBDD would increase under the action alternatives during the bank swallow breeding season, with model results predicting flow staying below 15,000 cfs. Average flows on the Sacramento River at Hamilton City, at Wilkins Slough, and at Freeport under the action alternatives would generally decrease during the bank swallow breeding season. Monthly flows are highest at Freeport during the bank swallow breeding season, with the action alternatives predicting monthly flows between 15,000 and 19,000 cfs.

Relative to the No Action Alternative, modeled results illustrate flows on Feather River would be slightly higher under Alternatives 1, 2, and 3 during the bank swallow breeding season. The modeled results illustrate the average flow on the Feather River being highest under Alternative 2 and 3, with flows under Alternative 1 falling in between the No Action Alternative and Alternatives 2 and 3. Projected differences between the No Action Alternative and the action alternatives occur from mid-May to July. Average flows on Feather River downstream of Thermalito Afterbay would increase under the action alternatives during the bank swallow breeding season, with model results predicting peak flows of 7,000 cfs.

Whereas, average flows on Feather River at the Sacramento River confluence, would decrease under the action alternatives during the bank swallow nesting season.

Based on illustrated modeled results of flow changes on the Sacramento and Feather Rivers, effects on bank swallow nesting habitat are anticipated; however, the degree of impacts are dependent upon the relative increase in flows and the timing of flow changes. Based on data indicating bank swallow colonies may be affected at 14,000 to 30,000 cfs, the action alternatives would not have a significant effect on erosion of bank swallow colonies compared to the No Action Alternative.

5.10.2 Program-Level Effects

Potential changes to existing marshes and associated special-status species in the Bay-Delta region

Alternative 1 and Alternative 3 would restore tidal wetlands, diked wetlands, and muted marsh habitat in the Bay-Delta region. Several sites, including Dutch Slough, Winter Island, Hill Slough, Arnold Slough/Bradmoor Island, Chipps Island, and Lower Yolo Ranch are being restored to tidal habitat as mitigation for adverse impacts on Delta Smelt and its habitat. Tidal habitat restoration at each site would be achieved by conversion of currently leveed, cultivated land through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Where appropriate, portions of restoration sites will be raised to elevations that will support tidal marsh vegetation following levee breaching. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing clean dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will create a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to establish and maintain itself naturally at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces.

Habitat restoration activities and restoration of tidal inundation could have deleterious short-term effects on existing tidal, nontidal, and managed marsh habitats and associated special-status species, including Suisun marsh aster, Mason’s lilaeopsis, Bolander’s water hemlock, soft bird’s beak, Suisun thistle, delta tule pea, western pond turtle, California black rail, California Ridgeway’s rail, Suisun song sparrow, saltmarsh common yellowthroat, short eared owl, Suisun shrew, and salt-marsh harvest mouse. The potential effects on tidal marsh habitat will include the conversion of mid- and high-marsh habitat types to low-marsh types; the conversion of low-marsh habitat to subtidal habitat; and the conversion of upland refugia habitat to tidal habitat. While it is expected that the habitat will persist after restoration of tidal action, the extent of mid- and high-marsh is expected to decrease in the near-term. In the longer-term, and with the implementation of remedial measures, the extent of habitat is expected to expand. The extent of habitat may not expand to pre-restoration conditions, although the habitat will be of great extent and more resilient to climate change because tidal habitat has potential to accrete sediment to keep up with sea-level rise, whereas diked wetlands do not. Furthermore, diked wetlands have the risk of breached dikes that cause excessive flooding of mid- and high-marsh habitats.

Tidal habitat restoration is not expected to occur in areas with occupied habitat for soft bird’s-beak or Suisun thistle, and no negative effects would be expected from restoration activities. Over time, the restored and enhanced area is expected to be suitable and of higher long-term value for the species because it will be less vulnerable to sea-level rise by including gradual slopes up from the current tidal region, potentially allowing introduction of the species into the restored areas. Thus, Alternatives 1 and 3 are expected to have a wholly beneficial effect on special-status plant species.

The effect of tidal marsh restoration on special-status species in the Bay-Delta will be greater under Alternative 3 compared to the No Action Alternative and Alternative 1 because Alternative 3 proposes 25,000 acres of habitat restoration within the Delta (as described in Table 3.6-1, Components of Alternative 3). Although it is unknown at this time how much of the affected habitat is suitable for special-status species, it is likely that additional habitat for special-status species will be affected under Alternative 3. Additional habitat restoration will require a greater extent of permanent and temporary habitat loss, the latter of which would be expected to recover and restore over time. Habitat restoration will ultimately benefit special-status species by increasing the amount of available habitat and enhancing degraded habitat areas.

Potential changes to existing riparian areas and associated special-status species

The No Action Alternative, Alternative 1, and Alternative 3 include 8,000 acres of habitat restoration as required by the existing 2008 and 2009 BOs. Alternative 2 does not include tidal habitat restoration. Relative to the No Action Alternative and Alternative 1, Alternative 3 proposes an additional 25,000 acres of habitat restoration within the Delta. Habitat restoration could result in the loss of riparian habitat and associated special-status species. Riparian species potentially affected include valley elderberry longhorn beetle, western yellow-billed cuckoo, foothill yellow-legged frog, least Bell's vireo, yellow warbler, Swainson's hawk, white-tailed kite, yellow-breasted chat, Cooper's hawk, osprey, bald eagle, ring-tailed cat, riparian brush rabbit, and riparian woodrat.

Alternative 1 and Alternative 3 include creation of spawning habitat and side channels along rivers, floodplain restoration, or other aquatic habitat restoration in riparian areas. The construction of setback levees to restore seasonally inundated floodplain could permanently remove species habitat and would be expected to transition species habitat from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of floodplain restoration is not expected to adversely affect nesting bird species because flooding is unlikely to occur during the breeding season, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse long-term effect on most riparian species because periodic scouring increases successional and structural diversity of the habitat.

Floodplain restoration may result in periodic flooding of habitat for riparian brush rabbit and riparian woodrat, which are primarily ground-dwelling species that are adversely affected by flooding if no upland refugia are available during flood events. In addition, the removal of oak trees in floodplains will remove nest building materials for riparian woodrats in floodplains. However, the mitigation measure for riparian brush rabbit and riparian woodrat (Mitigation Measure BIO-21) will avoid and minimize both of these impacts. Mitigation Measure BIO-21 requires floodplain restoration projects to include refugia habitat to provide shelter from flood events and avoidance of mature oak trees in areas a qualified biologist has identified as being occupied by riparian brush rabbit and riparian woodrat. Mitigation Measure BIO-21 also puts limits on the amount of habitat that can be affected by restoration.

The effect of aquatic habitat and floodplain restoration on special-status species in riparian areas will be greater under Alternative 3, compared to the No Action Alternative and Alternative 1, given that Alternative 3 proposes 25,000 acres of habitat restoration within the Delta (Table 3.6-1). More than triple the amount of habitat will be restored under Alternative 3 than under the No Action Alternative and

Alternative 1. Although it is unknown at this time how much of this habitat is suitable for special-status species in riparian areas, it is likely that additional habitat for special-status species will be affected under Alternative 3. Additional habitat restoration will result in a greater extent of permanent and temporary habitat loss, the latter of which would be expected to recover and restore over time. Habitat restoration will ultimately benefit special-status species in riparian areas by increasing the amount of available habitat and enhancing degraded habitat areas.

Potential changes to special-status reptile habitat

Relative to the No Action Alternative, Alternative 1 and Alternative 3 include creation of spawning habitat and side channels along rivers, channel margin restoration, floodplain restoration, and other aquatic habitat restoration on the banks of water bodies that could result in loss of habitat for giant garter snake and western pond turtle. Alternative 4 includes components to increase water use efficiencies in agricultural areas that may also result in loss of habitat for giant garter snake.

Under Alternatives 1 and 3, permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches are modified and flooded as part of the tidal habitat restoration process. Permanent effects on both giant garter snake and western pond turtle habitat could occur where channel margin restoration entails levee setback. For the giant garter snake, the conversion of rice fields to tidal habitat would be a permanent loss, however, rice is not common in the areas where tidal restoration and channel margin restoration would likely be sited. Other aquatic features that have potential to occur on restoration sites include natural channels and topographic depressions. Tidal aquatic edge habitat where open water meets the levee edge will also be permanently lost in those reaches where the levee is breached. Temporary effects on aquatic edge habitat are also likely to occur during the time of construction, though these effects would not be expected to last more than 2 years. Permanent effects on upland habitat will primarily occur where upland habitat is removed to create tidal connectivity.

The effect of aquatic habitat and floodplain restoration on special-status reptiles will be greater under Alternative 3, compared to the No Action Alternative and Alternative 1, given that Alternative 3 proposes 25,000 acres of habitat restoration within the Delta (Table 3.6-1). More than triple the amount of habitat will be restored under Alternative 3 than under the No Action Alternative and Alternative 1. Although it is unknown at this time how much of this habitat is suitable for special-status reptiles, it is likely that additional habitat for special-status reptiles will be affected. Additional habitat restoration will occur in a greater extent of permanent and temporary habitat loss, the latter of which would be expected to recover and restore. However, both western pond turtle and giant garter snake occur over a substantial range, which will reduce the magnitude of these effects. The giant garter snake range extends from Chico in Butte County to the Mendota Wildlife Area in Fresno County and the western pond turtle is found throughout Washington, Oregon, and California. Habitat restoration will ultimately benefit special-status reptiles by increasing the amount of available habitat and enhancing degraded habitat areas.

Under Alternative 4, permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches and canals are replaced with pipes to reduce water loss. In addition, the conversion of rice to dryland farming would be a permanent loss of habitat for giant garter snake. Permanent effects on upland habitat for giant garter snake will primarily occur where upland habitat is removed during construction of new on-farm irrigation or distribution systems or during alteration of existing on-farm distribution systems.

Potential to injure or kill special-status species

Construction-related actions associated with habitat restoration and the installation or upgrading of facilities under Alternatives 1 and 3, and construction of new agricultural water use efficiency facilities under Alternative 4, relative to the No Action Alternative, could injure or kill special-status species in occupied habitat. The operation of equipment for land clearing and restoration could result in injury or mortality of special-status species. This risk is highest for species with periods of dormancy, like California tiger salamander and giant garter snake. Increased vehicular traffic associated with construction activities could contribute to a higher incidence of vehicle strikes. However, construction monitoring and other mitigation measures have been identified to avoid and minimize injury or mortality of special-status species during construction.

In tidal marsh habitat, construction actions such as excavation of levees; construction of tidal control gates; movement and staging of large construction equipment; piling and storage of soils, dredging, and filling and grading of vegetated areas could cause the injury or mortality of special status species that may be in the vicinity of the construction area. Tidal marsh species are especially vulnerable during periods of higher tides and peak flooding by storms; during these periods these species move into upland marsh areas for protection. Tidal marsh species could drown or be preyed upon if construction activities or equipment isolate tidal marsh species from their refugia habitat or confuse or disturb them.

Equipment operation for the creation of side channels and levees in riparian habitat during periods of high seasonal activity, such as the nesting bird and bat maternity seasons, could also injure or kill special-status species. Risk is greatest to bird eggs and nestlings or bat pups that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment.

Under Alternative 4, removal of occupied valley elderberry shrubs along agricultural channels and ditches could kill or injure valley elderberry longhorn beetles. Similarly, reduced groundwater permeability from conversion of ditches and canals to pipes could kill elderberry shrubs, which could injure or kill any valley elderberry beetles in occupied habitat.

Night construction could disrupt animal behavior and/or sleep cycles or adversely affect bat foraging activity in all affected habitat types if special-status species are exposed to night lighting. For example, bird species are attracted to artificial lights, which may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). Night lighting can also result in circadian/behavior disruptions which can cause bird species to molt and develop their reproductive system earlier than in dark nights. Night lighting can also influence the endocrine system of vertebrates, which can lead to health deterioration (Fonken and Nelson 2014; Ouyang et al. 2018).

Construction-related noise levels could cause additional behavioral modifications if special-status species are present in the general vicinity. Construction activities may create noise up to 60 A-weighted decibels (dBA) at no more than 1,200 ft from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). Noise and visual disturbance outside the project footprint but within 200 ft of construction activities could temporarily affect the use of adjacent habitat by giant garter snake. These effects will be minimized by siting construction 200 ft from the banks of giant garter snake aquatic habitat, where feasible, as described in Mitigation Measure BIO-5.

Contaminants could be introduced into species' habitats as a result of construction. Exhaust from construction and maintenance vehicles may result in deposition of particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of vegetation and thereby affect presence and abundance of special-status species. The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect occupied, suitable, or adjacent habitat. These accidental spills could also affect special-status species prey, resulting in less food availability. Increased runoff from impervious surfaces into wetland areas carries pollutants that are harmful to reptiles and amphibians, which are particularly sensitive to contaminants and other pollutants in the water. These effects will be minimized by Mitigation Measure WQ-1 and Mitigation Measure WQ 2.

Construction-related effects will be greater under Alternative 3, compared to the No Action Alternative and Alternative 1, given that Alternative 3 proposes 25,000 acres of habitat restoration within the Delta (Table 3.6-1).Although the construction activities will be the same across the Alternatives 1 and 3 (e.g., noise, lighting, equipment), Alternative 3 has a greater potential to occur in special-status species habitat and directly affect (i.e., injure or kill) a special-status species. Given that construction under Alternative 3 will occur in three times more area than under Alternative 1, Alternative 3 has a greater potential to impact entire populations in the vicinity of the construction area or even an entire species, especially if that species has restrictive habitat requirements and a narrow range distribution. For example, Suisun shrew is found only in the northern borders of San Pablo and Suisun Bay and Suisun thistle is known from only two occurrences and is present in Suisun Marsh. However, if construction is properly sited and mitigation measures are in place, impacts on species with restrictive habitat requirements and range distribution can be avoided.

Potential changes to vernal pools and associated special-status species

Tidal habitat restoration and the construction of the Delta Fish Conservation Hatchery under the Alternative 1 and Alternative 3 could have direct and indirect effects on vernal pools and associated special-status species. Vernal pool species that could be affected include California tiger salamander, Contra Costa goldfields, and vernal pool invertebrates. Direct effects include loss of habitat and individual mortality as a result of construction. Tidal natural community restoration could result in the permanent loss of vernal pool crustacean habitat. It is anticipated that much of the existing vernal pool habitat that will be affected by the project is already degraded. Vernal pools in the Sacramento and San Joaquin Valleys have already experienced considerable disturbance due to agricultural development (e.g., plowing, disking, or leveling) which results in compacted soils, loss of hydrologic connections, and reductions in the size and extent of vernal pools.

Construction of the Delta Fish Conservation Hatchery could result in direct removal of vernal pools if it is constructed in an area that contains vernal pool complexes. Similarly, if these pools are occupied, vernal pool crustaceans could be destroyed. These effects will be avoided through the implementation of the proposed Mitigation Measures. Indirect conversion of vernal pool habitat could also occur due to hydrological changes as a result of tidal habitat restoration or construction of the hatchery. Construction restoration activities may result in the modification of hardpan and changes to the perched water table, which could lead to alterations in the rate, extent, and duration of inundation of nearby vernal pool crustacean habitat. USFWS typically considers construction within 250 ft of vernal pool crustacean habitat to constitute a possible conversion of crustacean habitat unless more detailed information is provided to further refine the limits of any such effects. Therefore, Mitigation Measure BIO-1 will ensure a buffer of 250 ft for construction or restoration near vernal pool habitat.

The effect of the project on vernal pools and special-status species will be greater under Alternative 3, compared to the No Action Alternative and Alternative 1, given that Alternative 3 proposes 25,000 acres of habitat restoration within the Delta (Table 3.6-1). Although it is unknown at this time how much occupied and suitable vernal pool habitat will be affected by each action alternative, additional habitat restoration is likely to affect a greater amount of vernal pool habitat. However, as stated above, Mitigation Measure BIO-1 requires full avoidance of vernal pools.

Potential to effect special-status bat species and their habitat.

Special-status bat species with potential to occur in the study area employ varied roost strategies, from solitary roosting in foliage of trees to colonial roosting in trees and artificial structures, such as tunnels, buildings, and bridges. Various roost strategies could include night roosts, maternity roosts, migration stopover, or hibernation. The habitat types used for special-status bats roosting habitat includes riparian habitat, developed lands and landscaped trees, including eucalyptus, palms and orchards. Potential foraging habitat includes all riparian habitat types, cultivated lands, developed lands, grasslands, and wetlands.

There is potential for four California bat species of special concern to occur in the study area (see Table P.1-1, Special-Status Wildlife Species), as well as a number of common bat species. Construction and restoration activities associated with Alternatives 1 and 3, as compared to the No Action Alternative, will result in both temporary and permanent losses of foraging and roosting habitat for special-status bat species. Tidal habitat restoration and floodplain restoration would result in permanent and temporary loss of riparian roosting habitat and conversion of foraging habitat from mostly cultivated lands and managed wetlands to tidal and nontidal wetlands. Development of the Delta Conservation Fish Hatchery could also result in the removal of roosting and foraging habitat. Noise and visual disturbances during implementation of riparian habitat restoration and other construction activities could result in temporary disturbances that, if bat roost sites are present, could cause temporary abandonment of roosts. Impacts on special-status bat species that occupy artificial structures are expected to be negligible in comparison to the amount of impacts on natural habitat types, but temporary and permanent impacts on special-status bat species occupying artificial structures could result in local adverse effects.

However, implementation of Alternative 1 and Alternative 3 would result in an overall benefit to special-status bats within the study area through restoration of their foraging and roosting habitats. The majority of affected habitat would convert agricultural land to natural communities with higher potential foraging and roosting value, such as riparian, tidal and nontidal wetlands, and periodically inundated lands. Restored foraging habitats primarily would replace agricultural lands. Restored habitats are expected to be of higher function because the production of flying insect prey species is expected to be greater in restored wetlands and uplands on which application of pesticides would be reduced relative to affected agricultural habitats. In addition, any impact from construction, restoration, or periodic inundation on special-status bats and their habitat would be mitigated through implementation of Mitigation Measure BIO-24, which would ensure there is no significant impact on roosting special-status bats, either directly or through habitat modifications and no substantial reduction in numbers or a restriction in the range of special-status bats.

Potential changes to wetlands and waters of the United States

The restoration projects associated with Alternatives 1 and 3 and the agriculture water use efficiency facilities associated with Alternative 4 will likely require some fill of wetlands and waters of the United States. Fill could occur from dredging work, spoils areas, side channel construction, and installation of the Delta Fish Conservation Hatchery. The majority of the impacts on wetlands and waters of the United

States are likely on tidal channels, emergent wetlands, and on wetlands and waters found within cultivated lands (agricultural ditches and seasonal wetlands). Reclamation will obtain and implement the conditions and requirements of state and federal permits that may be required prior to the construction of the proposed project.

Unavoidable impacts on waters of the United States would be offset such that the loss of acreage and functions due to construction activities are fully compensated. The restoration projects will ultimately result in a net increase of wetlands and waters of the United States, but it could result in short-term losses, and could also result in conversion from one wetland type to another. Wetland functions are defined as a process or series of processes that take place within a wetland. These include the storage of water, transformation of nutrients, growth of living matter, and diversity of wetland plants, and they have value for the wetland itself, for surrounding ecosystems, and for people. Functions can be grouped broadly as habitat, hydrologic/hydraulic, or water quality. Not all wetlands perform all functions nor do they perform all functions equally well. The location and size of a wetland may determine what functions it will perform. For example, the geographic location may determine its habitat functions, and the location of a wetland within a watershed may determine its hydrologic/hydraulic or water quality functions. Many factors determine how well a wetland will perform these functions: climatic conditions, quantity and quality of water entering the wetland, and disturbances or alteration within the wetland or the surrounding ecosystem. Wetland disturbances may be the result of natural conditions, such as an extended drought, or human activities, such as land clearing, dredging, or the introduction of nonnative species. Wetlands are among the most productive habitats in the world, providing food, water, and shelter for fish, shellfish, birds, and mammals, and serving as a breeding ground and nursery for numerous species. Many endangered plant and animal species are dependent on wetland habitats for their survival. Hydrologic and hydraulic functions are those related to the quantity of water that enters, is stored in, or leaves a wetland. These functions include such factors as the reduction of flow velocity, the role of wetlands as groundwater recharge or discharge areas, and the influence of wetlands on atmospheric processes. Water-quality functions of wetlands include the trapping of sediment, pollution control, and the biochemical processes that take place as water enters, is stored in, or leaves a wetland.

Relative to the No Action Alternative, the functions of the waters of the United States that would be temporarily or permanently affected by Alternative 1 and Alternative 3 will vary, given that Alternative 3 proposes to restore 25,000 acres while the No Action Alternative and Alternative 1 will restore 8,000 acres. The magnitude of the impact will depend primarily on existing land uses and historical levels of disturbance. Generally, agricultural ditches and conveyance channels, which are regularly maintained and often devoid of vegetation, support only minimal hydraulic function (water conveyance), with virtually no water quality or habitat function. Some facilities that are regularly maintained can still support some hydrologic, hydraulic, and water-quality functions (e.g., reduction of velocity, groundwater recharge, and trapping of sediment). Tidal channels affected by the action alternatives support functions in all three categories, but the level at which these functions perform will vary depending on setting, size, and level of disturbance. Alkaline wetlands and vernal pools exist in nonnative grasslands and have been subjected to some disturbance due to past land uses. Although these features likely support habitat, water quality, and hydrologic/hydraulic functions, the capacity of these features to perform such functions varies depending on the overall ecological setting and level of disturbance. Functions associated with emergent wetland, forest, and scrub-shrub, depend primarily on the location of these habitat types. Where they exist as in-stream (in-channel islands) or as the thick band of habitat adjacent to a waterway, these features are expected to function at a high level. However, where these habitats exist as thin bands, or where they are situated in agricultural fields, their habitat functions will be considerably lower. All of the wetlands classified as seasonal wetlands occur in agricultural fields. As such, their habitat functions have been greatly compromised, but they retain some water quality and hydrologic/hydraulic functions. Like seasonal wetlands, most depressions occur within agricultural areas; however, the depressions may support wetland vegetation at their edges

Potential changes to terrestrial species' critical habitat

Relative to the No Action Alternative, the restoration projects under Alternatives 1 and 3 could result in loss of terrestrial species' critical habitat.

Western yellow-billed cuckoo proposed critical habitat is present in Tisdale Bypass and Sutter Bypass. Flow increases could result in flooding and erosion at any restoration site or habitat for western yellow-billed cuckoo in the upper Sacramento River watershed, resulting in degradation in quality or possible loss of existing habitat. However, the action alternatives do not propose to modify flows in the Tisdale or Sutter Bypasses. Changes in frequency of inundation in the Sacramento River would be minor, and within the current minimum and maximum flows. The action alternatives could provide for some different riparian species that require year-round flows, compared to the No Action Alternative, where low flows in the fall would stress invasive plants and encourage drought tolerant native species to persist. The proposed action alternatives would not affect proposed critical habitat for yellow-billed cuckoo.

Critical habitat for valley elderberry longhorn beetle is present along the American River. However, under the action alternatives, Reclamation will avoid valley elderberry longhorn critical habitat.

Critical habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp is present in areas that

Reclamation could potentially use for tidal habitat restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for these species in the critical habitat units.

Critical habitat for California tiger salamander is present in areas that Reclamation could potentially use for tidal habitat restoration. Reclamation will, however, avoid areas that would affect the primary constituent habitat elements for this species in the critical habitat units.

Critical habitat for soft bird's beak and Suisun thistle is present in areas that Reclamation could potentially use for tidal habitat restoration. Reclamation will, however, avoid critical habitat for soft bird's beak and Suisun thistle.

5.10.3 Mitigation Measures

The following mitigation measures have been identified as appropriate to avoid or minimize effects on special-status species and their habitat. Species-specific measures described below have been developed to avoid and minimize effects that could result from the proposed action on listed and nonlisted species addressed in Appendix P, *Terrestrial Resources Technical Appendix*. For full descriptions of the proposed Mitigation Measures please see Appendix E.

Table 5.10-1. Summary of Species-Specific Mitigation Measures and Applicable Action Alternatives

Number	Title	Summary	Applicable Action Alternative
BIO-1	Vernal pool fairy shrimp, vernal pool tadpole shrimp, conservancy fairy shrimp, longhorn fairy shrimp	Avoidance of vernal pool habitat and critical habitat, regardless of occupancy, 250-foot buffer.	1, 3
BIO-2	Valley elderberry longhorn beetle	Habitat avoidance where possible, preconstruction surveys, fencing, monitoring. Mitigate unavoidable impacts consistent with USFWS's Framework for Assessing Impacts to the Valley Elderberry Longhorn Beetle (USFWS 2017b)	1, 3, 4
BIO-3	California tiger salamander	Habitat avoidance (including critical habitat).	1, 3
BIO-4	Foothill yellow-legged frog	Preconstruction survey, timing, compensate for unavoidable effects	1, 3
BIO-5	Giant garter snake	Habitat avoidance where possible, preconstruction survey, and biological monitoring. Unavoidable habitat loss will be offset through habitat protection and/or restoration at a 3:1 ratio.	1, 3, 4
BIO-6	Western pond turtle	Habitat assessment, preconstruction survey, and relocation.	1, 3
BIO-7	California black rail	Protocol surveys, habitat avoidance, nondisturbance buffer, and timing of project activity.	1, 3
BIO-8	California Ridgway's rail	Preconstruction protocol-level survey, timing, habitat avoidance.	1, 3
BIO-9	Greater and lesser sandhill crane	Timing of construction, habitat avoidance where possible. Preconstruction survey, avoid roosts where possible, directional lighting.	1, 3
BIO-10	Least Bell's vireo	Habitat assessment, preconstruction survey, nondisturbance buffer, noise analysis, limit construction activity near nests. Mitigate unavoidable impacts through habitat creation at a 2:1 ratio.	1, 3
BIO-11	Suisun song sparrow, saltmarsh common yellowthroat, yellow-breasted chat, yellow warbler	Preconstruction survey, nondisturbance buffer, biological monitoring of active nests, noise reduction, minimize construction traffic, directional lighting.	1, 3
BIO-12	Swainson's hawk	Preconstruction survey, habitat avoidance where possible, nondisturbance buffer. Mitigate unavoidable loss of foraging habitat through foraging habitat protection at a 1:1 ratio, and unavoidable loss of nesting habitat through riparian restoration at a 2:1 ratio.	1, 3
BIO-13	Tricolored blackbird	Preconstruction survey, habitat avoidance, biological monitoring. Mitigate unavoidable loss of foraging habitat at a 1:1 ratio and unavoidable loss of nesting habitat through restoration at a 2:1 ratio.	1, 3

Number	Title	Summary	Applicable Action Alternative
BIO-14	Western burrowing owl	Protocol level survey, Preconstruction survey, habitat avoidance, relocation during nonbreeding season, nondisturbance buffer, biological monitoring. Mitigate unavoidable loss of nesting, wintering, and satellite burrows, and burrowing owl habitat in comparable habitat at an approved mitigation ratio in consultation with the California Department of Fish and Wildlife.	1, 3
BIO-15	Western yellow-billed cuckoo	Habitat avoidance (including critical habitat), preconstruction surveys.	1, 3
BIO-16	White-tailed kite	Preconstruction survey, nondisturbance buffer, work window restriction, biological monitoring. Mitigate unavoidable loss of foraging habitat through foraging habitat protection at a 1:1 ratio, and unavoidable loss of nesting habitat through riparian restoration at a 2:1 ratio.	1, 3
BIO-17	Bald eagle	Nesting habitat avoidance, nondisturbance buffer, monitoring.	1, 3
BIO-18	Bank swallow	Preconstruction survey, nondisturbance buffer, monitoring, project design to avoid impacts.	1, 2, 3
BIO-19	Least tern	Habitat avoidance.	1, 3
BIO-20	Migratory nesting birds	Preconstruction survey, nondisturbance buffer, monitoring.	1, 3
BIO-21	Riparian brush rabbit and riparian woodrat	Habitat suitability assessment, protocol-level survey, habitat avoidance where possible. 3:1 compensation for unavoidable impacts.	1, 3
BIO-22	Salt marsh harvest mouse and Suisun shrew	Preconstruction survey, biological monitoring, exclusion fence.	1, 3
BIO-23	Ring-tailed cat	Avoid denning period, preconstruction survey, nondisturbance buffer, biological monitoring.	1, 3
BIO-24	Special-status bats	Preconstruction surveys, monitoring, exclusion, timing, buffers	1, 3
BIO-25	Soft bird's-beak and Suisun thistle	Botanical survey, habitat avoidance (including critical habitat), minimize introduction of invasive plants. 1:1 compensation for unavoidable impacts.	1, 3
BIO-26	Other special-status plant species	Botanical survey, habitat avoidance, prevent spread of invasive plant species. 1:1 compensation for unavoidable impacts.	1, 3
BIO-27	Wetlands and waters of the United States	Avoid fill of wetlands and waters of the United States to the extent feasible, offset unavoidable effects through wetland creation, restoration, or enhancement.	1, 3

5.11 Regional Economics

This impact assessment is based on the technical analysis documented in Appendix Q, *Regional Economics Technical Appendix*, which includes additional information on regional economics and technical analysis of the effects of each alternative. The analysis is based on results of several models: Statewide Agricultural Production (SWAP) model, which estimates economic effects on agriculture associated with changes in CVP and SWP deliveries; California Water Economics Spreadsheet Tool (CWEST), which estimates economic effects on M&I users from changes in CVP and SWP deliveries; and Impact Analysis for Planning (IMPLAN) model, which produces total economic effects.

5.11.1 Project-Level Effects

Potential M&I water supply related changes to the regional economy

Most water agencies conduct long-term resource planning every 5 years to ensure adequate water supplies are available to meet existing and future demands. If a substantial deficit is estimated during these planning exercises, water agencies may decide to secure alternate water supplies such as desalination and new groundwater development (considered new supply sources), water conservation projects, or water transfers/imported water. All or a portion of increased water costs to secure these alternate water supplies are passed on to the retail agencies and water customers through increased water rates. An increase in water rates would reduce disposable income and could result in less spending in the regional economy.

The No Action Alternative analysis includes CVP and SWP water supplies under existing conditions and future water demands (2030 water demands). M&I water supply costs under the No Action Alternative are expected to be higher in comparison to existing conditions since demands are expected to increase under the No Action Alternative with no change to supplies. Consequently, M&I contractors would need to invest in alternate water supplies to meet increases in demand.

Alternatives 1 through 3 would increase water supply deliveries to North of Delta and South of Delta M&I contractors in comparison to No Action Alternative (as discussed in Section 5.3). Alternative 1 would increase average annual M&I water supply deliveries by 320,700 AFY, and Alternatives 2 and 3 would increase M&I water supply deliveries by 646,500 AFY and 624,800 AFY, respectively. These increases in water supply deliveries could help water agencies meet their existing and future demands without alternate water supply projects. Under Alternative 4, M&I water supply deliveries to North of Delta and South of Delta M&I contractors would decrease by approximately 130,000 AFY annually. This reduction in M&I water supply deliveries would increase the supply gap and require water agencies to invest in alternate water supply project to meet their demands.

Table 5.11-1, M&I Water Supply Costs under the Action Alternatives Compared to the No Action Alternative, summarizes the average annual water supply costs over the 81-year hydrologic period for M&I water supplies. Average annual water supply costs are expected to decrease by approximately 9% under Alternative 1 and approximately 23% under Alternatives 2 and 3 compared to the No Action Alternative. Water supply costs include several marginal costs as summarized in Table 5.11-1. Marginal costs are costs that vary with the volume of water supply. The No Action Alternative would require development of alternate supplies to meet water demands, but increased CVP and SWP deliveries under Alternatives 1 through 3 would reduce water supply costs as alternate water supply projects would not need to be implemented. Additionally, there would be reductions in lost water sales revenues, transfer costs, groundwater pumping savings, and excess water savings. Typically, water supply cost increases are passed on to water customers through water rate increases. As summarized in Table 5.11-1, water supply costs under all the action alternatives would decrease in comparison to the No Action Alternative.

Consequently, water rates under Alternatives 1 through 3 could be lower than the No Action Alternative. This could result in an increase in disposable income and could result in more spending in the regional economy. Table 5.11-2, M&I Water Supply Costs Related to Regional Economic Effects under the Action Alternatives in Comparison to the No Action Alternative summarizes the regional economic effects on employment, labor income, and revenue from decreased water supply costs to CVP and SWP M&I contractors. Most of the economic developments would occur in the Southern California region (Ventura, Los Angeles, Orange, Imperial, San Diego, Riverside, and San Bernardino Counties) since approximately 85% of the increased M&I deliveries would be in this region. Under Alternative 4, decreased CVP and SWP deliveries would increase water costs due to increased alternate water supply costs. This increase in water supply costs could be passed on to the water customer through water rate increases. Increase in water rates could result in a decrease in disposable income and could result in less spending in the regional economy. Table 5.11-2 summarizes the regional economic effects on employment, labor income, and revenue from increased water supply costs under Alternative 4.

Table 5.11-1. M&I Water Supply Costs under the Action Alternatives Compared to the No Action Alternative

	Alternative 1 compared to No Action Alternative	Alternative 2 compared to No Action Alternative	Alternative 3 compared to No Action Alternative	Alternative 4 compared to No Action Alternative
Average Annual CVP/SWP Deliveries (TAF)[1]	321	647	625	−130
Delivery Cost for CVP/SWP Deliveries (thousand dollars)[2]	$41,756	$83,278	$80,717	−$15,640
Alternate Water Supply Deliveries (assumed new supply) (TAF)[3]	−52	−76	−70	9
Annualized Alternate Supply Costs (thousand dollars)[4]	−$17,315	−$25,957	−$24,206	$3,959
Water Storage Costs (thousand dollars)[5]	$954	−$3,755	−$3,574	$1,115
Lost Water Sales Revenues (thousand dollars)[6]	−$10,260	−$26,180	−$26,156	$6,743
Transfer Costs (thousand dollars)[7]	−$11,273	−$24,010	−$24,238	$7,384
Shortage Costs (thousand dollars)[8]	−$9,859	−$29,077	−$29,090	$8,681
Groundwater Pumping Savings (due to reductions in groundwater pumping) (thousand dollars)[9]	−$19,763	−$42,376	−$41,858	$9,615
Excess Water Savings (thousand dollars)[10]	−$4,357	−$11,833	−$11,094	$704
Average Annual Changes in Water Supply Costs (thousand dollars)	−$30,116	−$79,909	−$79,500	$22,562

TAF = thousand acre-feet
All costs in 2018 dollars.
[1] CalSim II model simulated CVP and SWP deliveries for North of Delta and South of Delta M&I contractors.
[2] Cost to deliver CVP and SWP deliveries (second line in table) based on Reclamation CVP M&I rates and Bulletin 132-10 rates.
[3] Alternate water supply deliveries, including desalination, new groundwater development, some types of conservation, water transfer, and/or imported water. See Appendix Q for summary of alternate water supply source by M&I contractor.
[4] Cost to develop alternate water supplies. This cost typically only includes development cost. Other marginal costs, such as delivery costs, are not included in this cost.
[5] Storage costs include costs to store water in local groundwater banks and storage reservoirs. Costs include put and take costs.
[6] Loss of revenue from retail water sales during supply shortages.

[7] Cost to purchase and deliver transfer water purchases on annual spot market, or other annual options if applicable.
[8] Estimated consumer surplus loss to water shortages.
[9] Costs savings from reduction in groundwater pumping between the action alternatives and the No Action Alternative.
[10] Cost savings from contract water not used to meet demand or reduce groundwater pumping.

Table 5.11-2. M&I Water Supply Costs Related to Regional Economic Effects under the Action Alternatives in Comparison to the No Action Alternative

	Employment (number of jobs)[1]	Labor Income (million dollars)	Revenue (million dollars)
Alternative 1 compared to No Action Alternative	120	$7	$11
Alternative 2 compared to No Action Alternative	292	$18	$11
Alternative 3 compared to No Action Alternative	290	$18	$11
Alternative 4 compared to No Action Alternative	−76	−$5	−$13

All costs in 2018 dollars.
[1] Jobs include full-time, part-time and temporary jobs created or lost.

Potential agriculture-related changes to the regional economy

During past water supply shortages, agricultural contractors have typically increased groundwater pumping to substitute for reduced water supplies. If groundwater is not available, growers would idle field crops and use available surface water to irrigate permanent crops. Similar to M&I water supply, agricultural water supplies under the No Action Alternative would not change in comparison to existing conditions. However, demands are projected to increase under No Action Alternative due to population growth leading to increase in food demand. This could result in agricultural contractors increasing groundwater pumping.

Alternatives 1 through 3 would increase water supply deliveries to North of Delta and South of Delta agricultural contractors in all year types compared to the No Action Alternative (see Section 5.3 for more information). Agricultural contractors would reduce their reliance on groundwater supplies because of increased surface water deliveries. Table 5.11-3, Agricultural Water Supply Costs under the Action Alternatives Compared to the No Action Alternative, summarizes the projected groundwater pumping volumes, groundwater pumping costs, irrigated acreage, and revenues under the No Action Alternative and action alternatives. Overall groundwater pumping volumes and associated pumping costs under Alternatives 1 through 3 would be lower than under the No Action Alternative because of increased surface water deliveries. Consequently, operation costs associated with crop production would be lower and would result in increased profitability to the growers.

Irrigated acreage in the San Joaquin Valley is expected to increase under Alternatives 1 through 3 compared to the No Action Alternative. This increase would result in increased agricultural revenues for the growers as summarized in Table 5.11-3. Additionally, these revenues would affect businesses and individuals who support farming activities, such as farm workers, fertilizer and chemical dealers, wholesale and agricultural service providers, truck transport, and others involved in crop production and processing. Under Alternative 4, the agricultural water supply deliveries and irrigated acreage are expected to decrease in comparison to the No Action Alternative (see Table 5.11-3). This decrease in CVP and SWP water supply could increase reliance on groundwater to meet demands. Additionally, some growers would fallow lands if groundwater supplies are not available. Increased operation costs from groundwater pumping and land fallowing would decrease revenues in the Sacramento River and San Joaquin River Regions.

Table 5.11-4, Agricultural Water Supply Costs Related to Regional Economic Effects under the Action Alternatives in Comparison to the No Action Alternative, summarizes the regional economic effects on employment, labor income, and revenue from increased surface water deliveries to agricultural contractors. Alternative 4 would reduce employment, labor income, and output a result of reductions in deliveries.

Table 5.11-3. Agricultural Water Supply Costs under the Action Alternatives Compared to the No Action Alternative

	Alternative 1 compared to No Action Alternative	Alternative 2 compared to No Action Alternative	Alternative 3 compared to No Action Alternative	Alternative 4 compared to No Action Alternative
Average Conditions				
Average Annual CVP/SWP Deliveries (TAF)	334	686	666	−60
Annual Groundwater Pumping (TAF)	−231	−523	−508	26
Groundwater Pumping Cost (million dollars)	−$50	−$106	−$103	$6
Irrigated Acreage (thousand acres)	3	5	5	−6
Agricultural Revenue (million dollars)	$10	$14	$15	−$14
Dry Conditions				
Average Annual CVP/SWP Deliveries (TAF)	222	447	428	−149
Annual Groundwater Pumping (TAF)	−133	−236	−225	57
Groundwater Pumping Cost (million dollars)	−$32	−$58	−$56	$14
Irrigated Acreage (thousand acres)	24	56	56	−15
Agricultural Revenue (million dollars)	$50	$121	$121	-$33

CVP = Central Valley Project; SWP = State Water Project; TAF = thousand acre-feet
All costs in 2018 dollars.

Table 5.11-4. Agricultural Water Supply Costs Related to Regional Economic Effects under the Action Alternatives in Comparison to the No Action Alternative

	Employment (number of jobs)[1]t	Labor Income (million dollars)	Revenue (million dollars)
Average Conditions			
Alternative 1 compared to No Action Alternative	136	$6	$17
Alternative 2 compared to No Action Alternative	184	$8	$24
Alternative 3 compared to No Action Alternative	196	$9	$25
Alternative 4 compared to No Action Alternative	−169	−$8	−$24
Dry Conditions			
Alternative 1 compared to No Action Alternative	482	$25	$83
Alternative 2 compared to No Action Alternative	1,467	$66	$205
Alternative 3 compared to No Action Alternative	1,461	$66	$204
Alternative 4 compared to No Action Alternative	−450	−$18	−$56

All costs in 2018 dollars.
1 Jobs include full-time, part-time and temporary jobs created or lost.

Potential fisheries related changes to the regional economy

The commercial and recreational (ocean sports) ocean salmon fishery along the southern Oregon and northern California coast are affected by the population of salmon that rely upon the northern California rivers, including the Klamath, Trinity, Sacramento, and San Joaquin Rivers. Changes in CVP and SWP water operations would affect the flow patterns and water quality of these rivers and the survivability of the salmon that use those rivers for habitat, as described in Section 5.9. As described in Section 5.9, population of salmon along the southern Oregon and northern California coast would be higher under Alternatives 1 and 4 compared to the No Action Alternative. Increases in salmon population could potentially increase commercial and recreational ocean salmon harvest. Increases in commercial ocean salmon harvest would increase revenues received by fisherman—ocean fisheries support industries such as fish processors and boat manufacturers. Repair and maintenance also would see an increase in revenue. Overall, increased fisheries under Alternative 1 would be beneficial to the regional economy.

Under Alternatives 2 and 3, population of salmon along the southern Oregon and northern California coast could be lower compared to the No Action Alternative. The reduction under Alternative 2 is expected to be higher than under Alternative 3. Decreases in salmon population could potentially decrease commercial and recreational ocean salmon harvest. This could have a detrimental impact on fishermen and other ocean fisheries-supported industries.

5.11.2 Program-Level Effects

Potential changes to the regional economy

Alternatives 1 and 3 include several program actions that would require construction: the American River drought temperature facility improvements, TFCF improvements, Skinner Fish Facility improvements, Delta Fish Species Conservation Hatchery, upper Sacramento small screen program, upper Sacramento coldwater management tools, and juvenile trap and haul programs in the Sacramento River. Construction activities associated with these actions would temporarily increase construction-related employment and spending in the areas near the construction sites. These impacts would be beneficial to the regional economy and would result in a temporary increase in employment, labor income, and revenue in Shasta, Sacramento, San Joaquin, and Contra Costa Counties.

In addition to the construction actions, Alternatives 1 and 3 include habitat restoration projects along the upper reaches of the Sacramento, American, Stanislaus, and lower San Joaquin Rivers and 8,000 acres of tidal habitat restoration projects. Alternative 3 includes 25,000 acres of additional habitat restoration within the Delta. These habitat restoration projects could remove agricultural lands or grazing lands out of production. These impacts could reduce irrigated acreage and agricultural revenues that would negatively impact growers and businesses and individuals who support farming activities.

Alternative 2 does not have any components considered at a program level. Therefore, there would be no program-level effects on the regional economy.

Alternative 4 includes water use efficiency components that could include construction actions, public outreach programs and operational changes to improve system efficiency. Construction activities associated with program action would temporarily increase construction-related employment and spending in the areas near the construction sites. These impacts would be beneficial to the regional economy and would result in a temporary increase in employment, labor income, and revenue.

5.12 Land Use and Agricultural Resources

5.12.1 Project-Level Effects

Several of the proposed project-level components of the action alternatives (e.g., manipulating flows to provide appropriate flows and temperatures for fish habitat, managing water operations, raising the Shasta Dam crest, regulating runoff from Spring Creek Debris Dam) could result in changes to land use and effects on agricultural lands.

As discussed in Appendix R, *Land Use and Agricultural Resources Technical Appendix*, changes in land use are not anticipated for any of the action alternatives because sufficient water would be available for local jurisdictions to implement their existing general plans. While a small area of agricultural land may be converted to nonagricultural uses under the action alternatives, changes to agricultural land are analyzed under a separate effects analysis.

Project-level activities that would control flow would not affect irrigated agricultural land because flows would not decrease substantially. Table 5.12-2, Average Year Change in Irrigated Agricultural Farmland (acres) Acreage and Total Production Value from No Action Alternative (millions of dollars, 2018 value), and Table 5.12-3, Dry and Critically Dry Year Average Year Change in Irrigated Agricultural Farmland (acres) Acreage and Total Production Value from No Action Alternative (millions of dollars, 2018 value), provide more detail.

While some proposed project-level activities could indirectly affect agricultural land by changing the temperature of water that would be used for irrigating rice fields, adversely affecting rice harvest, or by directly converting the land through use of the land in a proposed activity, these effects are the same as under the No Action Alternative.

Habitat restoration activities would directly affect agricultural land if they are located on agricultural land.

None of the action alternatives would negatively affect water transfers. Modeling shows that water transfer costs would decrease overall for all of the action alternatives compared to the No Action Alternative.

Potential changes in land use as a result of changes in flows, reservoir levels, water temperatures, and restoration activities

Of the project-level components of the action alternatives, manipulating flows to benefit fish habitat and managing water operations could affect irrigated agricultural acreage and total production value through changing water deliveries. Under Alternatives 1, 2, and 3, overall average annual water supply costs would decrease, whereas costs would increase under Alternative 4, as modeled under CWEST. Table 5.12-1, Change in Average Annual Water Supply Costs from No Action Alternative (thousands of dollars, 2018 value), shows the change in average annual water supply costs in each region compared to the No Action Alternative.

Table 5.12-1. Change in Average Annual Water Supply Costs from No Action Alternative (thousands of dollars, 2018 value)

Regions	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Trinity River	$0	$0	$0	$0
Sacramento River	-$127	-$60	-$50	$137
San Joaquin River	-$490	-$4,012	-$3,878	$1,211
Delta	-$755	-$1,338	-$1,361	$1,509
San Francisco Bay Area	-$3,199	-$9,029	-$9,029	$3,242
Central Coast	$37	-$417	-$398	$184
Southern California	-$25,583	-$65,054	-$64,782	$16,278
TOTAL	-$30,116	-$79,909	-$79,500	$22,562

As shown in Table 5.12-1, Alternative 4 is projected to involve the greatest increase in average annual water supply costs compared to the No Action Alternative, at approximately $23,000,000. Alternative 1 is projected to yield the smallest decrease in average annual water supply costs at approximately $30,000,000. Alternatives 2 and 3 would both have a decrease of approximately $80,000,000.

As discussed in Appendix R*,* under Alternatives 1, 2, and 3, the overall decrease in costs in affected regions can be accounted for by an increase in CVP/SWP deliveries and a corresponding decrease in lost water sales revenues, water transfer costs, shortage costs, groundwater pumping savings, and excess water savings. Because water would be available to local jurisdictions at affordable costs, specifically, lower than current costs, these jurisdictions would have sufficient water to implement their general plans, and no change in land use is anticipated.

For Alternative 4, the overall increase in costs in affected regions can be accounted for by a decrease in CVP/SWP deliveries and a corresponding increase in lost water sales revenues, water transfer costs, shortage costs, groundwater pumping savings, and excess water savings. Although costs would increase, water would continue to be available to local jurisdictions to implement their general plans, and no change in land use is anticipated.

Potential changes in irrigated agricultural acreage and total production value as a result of changed flows and reservoir levels

Of the project-level components of the action alternatives, manipulating flows to benefit fish habitat, and managing water operations could affect irrigated agricultural acreage and total production value through changing the availability of irrigation water. These project-level components of the action alternatives could change river flows and reservoir levels. If river flows or reservoir levels have substantive declines or if timing changes considerably so that flows are not available when needed for crops, the diminished availability of surface water for agricultural purposes could in the short term decrease total production value and in the long term lead to conversion of agricultural farmland to nonagricultural uses in some locations, thus resulting in a long-term loss in total production value. The effect would be more pronounced in dry years than in years with average precipitation.

The SWAP model (see discussion in Appendix R and Appendix F) was used to predict crop acreage changes in the Sacramento River and San Joaquin River regions under the action alternatives. The Delta region is split between the Sacramento River region and the San Joaquin region because the SWAP regions comprising the Delta region span these other two regions. Assumptions in the SWAP model do not account for any change in groundwater use under SGMA implementation, which requires that local public agencies and GSAs in high- and medium-priority basins develop and implement GSPs or Alternatives to GSPs to map how groundwater basins will reach long-term sustainability. However, because in-streamflows are expected to increase with Alternatives 1, 2, and 3, no reduction in groundwater is anticipated. The additional surface water supply is expected to reduce the reliance of those areas on groundwater, no reduction in groundwater is anticipated. Alternative 4 would reduce CVP and SWP deliveries, so demand on groundwater and other alternative water sources could increase. Because sufficient groundwater might not be available in the future to replace reduced CVP/SWP supplies, it is possible that SWAP acreage and production value decreases under Alternative 4 could be greater than modeled under SWAP.

Tables 5.12-2 and 5.12-3 show the change in irrigated agricultural farmland for average and dry years in acres and total production value of agricultural crops by millions of dollars, 2018 value, for the action alternatives, compared to the No Action Alternative.

In both average and dry or critically dry year types, the overall acreage of irrigated farmland acreage and production value would increase for Alternatives 1, 2, and 3 compared to the No Action Alternative. In both average and dry or critically dry year types, the overall acreage of irrigated farmland and production value would decrease under Alternative 4.

In a year with average precipitation, Alternative 1 would see the smallest increase and Alternative 3 would see the greatest increase in both acreage and production value. Alternative 4 would see a decrease in both irrigated farmland acreage and production value.

In a dry or critically dry year, Alternative 1 would see the smallest increase and Alternative 2 would see the greatest increase of irrigated agricultural farmland acreage compared to the No Action Alternative. Alternative 1 would see the smallest increase in total production value, and Alternatives 2 and 3 would see a similar and larger increase. Alternative 4 would see a decrease in both irrigated farmland acreage and production value.

Table 5.12-2. Average Year Change in Irrigated Agricultural Farmland (acres) Acreage and Total Production Value from No Action Alternative (millions of dollars, 2018 value)

Regions	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Acreage	Production Value	Acreage	Production Value	Acreage	Production Value	Acreage	Production Value
Sacramento River	0	$0	0	$0	0	$0	-60	$0
San Joaquin River	2,770	$10	4,541	$14	4,858	$15	-5,758	-$14
TOTAL	2,770	$10	4,541	$14	4,858	$15	-5,818	-$14

Table 5.12-3. Dry and Critically Dry Year Change in Irrigated Agricultural Farmland (acres) Acreage and Total Production Value from No Action Alternative (millions of dollars, 2018 value)

Regions	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Acreage	Production Value	Acreage	Production Value	Acreage	Production Value	Acreage	Production Value
Sacramento River	0	$0	0	0	0	0	-2,427	-$3
San Joaquin River	23,668	$50	56,147	$121	56,039	$121	-12,333	-$29
TOTAL	23,668	$50	56,147	121	56,039	121	-14,760	-$33

In addition, the Bay-Delta region under Alternatives 1 and 4, in years with Summer-Fall Delta Smelt Habitat actions could, could, in some years, experience in a reduction of agricultural water that could result in reduction of irrigated agricultural acreage, potentially leading to conversion of agricultural land to nonagricultural uses. Mitigation Measure AG-1 could reduce effects by encouraging water agencies to diversify their water portfolios, thus increasing the likelihood that water users would have adequate water in years with these actions.

Potential changes in irrigated agricultural acreage and total production value as a result of construction and habitat restoration efforts

Loss of agricultural farmland under all action alternatives could result from direct conversion if farmland is used for project actions that involve ground-disturbing activities such as construction or restoration, depending on where these projects are sited, and from indirect conversion if the future project severs access to agricultural farmland by closing roads or results in remnant parcels that are too small or oddly shaped to farm economically. To mitigate this effect, Mitigation Measure AG-2 could reduce the magnitude of the effect by imposing conditions on discretionary land use approvals, such as land or conservation easement grants or payment of in-lieu fees. Mitigation activities would be performed by local jurisdictions. Because carrying out this mitigation would not be within the jurisdiction of Reclamation, Reclamation cannot ensure that it will be implemented or enforced. Therefore, it is uncertain to what extent mitigation would reduce direct conversion of farmland.

Temporary use of agricultural farmland for construction under all action alternatives would not be likely to result in permanent conversion of farmland to nonagricultural uses, although it could lead to temporary reduction in production value on a local scale.

Potential effects related to water transfers

According to CWEST modeling, costs for water transfers would decrease overall for Alternatives 1, 2, and 3 compared to the No Action Alternative. Costs for water transfers would increase for Alternative 4. Table 5.12-4, Change in Water Transfer Costs from No Action Alternative (thousands of dollars, 2018 value), shows the change in water transfer costs by region for each action alternative compared to the No Action Alternative.

Table 5.12-4. Change in Water Transfer Costs from No Action Alternative (thousands of dollars, 2018 value)

Regions	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Trinity River	$0	$0	$0	$0
Sacramento River	-$108	-$44	-$35	$121
San Joaquin River	-$307	-$3,667	-$3,659	$1,115
Delta	-$1,001	-$485	-$510	$369
San Francisco Bay Area	-$5,793	-$6,000	-$6,000	$2,789
Central Coast	$25	$0	$0	$0
Southern California	-$4,088	-$13,813	-$14,194	$2,990
TOTAL	-$11,273	-$24,010	-$24,398	$7,384

Alternative 4 alone would result in an increase in water transfer costs of approximately $7,000,000. Alternatives 2 and 3 show the greatest decreases in water transfer costs compared to the No Action Alternative, of approximately $24,000,000. Alternative 1 would result in decreases in water transfer costs of approximately $11,000,000. Under Alternatives 2 and 3, all regions except for the Trinity River region and the Central Coast region show decreases in water transfer costs. These two regions stay the same with respect to the No Action Alternative. Under Alternative 1, the Trinity River region would have the same costs as under the No Action Alternative, and the Central Coast region would have increased costs of approximately $25,000. The overall decrease in water transfer costs and decrease in water transfer deliveries is balanced by increases in CVP/SWP deliveries. In contrast, Alternative 4 would result in an increase in water transfer costs for all regions except the Trinity River and Central Coast regions.

While water transferors would have less income from water transfers under Alternatives 1, 2, and 3 than under the No Action Alternative, all regions would be able to afford water acquired by transfer for Alternatives 1, 2, and 3 because water transfer costs would decrease. Further, as shown in Appendix R, overall water costs for all of the regions under Alternatives 1, 2, and 3 either stay the same or decrease, except for a small increase in the Central Coast region under Alternative 1. Under Alternative 4, it is possible that changes in water transfers could result in changes in land use or conversion of agricultural land in the San Joaquin River, San Francisco Bay, and Southern California regions. Implementation of Mitigation Measure AG-1 could reduce effects by encouraging water agencies to diversify their water portfolios, thus increasing likelihood that water users would have adequate water in years with these actions.

5.12.2 Program-Level Effects

Several of the proposed program-level components of Alternatives 1, 2, 3, and 4 (e.g., habitat restoration; installation of new or repairing existing equipment for diversions, fish screening, repairing/replacing locks in a ship channel, and automation of Delta Cross-Channel gates; trapping and hauling adult salmonids and sturgeon and electro-shocking predators to relocate them in more appropriate waters; increasing nutrients in waters; construction and operation of a conservation hatchery; managing flows to maintain temperatures for fish habitat; and water use efficiency improvements) could result in changes to land use and effects on agricultural lands. Because Alternative 2 does not include program actions, the discussions below omit discussion of Alternative 2.

Potential changes in land use

Because the program actions under Alternatives 1 and 3 would either increase or not affect CVP and SWP flows, the water supply available to local jurisdictions to implement their general plans would not be adversely affected. Accordingly, no changes in the ability of local jurisdictions to implement their general plans compared to the No Action Alternative. No changes in land use are anticipated for Alternatives 1 and 3. While a small area agricultural land may be converted to nonagricultural uses under the action alternatives, changes to agricultural land are analyzed under a separate effects analysis. Water use efficiency measures under Alternative 4 have the potential to result in changes in land use when altering land use for land with exceptionally high water use or irrigation which contributes to significant problems. The exact nature of the water use efficiency measures has not been defined; however, implementation of water efficiency measures could have an effect on land uses in the study area under Alternative 4.

Potential changes in irrigated agricultural acreage and total production value

Of the program-level components of Alternatives 1 and 3, managing flows to maintain temperatures and construction activities such as those associated with constructing the conservation hatchery could affect agricultural farmland. Changes in quantities of flows would not affect agricultural land because CVP and SWP deliveries are anticipated to increase. Implementation of program-level measures under

For future projects that involve ground-disturbing activities under Alternatives 1, and 3 depending on where the projects are sited, loss of agricultural farmland could result from direct conversion if farmland is used for the new project, and from indirect conversion if the project severs access to agricultural farmland by closing roads or results in remnant parcels that are too small or oddly shaped to farm economically. To mitigate this effect, Mitigation Measure AG-2 would encourage grants of land or conservation or payment of in-lieu fees for conversion of agricultural land. Mitigation activities would be performed by agricultural local jurisdictions.

Temporary use of agricultural farmland for construction would not be likely to result in permanent conversion of farmland to nonagricultural uses, although it could lead to temporary reduction in production value on a local scale.

Alternative 4 has the potential to convert agricultural land to nonagricultural uses or to convert existing crops to more water efficient crops, changing the total production value. The exact nature of the water use efficiency measures to be implemented has not been defined and the magnitude of this effect is speculative at this time; however, implementation of conversion of land use could have a large scale effect on agricultural land in the study area under Alternative 4. Mitigation Measure AG-2 could reduce effects by encouraging agencies with discretionary land approval powers to require land or conservation easements or in-lieu fees to mitigate for conversion of agricultural land. These effects will be determined and analyzed at a later date.

Potential changes irrigated agricultural acreage as a result of changed water temperatures

Water temperatures below 69°F during the early rice growing season under Alternative 1 could affect the productivity of the harvest (Raney 1963). Fields used for rice are flooded during part of the growing season. However, the proposed temperature management regime for the Sacramento River, Clear Creek, and the American River differs from the temperature management regime under the No Action Alternative in only minor ways. It is therefore unlikely that effects on rice fields would lead to permanent conversion of agricultural land to nonagricultural use.

Potential effects related to water transfers

No modeling information is available for the program actions to suggest what changes, if any, would result from changes in operations under the Action Alternatives. Because CVP and SWP flows are anticipated to increase under Alternatives 1, 2, and 3, it is unlikely that water transfers would increase. This conclusion is, however, speculative. For Alternative 4, because deliveries would decrease, it is possible that demand for water transfers would increase. However, because Alternative 4 would allow the same volume of water transfers as the No Action Alternative to take place over a longer period of time (from July to November rather than July to September) than under the No Action Alternative, this alternative would allow for more flexibility than the No Action Alternative. Nevertheless, it is possible that changes in water transfers could result in changes in land use or conversion of agricultural land in the San Joaquin River, San Francisco Bay, and Southern California regions. Nevertheless, it is possible that changes in water transfers could result in changes in land use or conversion of agricultural land in the San Joaquin River, San Francisco Bay, and Southern California regions.

5.12.3 Mitigation Measures

These mitigation measures would help avoid or minimize potential effects related to land use and agricultural resources:

- Mitigation Measure AG-1: Diversify water portfolios
- Mitigation Measure AG-2: Impose conditions on discretionary land use approvals

Under Alternative 4, Irrigated farmland acreage and crop productivity would decrease in the Sacramento River and San Joaquin River regions. In addition, agricultural water deliveries to the San Francisco Bay Area would decrease, so some conversion of agricultural farmland could result. Implementation of Mitigation Measure AG-1 could reduce effects by encouraging water agencies to diversify their water portfolios, thus increasing the likelihood that water users would have adequate water in years with these actions. Mitigation Measure AG-2 could reduce effects by encouraging agencies with discretionary land approval powers to require land or conservation easements or in-lieu fees to mitigate for conversion of agricultural land.

The Bay-Delta region under Alternative 1, in years with Summer-Fall Delta Smelt Habitat actions could, could, in some years, experience in a reduction of agricultural water that could result in reduction of irrigated agricultural acreage, potentially leading to conversion of agricultural land to nonagricultural uses. Mitigation Measure AG-1 could reduce effects by encouraging water agencies to diversify their water portfolios, thus increasing the likelihood that water users would have adequate water in years with these actions.

Reduced deliveries would increase water transfer costs and potentially result in changes in land use or conversion of agricultural land to nonagricultural use in the San Joaquin River, San Francisco Bay, and Southern California regions. Mitigation Measure AG-1 could reduce effects by encouraging water agencies to diversify their water portfolios, thus potentially providing alternative sources of water, such as recycled or desalinated water, in addition to water transfers.

Several of the program-level components under Alternatives 1, 3, and 4 could result in conversion of agricultural lands to nonagricultural uses as a result of construction, habitat restoration, or water use efficiency measures. Mitigation Measure AG-2 could reduce effects by encouraging agencies with discretionary land approval powers to require land or conservation easements or in-lieu fees to mitigate for conversion of agricultural land.

Please see Appendix E for full descriptions of the mitigation measures.

5.13 Recreation

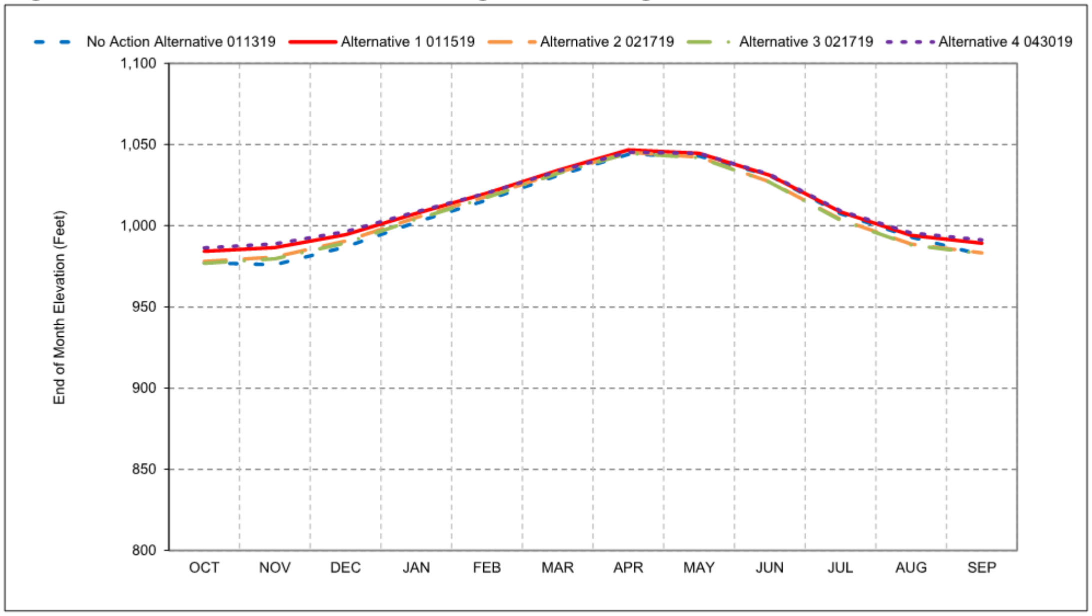
This impact assessment is based on the technical analysis documented in Appendix S, *Recreation Technical Appendix*, which includes additional information on recreation existing conditions and technical analysis of the effects of each alternative. The analysis is based on CalSim II model results.

5.13.1 Project-Level Effects

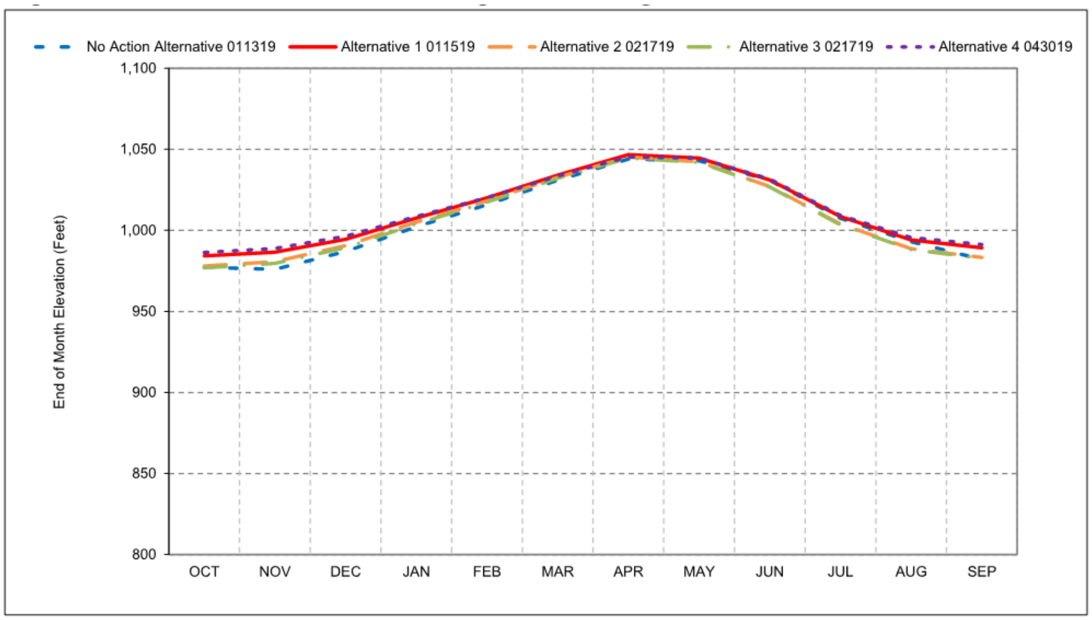
Potential changes to recreational opportunities

The action alternatives would change operations of the CVP and SWP, which would change river flows and reservoir levels. If river flows have substantive declines or increases in areas with recreational opportunities, those changes could limit available opportunities (including potential impacts on boating, camping, and day use activities). For example, higher flows could inundate beach areas or lower flows could reduce boating or rafting opportunities. Additionally, lower reservoir levels during the summer recreation season could reduce boating opportunities because boat ramps may no longer be inundated and the areas for recreation would be smaller. This in turn could reduce desirability of other associated recreational opportunities, such as use of camping sites and day use areas.

Alternatives 1 through 4 are anticipated to change the water levels in reservoirs. Figure 5.13-1, Shasta Lake Elevation Changes, Average during Above Normal Year Type shows changes in Shasta Lake water elevations as an example; other reservoirs show similar patterns of elevations compared to the No Action Alternative. In most cases, reservoirs have only small changes and alternatives would not substantively affect recreation in these facilities. River flows would generally have only small changes during the recreation season (for example, see Figure 5.13-2, Sacramento River Flows Downstream of Keswick Reservoir, Average during Above Normal Year Type). The flow changes are relatively small during each year type and would not result in substantive changes to the available recreational opportunities.

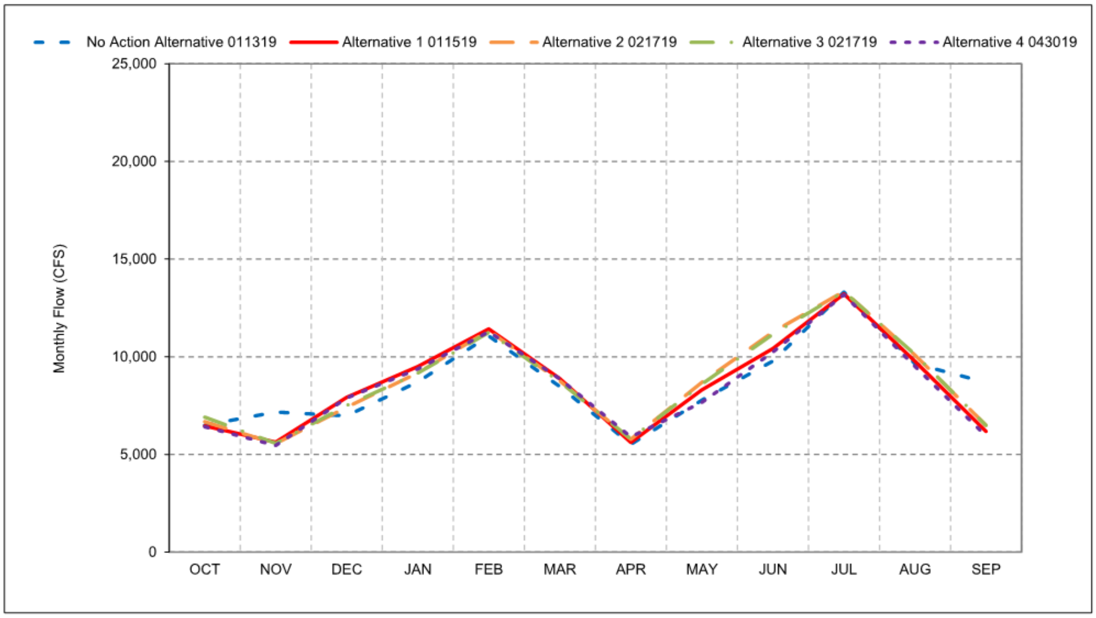


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft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

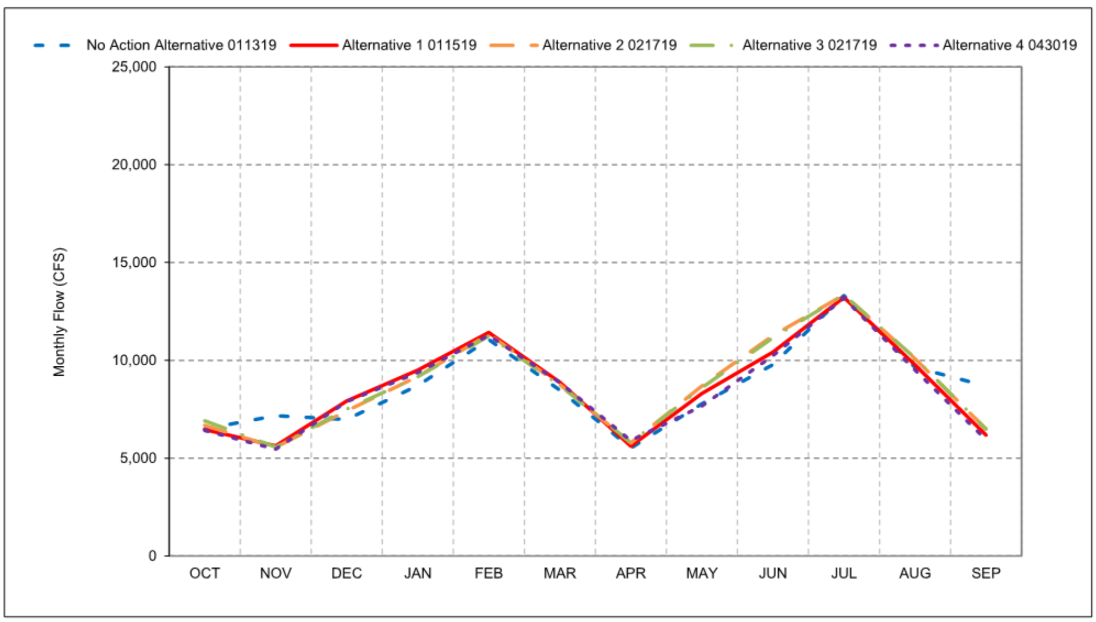


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft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

Figure 5.13-1. Shasta Lake Elevation Changes, Average during Above Normal Year Type



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



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

Figure 5.13-2. Sacramento River Flows Downstream of Keswick Reservoir, Average during Above Normal Year Type

Relative to the No Action Alternative, Alternatives 1 through 4 operations would change conditions for fish, which could affect the populations of recreational fish and fishing opportunities. Alternatives 1 and 4 would benefit fish (as discussed in Section 5.9), and they would provide similar benefits to recreational fish species. Compared to the No Action Alternative, Alternatives 2 and 3 could have some minor benefits and some minor adverse effects on recreation, including recreational fishing, depending on the location and season.

5.13.2 Program-Level Effects

Potential changes to recreational opportunities

The No Action Alternative would not change recreational fishing opportunities because operations would not change from current operations. Alternatives 1 and 3 would implement program-level habitat restoration and intervention measures. These measures would increase abundance of fish and could have a beneficial impact on recreational fishing opportunities relative to the No Action Alternative. No other forms of recreation, including camping, day use, and boating, would be affected by the proposed habitat restoration and fish intervention. Alternatives 2 does not include additional program-level components. Under Alternative 4, programmatic actions would not affect recreation.

5.14 Environmental Justice

This impact assessment is based on the technical analysis documented in Appendix T, *Environmental Justice Technical Appendix*, which includes additional information on low-income and minority populations in the area of analysis and technical analysis of the effects of each alternative. The analysis considers the action alternatives' disproportionate adverse effects impacts on low-income and minority populations.

5.14.1 Project-Level Effects

Potential effects to minority and low-income populations from urban water supply and water costs

The action alternatives would change operations of the CVP and SWP and CVP and SWP water deliveries to M&I water service contractors. An increase in water supply would translate to lower water costs for M&I users in the region. As discussed in more detail in Section 5.11, *Regional Economics*, changes in CVP and SWP operations would decrease average annual water supply costs by approximately 9% under Alternative 1 and approximately 23% under Alternatives 2 and 3 compared to the No Action Alternative. Reduced water costs would result in an increase of disposable income. Under Alternative 1, the Central Coast would experience a slight increase of water costs due to a minor increase in delivery costs for the additional CVP and SWP water. Consequently, an increase in water cost would result in a decrease in spending. The decrease in spending, when distributed over regional industries, would result in a loss of one job in the service sector within the region. Although Santa Barbara County is considered a minority area (with its minority populations accounting for more than 50% of the total county population), the increase in water cost would be spread across all M&I users in the region and the loss of one job would not be a disproportionate impact on minority or low-income communities. Under Alternative 4 average annual water supply cost would increase by approximately 7% in comparison to the No Action Alternative, resulting in a decrease in spending. The decrease in spending, when distributed over regional industries, would result in a loss of approximately 76 job losses across all regions and sectors, which would not be a disproportionate effect on minority or low-income populations.

Potential effects to minority and low-income populations from reduced agricultural employment

Under Alternative 4, average annual agricultural water supply deliveries are expected to decrease in the San Francisco Bay Area and Southern California regions. The decrease in agricultural water supply would result in a decrease in irrigated acreage and agricultural revenue in the regions. This would have an adverse effect to agricultural jobs, which are mostly held by minority or low-income populations. Both San Francisco Bay Area and Southern California regions are considered minority areas. The decrease in agricultural water supply deliveries could disproportionately affect minority or low-income communities in these counties.

In addition, modeling for the Sacramento River and San Joaquin regions estimates that changes in SWP and CVP deliveries would result in a decrease in agricultural productivity under Alternative 4. This decrease in agricultural productivity would result in decreased agricultural revenues for the growers and would lead to a loss of agricultural jobs particularly in the San Joaquin region. Minority populations accounted for 50% or more of the total county population in all San Joaquin region counties, and Fresno, Kern, King, Madera, Merced, and Tulare Counties are defined as poverty areas. Data show that the vast majority of crop workers in California are Spanish-speaking (92.9%) and born in Mexico (91.4%) (Schenker et al. 2015). Since most agricultural jobs are held by minority or low-income populations, the loss of 169 agricultural jobs in average water years caused by changes in CVP and SWP operations could disproportionately affect minority or low-income communities in these counties.

5.14.2 Program-Level Effects

Program-level habitat restoration and intervention measures under Alternatives 1 and 3 are designed to improve habitat conditions and survival rates for the biological resources across the study area. It is assumed that they could improve conditions relative to those resources' future survival and population health and would lead to an increase in salmon population and commercial salmon harvest. An increase in commercial salmon harvest would generate more income for fisherman, including those from minority or low-income populations.

Habitat restoration or water efficiency measures under Alternatives 1, 3, and 4 could have health effects related to construction hazards. Construction or operation and maintenance of any CVP or SWP projects that are planned or currently underway or any ongoing operations and maintenance activities that may require the use of heavy equipment (front loaders, dump trucks, excavators, cranes) that require the use of hazardous materials, including fuels, lubricants, and solvents, could create a hazard to the public and environment through the accidental release of those hazardous materials. However, these impacts would be avoided through mitigation measures for hazards and hazardous materials (see Section 5.17, *Hazards and Hazardous Materials*).

In addition, the wetland and floodplain habitats restored under Alternatives 1 and 3 could create mosquito breeding habitat. Tidal wetlands and floodplains provide habitat for mosquito breeding, especially in tidally influenced wetlands with slow-moving water and floodplains after the majority of the water recedes. Depending on the areas in which these impacts occur, minority or low-income populations who live or work near these areas may be disproportionately affected. However, as discussed in Section 5.17, applicable regulations and construction BMPs are in place to reduce impacts to existing levels.

5.15 Power

This impact assessment is based on the technical analysis documented in Appendix U, which includes additional information on power and energy resources and a technical analysis of the effects of each alternative. The results are based on CalSim II modeling and the LTGen and SWP Power post-processing tools.

5.15.1 Project-Level Effects

Potential changes in statewide energy resources

5.15.1.1 *Central Valley Project Power and Energy*

Each of the action alternatives except Alternative 4 would increase the long-term annual energy use of the CVP through increases in water movement throughout the CVP. Similarly, each of the action alternatives except Alternative 4 would increase the long-term annual generation of the CVP. On an annual level, the increases in generation would be less than the increases in energy use, reducing the overall net CVP generation for each of the action alternatives except Alternative 4, which would have an increase in net generation, relative to the No Action Alternative. Figure 5.15-1, Comparison of Simulated Long-Term Average Annual CVP Energy Use, Generation, and Net Generation, shows a comparison of long-term average annual CVP energy use, generation, and net generation for the No Action Alternative and the action alternatives.

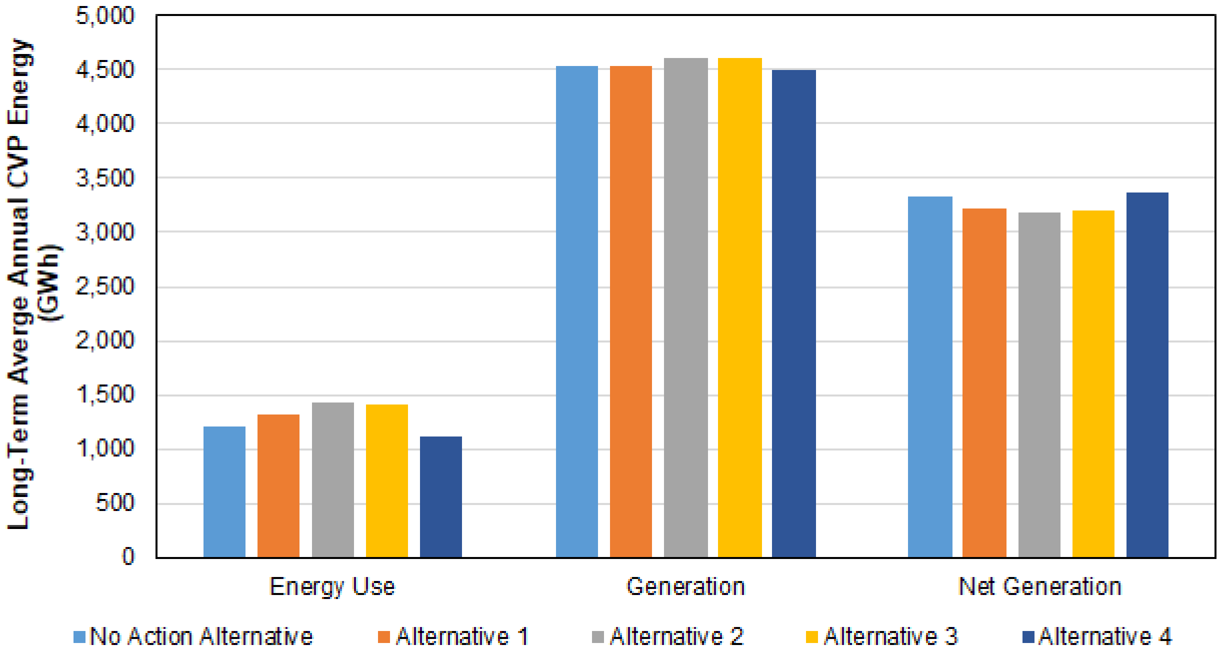


Figure 5.15-1. Comparison of Simulated Long-Term Average Annual CVP Energy Use, Generation, and Net Generation

Each of the action alternatives would result in a change in long-term average net generation on a monthly basis; reductions in monthly net generation could require the procurement of additional generation energy from within California or the Western Area Power Administration or construction of new generation facilities if there is inadequate generation available elsewhere within California's energy system, even with relatively small changes in long-term annual changes. Since LT-Gen models CVP generation on a monthly basis, small percentage fluctuations between the no action alternative and other alternatives on a monthly basis may not capture or reflect actual price variances as to the value of that power in California's market-based energy market where prices are determined on an hourly and sub-hourly basis. Monthly reductions in long-term average net generation for the action alternatives from the No Action Alternative would be greatest in November, April, and September. Figure 5.15-2, Comparison of Simulated Long-Term Monthly CVP Net Generation and Percent Change in Net Generation from the No Action Alternative, shows a comparison of long-term monthly average net generation for the No Action Alternative and the action alternatives, as well as the change between the action alternatives and the No Action Alternative.

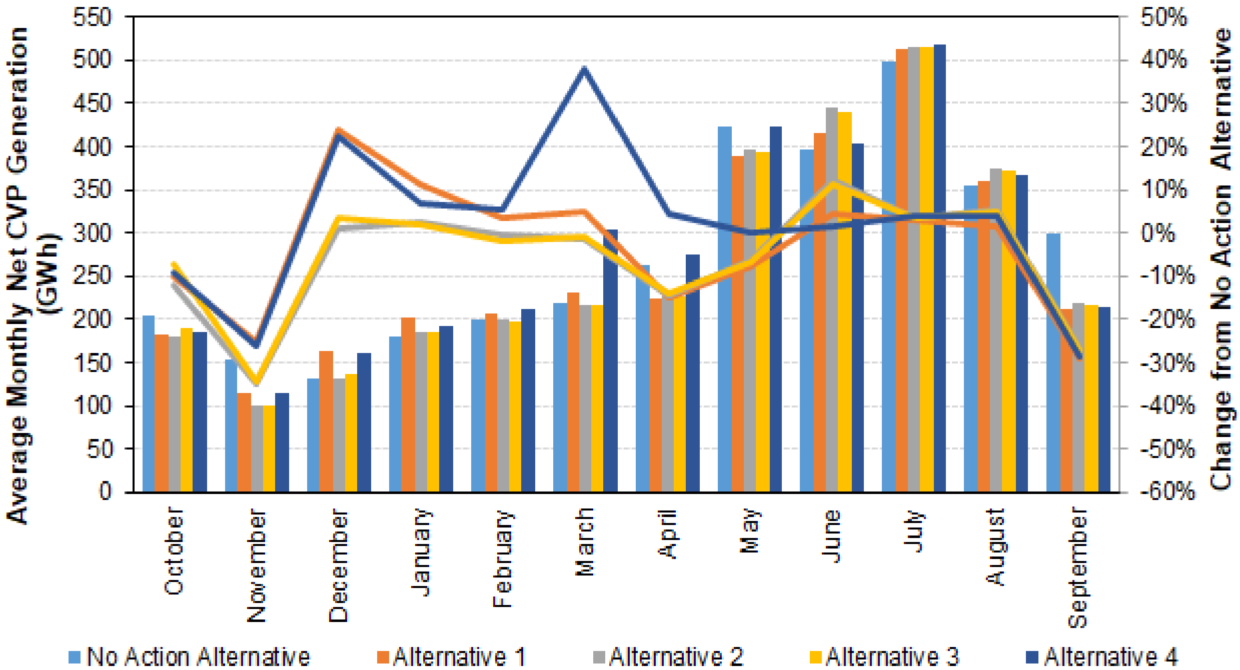


Figure 5.15-2. Comparison of Simulated Long-Term Monthly CVP Net Generation and Percent Change in Net Generation from the No Action Alternative

5.15.1.2 *State Water Project Power and Energy*

Each of the action alternatives except Alternative 4 would increase both the SWP energy use for water movement and the SWP hydropower generation relative to the No Action Alternative. Alternative 4, conversely, would result in a decrease in annual SWP energy use, and a decrease in SWP generation. However, changes in energy use would be greater than changes in generation, so average annual net generation would decrease for all of the action alternatives except Alternative 4, which would result in an increase in net generation, relative to the No Action Alternative. Figure 5.15-3, Comparison of Simulated Long-Term Average Annual SWP Energy Use, Generation, and Net Generation, shows a comparison of average annual SWP energy use, generation, and net generation for the No Action Alternative and the four action alternatives.

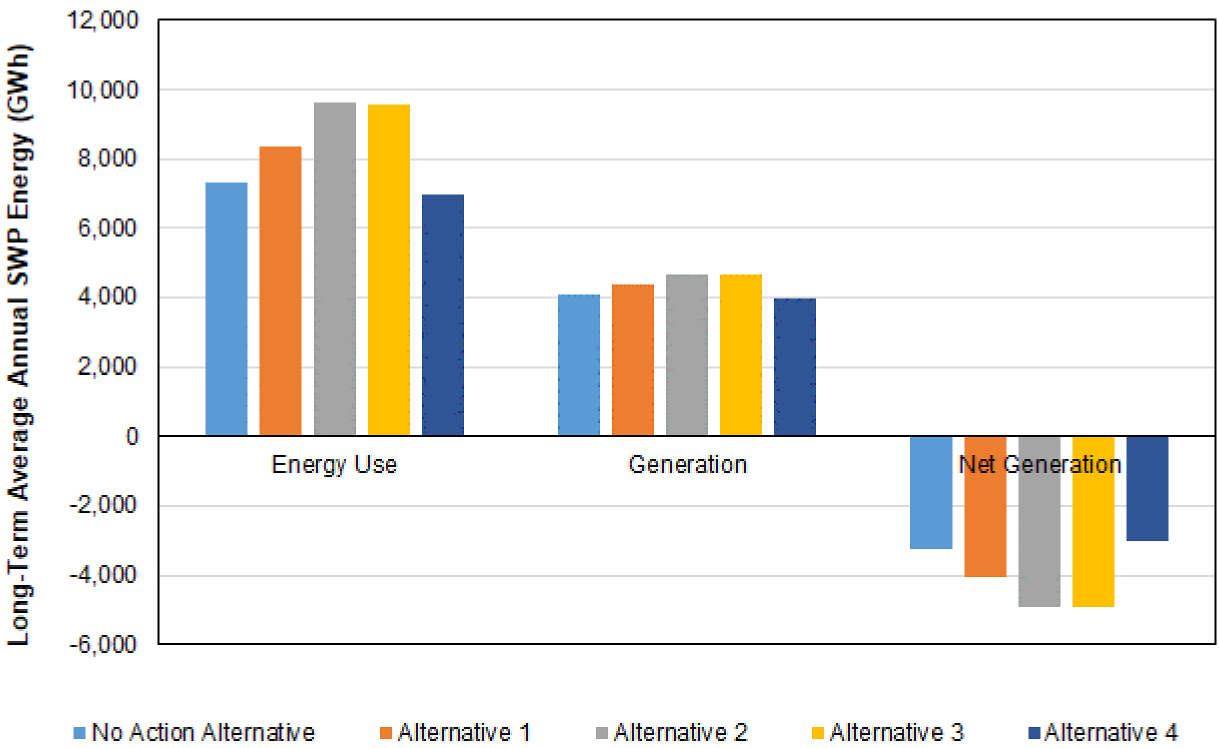


Figure 5.15-3. Comparison of Simulated Long-Term Average Annual SWP Energy Use, Generation, and Net Generation

Except for Alternative 4, the reduction in average annual net generation reflects a reduction in average monthly net generation for all months for the action alternatives relative to the No Action Alternative. The reduction in net SWP generation relative to the No Action Alternative was greatest for Alternative 1 in April and for Alternatives 2, 3, and 4 in January and February. Alternative 4 would only result in reductions in average annual net generation in October, November, January, and February. Reductions in long-term average monthly net generation imply that each of the action alternatives would require additional generation elsewhere within the California energy system. This additional generation could be in the form of additional renewable energy, such as solar, wind, or hydropower, or it could be procurement of additional thermal generation from out of state, such as from the Pacific Northwest or elsewhere in the Southwest.

Figure 5.15-4, Comparison of Simulated Long-Term Monthly SWP Net Generation and Percent Change in Net Generation from the No Action Alternative, shows long-term average monthly net generation for the No Action Alternative and the action alternatives and the percent change in net generation for each action alternative relative to the No Action Alternative.

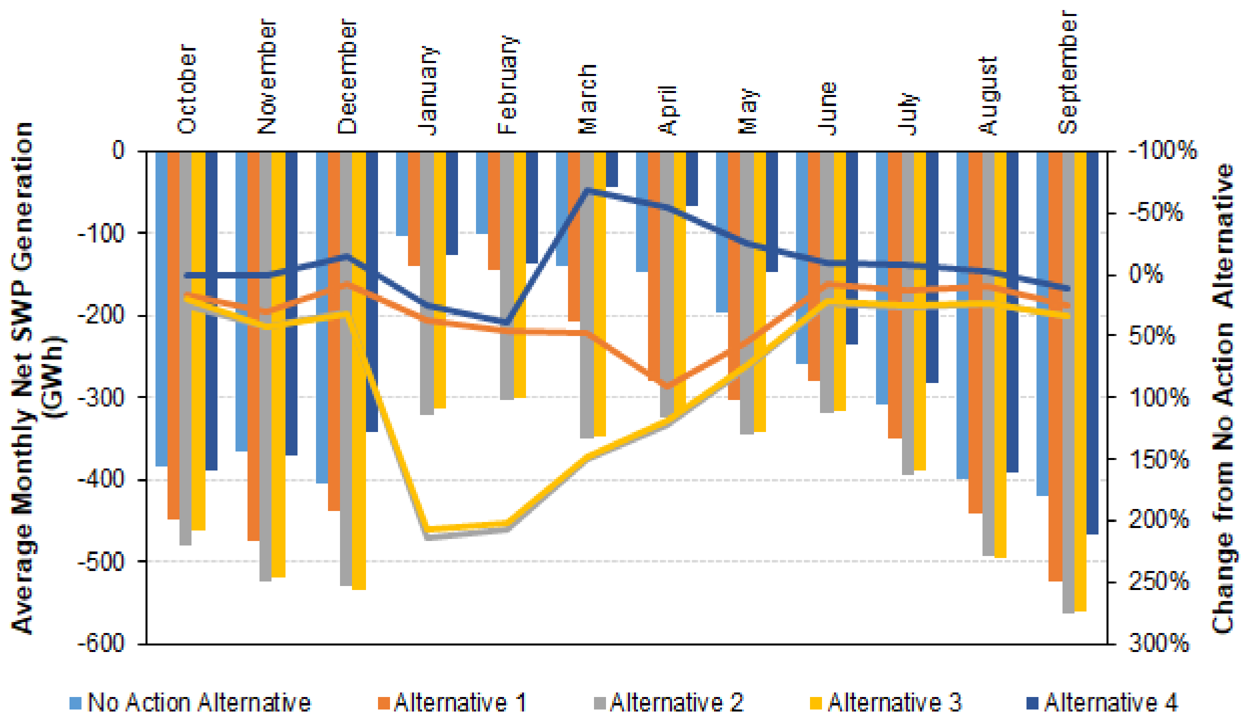


Figure 5.15-4. Comparison of Simulated Long-Term Monthly SWP Net Generation and Percent Change in Net Generation from the No Action Alternative

5.15.2 Program-Level Analysis

Construction-related actions analyzed at a program level would not affect power or energy resources.

5.16 Noise

5.16.1 Project-Level Effects

Temporary and permanent equipment noise and vibration levels for each action alternative would be the same as the No Action Alternative. There would be no project-level effects for any of the action alternatives.

5.16.2 Program-Level Effects

Potential exposure of sensitive receptors to temporary construction-related noise

Program-level habitat restoration and fish intervention actions under Alternatives 1 and 3 would involve temporary use of construction equipment, which may result in increased ambient noise levels at sensitive receptor locations relative to the No Action Alternative. Noise effects could occur within approximately 0.25 mi (1,320 ft) of the activity. Construction activities are not expected to result in discernible vibration levels inside structures.

Program-level restoration and interventions under Alternative 3 would be greater than those under Alternative 1 because the construction of the additional 25,000 acres of habitat would be expected to involve an increased use of construction equipment over a larger area for a longer period of time. Construction activities at the TFCF and Skinner Fish Facility would result in increases to ambient noise levels on a temporary basis, as receiver locations are within approximately 0.25 mi of each facility.

Program-level water use efficiency measures proposed under Alternative 4 could involve construction of new facilities, such as new on-farm irrigation systems, distribution canal improvements, or distribution system improvements. Measures to improve agricultural water use efficiency such as installation of new irrigation systems and canal improvements are unlikely to take place in the vicinity of sensitive receptors and ambient noise level increases would be temporary. Measures to improve municipal and industrial water use efficiency have a higher potential to take place in the vicinity of sensitive receptors; however, construction activities related to these improvements are not expected to result in discernible noise or vibration levels. The location, timing, size, and precise improvements implemented as part of this program-level action have not been defined at this time and will be subject to further analysis.

Potential exposure of sensitive receptors along truck haul routes to a temporary increase in traffic noise

Program-level habitat restoration, interventions, and construction activities could temporarily increase truck traffic along truck haul routes under Alternatives 1 and 3 relative to the No Action Alternative. Program-level activities with the greatest potential for truck haul routes that would increase traffic noise are spawning and rearing habitat restoration, DCC gate improvements, Delta Fish Species Conservation Hatchery construction, and the TFCF and Skinner Fish Facility improvements. Truck haul routes would be determined prior to construction, with exposure of sensitive receptors taken into consideration to the extent possible.

Hauling activities under Alternative 3 would be greater than those under Alternative 1 as the construction of the additional 25,000 acres of habitat would be expected to involve increased material transport over a larger area for a longer period of time.

Hauling activities under Alternative 4 are expected to be minimal and would depend greatly on the type of water use efficiency measure being implemented. Agricultural improvements would likely require longer and increased truck traffic along remote roads and are unlikely to expose sensitive receptors to increases in traffic noise. Truck haul routes would be determined prior to construction, with exposure of sensitive receptors taken into consideration to the extent possible. Hauling activities under Alternative 4 would remain similar to those under the No Action Alternative.

Potential exposure of sensitive receptors to intermittent noise due to long-term maintenance activity including emergency repair activities

Increased levels of long-term maintenance are anticipated for spawning and rearing habitat restoration and Delta Fish Species Conservation Hatchery production under Alternatives 1 and 3 relative to the No Action Alternative. The frequency and magnitude of maintenance will be determined for each project at a later date and captured in an operation and maintenance plan. Maintenance of the DCC gate, TFCF, and Skinner Fish Facility is not expected to be greater than that under the No Action Alternative because operation and maintenance would continue in much the same manner despite facility upgrades.

Program-level maintenance activities under Alternative 3 would be greater than those under Alternative 1 because of the additional 25,000 acres of habitat that would be constructed. Maintenance activities for

25,000 acres of habitat would be greater than the maintenance activities under the No Action Alternative (which includes 8,000 acres).

Water use efficiency measures under Alternative 4 that improve existing facilities would likely result in a decreased or similar level of long-term maintenance and need for emergency repairs compared to the No Action Alternative. The frequency and magnitude of maintenance will be determined for each project at a later date and captured in an operation and maintenance plan.

5.16.3 Mitigation Measures

To avoid and minimize for adverse noise effects compared to the No Action Alternative, Mitigation Measure NOI-1, Employ Standard Measures to Reduce Noise Levels from Heavy Equipment, has been identified. Where applicable, Reclamation and DWR will implement best practices to reduce construction noise levels at noise-sensitive land uses to reduce the potential for negative community reaction.

5.17 Hazards and Hazardous Materials

5.17.1 Project-Level Effects

Potential changes in the potential for Valley fever related to agricultural land irrigation

Analysis of SWAP modeling results indicated that relative to the No Action Alternative, although there would be a reduction in irrigated acreage under Alternative 4 for project-level components in the San Joaquin River region where *Coccidioides*, a soil-dwelling fungus that causes Valley fever, is endemic, this nominal reduction would likely not change the potential for Valley fever. Implementation of Mitigation Measure AG-1 would further minimize the potential.

5.17.2 Program-Level Effects

Potential changes in the potential for Valley fever related to agricultural land irrigation

The implementation of water-use efficiency measures under Alternative 4 may involve the conversion of land with exceptionally high water use or with irrigation problems to a different crop or to nonagricultural use. Conversion of agricultural land to another land use (e.g., developed land) could reduce the potential for the growth of *Coccidioides* and thus the risk of Valley fever. Conversion to a different crop or implementation of other water-use efficiency measures (e.g., recycled water use, or improving pump efficiencies in distribution systems) would not result in a change in the potential for growth of *Coccidioides*. Therefore, there could potentially be a benefit (i.e., reduction in Valley fever risk) due to agricultural land conversion or no change in the potential for Valley fever relative to the No Action Alternative under this alternative.

Potential changes in habitat restoration could increase the potential for mosquito-borne diseases related to habitat restoration

Tidal and floodplain habitat restoration components under Alternatives 1 and 3 could potentially provide suitable mosquito breeding habitat, which would potentially increase the public's risk of exposure to mosquito-borne diseases compared to the No Action Alternative. Implementation of Mitigation Measure HAZ-1 could avoid or minimize the potential for adverse effects.

Potential changes in methylmercury production and resultant changes in bioaccumulation of mercury in fish and shellfish for human consumption

There would be substantially more habitat restored under Alternative 3 relative to the No Action Alternative. This habitat restoration in the Delta under Alternative 3 could result in a greater potential for methylmercury generation in the restored areas and bioaccumulation in fish and shellfish, which could increase the potential for human exposure to mercury through fish consumption relative to the No Action Alternative. The degree to which new tidal habitat areas may be future sources of methylmercury to the aquatic environment is uncertain. The specific siting and design of the restored areas would be factors that affect the potential for methylmercury generation, transport, and bioaccumulation. Office of Environmental Health Hazard Assessment standards for the consumption of fish would continue to be implemented and thus would serve to protect people against the overconsumption of fish with increased body burdens of mercury.

Potential changes in the potential for bird-aircraft strikes related to habitat restoration

Habitat restoration of the type that could attract waterfowl and other birds to restored areas within 5 mi of a public-use airport could increase the potential for bird-aircraft strikes under Alternatives 1 and 3 relative to the No Action Alternative. Implementation of Mitigation Measure HAZ-2 would avoid or minimize the potential for bird-aircraft strikes resulting from habitat restoration.

Potential changes in the potential for construction and operation and maintenance activities to result in hazards and effects related to hazardous materials

Construction and operation and maintenance of facilities could result in the potential for hazards to the public or environment through the transport, use, accidental release, or disposal of hazardous materials, as well as through damage to existing hazardous infrastructure (e.g., natural gas pipelines). To minimize, avoid, and reduce effects related to hazards and hazardous materials, for construction activities under Alternatives 1, 3, and 4 that would disturb 1 or more acres, BMPs would be implemented under the Construction General Permit to control pollutant discharges. No hazardous materials would be used in reportable quantities (pursuant to California Code of Regulations [CCR] Title 19, Division 2) unless approved in advance by the California Office of Emergency Services (OES), in which case a hazardous materials management plan would be prepared and implemented, as part of Mitigation Measure HAZ-3. In addition, implementation of Mitigation Measure WQ-1 (spill prevention, control, and countermeasure plan) under Alternatives 1, 3, and 4 would minimize the potential for, and effects from, spills of hazardous, toxic, and petroleum substances during construction and maintenance. BMPs would be implemented under the General Pesticide Permit for herbicide and algaecide application at CCF under Alternative 1.

5.17.3 Mitigation Measures

These mitigation measures would help avoid or minimize potential effects related to hazards and hazardous materials:

- Mitigation Measure HAZ-1: Prepare and Implement Site-specific Mosquito Management Plans
- Mitigation Measure HAZ-2: Comply with Federal Aviation Administration (FAA) Safety Guidelines on Wetlands and Wildlife Attractants as Identified in the FAA Draft Advisory Circular 150/5200-33C

- Mitigation Measure HAZ-3: Prepare and Implement a Hazardous Materials Management Plan for Actions that will Require Handling Hazardous Materials in Reportable Quantities (CCR Title 19, Division 2)
- Mitigation Measure AG-1: Diversify Water Portfolios
- Mitigation Measure WQ-1: Implement a Spill Prevention, Control, and Countermeasure Plan

5.18 Cultural Resources

This analysis identifies potential project and program-level effects of implementation of the action alternatives on archaeological and built-environment historic properties. The effects analysis considers the known historic property environmental setting in the plan area, as well as the potential for previously undocumented historic properties and physical effects (i.e., disturbance, trenching, demolition) to known and previously undocumented properties that could result from implementation of the action alternatives. The analysis is also informed by the requirements of federal and state laws and regulations that apply to cultural resources.

There are three key potential impacts on cultural resources: (1) disturbance or destruction of archaeological historic properties; (2) exposure of buried archaeological historic properties; and (3) the alteration, destruction, or demolition of built-environment historic properties. Each alternative has been considered for its potential to involve activities that would include ground disturbance that could disturb or destroy archaeological historic properties, cause erosion that could expose buried archaeological historic properties, or damage, alter, or demolish built-environment historic properties.

5.18.1 Section 106 of the National Historic Preservation Act

Because ROC on LTO is subject to Section 106 of the National Historic Preservation Act (NHPA). The U.S Bureau of Reclamation will oversee compliance with Section 106. Section 106 requires Federal agencies to consider the effects of their undertakings on historic properties, properties determined eligible for inclusion in the National Register, and to afford the Advisory Council on Historic Preservation an opportunity to comment. Compliance with Section 106 follows a series of steps, identified in its implementing regulations found at 36 CFR Part 800, that include identifying consulting and interested parties, delineating an area of potential effects, identifying historic properties within the area of potential effect, and assessing effects on any identified historic properties, and resolving adverse effects through consultations with the SHPO, Indian tribes and other consulting parties.

Resolution of adverse effects may result in a memorandum of agreement or programmatic agreement stipulating how historic properties will be treated.

Project-level activities under the action alternatives will not result in changes to peak flows or reservoir levels compared to the No Action Alternative. As a result, project level actions have no potential adverse effects to historic properties and do not require further consideration under Section 106 of the NHPA.

Program-level activities under the action alternatives have the potential to cause adverse effects to historic properties due to ~~changes river flows, reservoir levels, and~~ construction of new habitat restoration sites and a new conservation hatchery facility. However, since program-level activities are broad in scope and not fully defined, these activities will be subject to additional environmental compliance procedures in the future. Once a program alternative is selected, the federal agency carrying out the action will comply with Section 106 and the consideration of effects to historic properties. This may be in the form of a

Programmatic Agreement or other Section 106 compliance efforts depending on supplemental NEPA documents or phasing of program level activities.

5.18.2 Project-Level Effects

Potential changes in river flows and reservoir levels, habitat restoration, and conservation hatchery production affecting cultural resources

Project-level actions proposed under Alternatives 1 through 4 that would increase water flow and raise water levels beyond the No Action Alternative and develop habitat restoration and conservation hatchery infrastructure have potential to cause erosion that could adversely affect buried archaeological historic properties and alter or demolish built-environment historic properties. If peak river flows or reservoir levels have substantive increases beyond the No Action Alternative, they could result in erosion in areas with buried archaeological resources and therefore adversely affect the resources. However, evaluation of changes in peak flow rates taken from the surface water supply analysis conducted using the CalSim II model (as described in Appendix F and analyzed in Appendix X) indicates that Alternatives 1 through 3 would not result in changes to peak flows compared to the No Action Alternative. There may be an increase in erosion under Alternative 4. However, erosion may occur primarily due to crop reduction as a result of reduced water deliveries and this type of erosion is unlikely to adversely affect buried resources or built-environment historic properties.

5.18.3 Program-Level Effects

Potential changes in river flows and reservoir levels, habitat restoration, and conservation hatchery production affecting cultural resources

Program-level components proposed under Alternatives 1, 3, and 4 that would require construction and restoration activities would result in associated ground disturbance that could affect archaeological and built-environment historic properties. The likelihood of effects on cultural resources is greater under Alternative 3 than Alternatives 1 and 4 because of the greater quantity of habitat restoration proposed. Installation of irrigation systems under Alternative 4 would have the potential to affect unknown archaeological and built-environment historic properties. The potential for effects would be minimized through Mitigation Measures CUL-1, CUL-2, CUL-3, and CUL-4.

5.18.4 Mitigation Measures

Under Section 106 of the National Historic Preservation Act, adverse effects to historic properties would be resolved through the execution of a programmatic agreement that will include NEPA mitigation measures as stipulations of the agreement.

Mitigation measures under NEPA are provided to avoid, minimize, or compensate for adverse effects on cultural resources for Alternatives 1, 2, 3, and 4 at the project and program levels.

Mitigation Measure CUL-1, Conduct Archaeological Surveys before the Beginning of Any Project or Program–Related Action and Implement Further Mitigation as Necessary, would be applicable prior to any program-level action that would include ground-disturbing activities that might expose or damage archaeological historical properties.

If implementation of Mitigation Measure CUL-1 reveals the presence of cultural resources on the project site, the procedures outlined in Mitigation Measure CUL-2, Restrict Ground Disturbance and Implement

Measures to Protect Archaeological Resources if Discovered during Surveys or Ground-Disturbing Activities, will be followed as determined under Section 106.

In the event Native American human remains are discovered, Mitigation Measure CUL-3, Stop Potentially Damaging Work if Human Remains Are Uncovered During Construction, Assess the Significance of the Find, and Pursue Appropriate Management, would be implemented as determined under Section 106.

Mitigation Measure CUL-4, Complete Built-Environment Inventory and Evaluation prior to Construction and Implement Treatment Measures for Adverse Effects, would be applicable only to Alternatives 1 and 3 when implementing habitat restoration and other ground disturbing measures that may reveal built-environment historic properties.

5.19 Geology and Soils

5.19.1 Project-Level Effects

Potential changes in soil erosion

There would be no project-level effects on erosion for Alternatives 1, 2, or 3 related to geology and soil resources. There may be an increase in erosion under Alternative 4. Erosion may occur primarily due to crop reduction as a result of reduced water deliveries.

No changes in peak flows are expected in the Trinity River below Lewiston, in the affected stream reaches for the Sacramento River, Clear Creek, Feather River, and American River, or in the affected stream reaches for the San Joaquin River and Stanislaus River under Alternatives 1, 2, or 3, compared to the No Action Alternative, therefore, stream channel erosion will not be a concern in this area. Increased releases and reduced water deliveries would occur in the Sacramento River, Clear Creek, Feather River, and American River under Alternative 4. No changes are expected in peak flow for the San Joaquin or Stanislaus Rivers under Alternative 4.

No changes in peak flows are expected in the Bay-Delta region, including Suisun Marsh and the San Francisco Bay, under Alternatives 1 and 2. Under Alternative 3, an increase in peak flows of approximately 4% is expected during the month of January, compared to the No Action Alternative. This minor increase in flow in January would be far less than flood flows during major winter storm events, and given the low channel gradient, large cross-sectional area for flow, and low flow velocities at the margins of the Delta, this minor increase in peak flow under Alternative 3 is not a substantial concern for erosion in this area. Under Alternative 4, an almost 10% increase in outflow could occur and would result in greater levels of water moving through the Delta; however, the area miles of shoreline in the Delta are significant and the increase in outflow would likely not be sufficient enough for notable erosion to occur.

As described in Appendix R, compared to the No Action Alternative in the Sacramento Valley, crop acreage would decrease by approximately 2,427 acres during dry conditions and remain relatively similar to the No Action Alternative during normal conditions under Alternative 4. In the San Joaquin River, both dry (12,333-acre reduction) and average (5,578-acre reduction) conditions result in notable reductions of crop acreage under Alternative 4, compared to the No Action Alternative. Some conversion of agricultural land to nonagricultural uses could occur over time. Also, crops are modeled to shift from water-intensive crops to less water-intensive crops, which may reduce the total acreage subjected to crop idling. As suggested in Appendix R, Mitigation Measures AG-1 and AG-2 could reduce the effects of conversion of agricultural land to nonagricultural use. As a result, erosion due to crop idling may increase and could be offset to a degree by conversion or mitigation; however, the sizable decrease in acreage may still result in increased erosion. Specifically, for the CVP and SWP service areas south to Diamond Valley, water delivery would reduce by less than 5%. The reduction would not likely result in a notable impact to crops or result in the increased potential for erosion.

Potential changes in rate of land subsidence due to increased use of groundwater

There would be no project-level effects on the rate of land subsidence for Alternatives 1, 2, or 3 related to geology and soil resources.

The area along the Trinity River is not known to be susceptible to subsidence and groundwater pumping is not expected to increase in this region, therefore, subsidence is not a concern in this area. Groundwater levels are generally not expected to decrease in the Sacramento Valley or San Joaquin Valley under Alternatives 1, 2, or 3 compared to the No Action Alternative, therefore, it is unlikely that additional land subsidence would occur.

Compared to the No Action Alternative, Alternative 4 is expected to result in surface water supply to both the Sacramento and San Joaquin Valleys increasing and decreasing, depending on the year. An increase in supply, especially when made to meet agricultural demands, would result in a decrease in the need for groundwater pumping to meet demands. A decrease in supply may result in an increase in groundwater pumping. Most of the change in pumping is expected to be in the San Joaquin Valley. Modeled simulation shows that the change in groundwater-surface water interaction is 0.7% (reduced flow from groundwater to surface water) under Alternative 4 compared to the No Action Alternative. As described in Appendix H, delivery to CVP and SWP service areas south to Diamond Valley would experience a reduction in water deliveries, but modeled change is less than 5% and likely to not to substantially increase groundwater pumping. Subsidence as a result of groundwater pumping is not expected.

5.19.2 Program-Level Effects

Potential temporary change in soil mobilization

Under Alternative 1 and Alternative 3, restoration of seasonal floodplains and tidally influenced wetlands could potentially affect soil resources at the restoration locations. The following program-level projects may result in temporary soil alteration or disturbance:

- Upper Sacramento River Spawning and Rearing Habitat Restoration
- American River Spawning and Rearing Habitat Restoration
- Stanislaus River Spawning and Rearing Habitat Restoration
- Lower San Joaquin River Habitat Program
- Tidal Habitat Restoration (8,000 acres)
- Additional Delta Habitat Restoration (25,000 acres)

Although soils may be affected during construction, all necessary permits required for construction would be obtained to minimize any short-term adverse effects, whereas the long-term effects of restoration are expected to be stabilizing and beneficial to soils. Therefore, these changes are not analyzed further in this EIS.

Program-related potential effects to geology and soil resources were not identified for Alternative 4.

5.20 Cumulative Effects

The following resource discussions provide a summary of the expected cumulative impacts that would occur und**er the No Action Alternative or Alternatives 1, 2, 3, or** 4. The summaries are based on the foundational information contained in Appendix Y *Cumulative Methodology* and the each of the appendices which in**clude** detailed **background information and the evaluation of alternatives** for each resource topic (Appendices G through X –Z). **Reviewers of this EIS are** directed to these appendices for additional **information** supporting the **cumulative impact** discussions below.

5.20.1 Water Quality

5.20.1.1 *No Action Alternative*

The No Action Alternative would generate no changes to water operations compared to existing conditions. As such, there would be no change to the water quality conditions that currently contribute to the limits on water supply deliveries. Continued tidal restoration actions under the No Action Alternative, could lead to adverse water quality effects. However, the extent would be dependent on habitat design and locations. Thus, the No Action Alternative would not result in a cumulatively considerable effect on water quality.

5.20.1.2 *Alternatives 1, 2, 3, and 4*

Alternative 2 would negatively impact water quality in Clear Creek and the Stanislaus River by reducing flows in all water year types. However, Alternative 2's contribution to degradation of water quality conditions would not be substantial. Alternatives 1, 3, and 4 would have similar or less impacts and would not generate substantial contributions to cumulative water quality conditions in the study area. Specific to the CVP and SWP Service Area, the changes in water quality attributable to Alternatives 1 through 4 would not be considered cumulatively considerable when compared to the changes attributable to all projects considered in this analysis.

Specific to the Bay-Delta, the CVP and SWP operations under the action alternatives could have some effect on EC, chloride, bromide, methylmercury, selenium, nutrients, and organic carbon. The future cumulative conditions for EC, chloride, bromide, methylmercury, and selenium are considered to be adverse. Organic carbon concentrations at the future cumulative condition are considered to be potentially adverse relative to treatment of Delta waters for drinking water supplies, but not adverse relative to conditions necessary to support the food web. Nutrient conditions would not be adverse. CVP and SWP operations under Alternatives 1 through 4 would not contribute to the future cumulative adverse conditions for EC, chloride, bromide, methylmercury, selenium, and organic carbon. Implementation of tidal habitat in the Bay-Delta region under Alternatives 1 and 3 could create conditions resulting in methylation of mercury and potentially lead to new sources of total and dissolved organic carbon loading within the Delta. Tidal habitat design and location considerations could minimize these effects attributable to the alternatives and avoid a cumulatively considerable contribution when compared with the other cumulative projects.

5.20.2 Water Supply

This section provides an overview of the cumulative water supply impacts resulting from implementing the No Action Alternative or Alternatives 1, 2, 3, or 4. It should be noted that results of the water supply analysis was also used to support the project, program, and cumulative assessments for other resource topics. These resources include water quality, groundwater, aquatics, recreation, land use, agriculture, and power. Reviewers may refer to those discussion to better understand how the water supply assessment was considered as part of those cumulative impact assessments.

5.20.2.1 *No Action Alternative*

The No Action Alternative would generate no changes to water operations and there would be no improvement in the existing limits on water supply availability that impact CVP and SWP water users. Thus, the No Action Alternative would not have a cumulative effect on water supply within the study area.

5.20.2.2 *Alternatives 1, 2, 3, and 4*

Alternative 1 would improve water supply deliveries to some CVP and SWP contractors and for other water users result in reductions below 1%, which are considered similar to conditions under the No Action Alternative.

The projects included in the water supply cumulative impact assessment would generate improvements (directly or as an ancillary benefit) in either local or broader regional water supply conditions. These cumulative projects could, however, generate potential short-term impacts on water supply during construction, or, in the case of local water supply projects, generate reductions in water supply deliveries to neighboring water users through improved efficiency of local water use at the expense of regional surplus water availability.

The contribution of Alternative 1 to these conditions would not be considered cumulatively substantial. In the case of the cumulative projects anticipated to potentially generate temporary reductions in water supply deliveries or reduce surplus water supply availability to neighboring water users, the improvement to water supply deliveries under Alternative 1 for many water users would help to reduce the severity of any potential cumulative effect. In the case of water users for whom Alternative 1 is not forecast to improve deliveries, the potential changes in water supply deliveries under this alternative would not contribute to any cumulative water supply impacts because Alternative 1 is similar to the No Action Alternative.

Alternatives 2 and 3, would have similar impacts to Alternative 1 and would not generate substantial contributions to cumulative water supply conditions.

Similar to Alternatives 1, 2, and 3, Alternative 4 would result in reductions in average water supply deliveries to some CVP and SWP contractors. The reductions in surface water deliveries under Alternative 4 would for many water users be larger than the reductions anticipated under the other action alternatives. Given its larger reductions in CVP and SWP deliveries, Alternative 4 could substantially contribute to cumulative conditions in the event of a dry or critically dry water year, if another project was generating temporary reductions in water supply deliveries or reducing surplus water supply availability to neighboring water users. Alternative 4 could, in that situation, amplify an adverse effect on water users affected by that cumulative project.

5.20.3 Groundwater

5.20.3.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations. Therefore, there is expected to be no additional groundwater pumping and resulting effects on groundwater elevations, groundwater-surface water interaction, or land subsidence. As such, the No Action Alternative would not result in a cumulative effect on groundwater resources within the study area.

5.20.3.2 *Alternatives 1, 2, 3, and 4*

The cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for species whose special status, in many cases, can constrain water supply delivery operations. Collectively, these cumulative projects would be anticipated to directly or indirectly generate improvements in either local or broader regional water supply conditions. An increase in surface water supply from these cumulative projects would also have the effect of decreasing reliance on groundwater and reducing groundwater pumping.

Alternatives 1, 2, and 3 would generally increase surface water supplies to CVP and SWP contractors. An increase in surface water supply would decrease the reliance on groundwater and result in less groundwater pumping. Alternative 4 would generally decrease surface water supplies to CVP and SWP contractors. The contribution of Alternative 1 to these cumulative conditions would not be substantial. In the case of cumulative projects anticipated to potentially generate temporary reductions in water supply deliveries or reduce surplus water supply availability to neighboring water users, Alternative 1's reduction in groundwater pumping would help to reduce the severity of any potential cumulative effect and as such may be characterized as a beneficial effect on groundwater. Alternatives 2 and 3 would have similar effects as Alternative 1 and may also be characterized as a beneficial effect on groundwater when compared to changes attributable to the other project considered.

The contribution of Alternative 4 to these cumulative conditions is also not expected to be substantial. The increase in groundwater pumping under Alternative 4 is relatively small and would not be considered cumulatively considerable as it would not substantially worsen groundwater conditions.

5.20.4 Indian Trust Assets

5.20.4.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Continued tidal restoration actions could lead to adverse effects; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to cumulative changes to ITAs within the study area.

5.20.4.2 *Alternatives 1, 2, 3, and 4*

Implementation of habitat restoration under Alternatives 1 and 3 could potentially lead to water quality effects as well as disturbance of land or sites of importance to federally recognized Indian tribes. However, the degree to which these effects would occur is uncertain. Tidal habitat design and location considerations will minimize the degree to which new habitat areas will affect ITAs. Alternative 4 may result in adverse effects to federally recognized Indian tribes that have fishing rights resulting from effects on salmonid populations. Those location of those activities are, at this time, are unknown and will be evaluated at a later date. Any impacts on ITAs would be consulted and coordinated with potentially affected tribes to identify and address concerns for ITAs. Therefore, it is not anticipated that there will be a substantial effect on ITAs, and the potential adverse effect is not considered cumulatively considerable.

5.20.5 Cultural Resources and Indian Sacred Sites

5.20.5.1 *No Action Alternative*

The No Action Alternative would not result in changes to water operations. Anticipated tidal habitat restoration in the Delta may result in adverse impacts on cultural resources through those activities that require ground-disturbing actions and/or alteration of a built historic property to implement (i.e., ecosystem restoration, hatchery construction, etc.). However, the extent of these construction activities, when compared to the probable projects included in the analysis, would not be considered cumulatively considerable. Therefore, the No Action Alternative would not contribute to cumulative effects on cultural resources that may occur as result of other projects in the study area.

5.20.5.2 *Alternatives 1, 2, 3, and 4*

Alternatives 1, 3, and 4 may result in adverse impacts on cultural resources through those activities that require ground-disturbing actions and/or alteration of a built historic property to implement (i.e., ecosystem restoration, hatchery construction, etc.). Those activities requiring ground-disturbing actions and/or alteration of a built historic property are, at this time, programmatic and their contribution to the cumulative effect is unknown. Adverse effects that would be cumulatively considerable will be addressed through execution of a Section 106 Programmatic Agreement, which will address those cumulative effects related to cultural resources. Alternative 2 would not result in any activities that could require ground disturbance or alteration of a built historic property. Therefore, Alternative 2 would not contribute to cumulative effects on cultural resources that may occur as a result of other projects in the study area.

5.20.6 Air Quality

5.20.6.1 *No Action Alternative*

The No Action Alternative would not result in any changes to operations of existing facilities or construction of new facilities and so would not have air quality impacts. Thus, no cumulative effects of the project on air quality would occur under the No Action Alternative.

5.20.6.2 *Alternatives 1, 2, 3, and 4*

As described in Appendix L, Alternative 1 would lead to increases in regional emissions of carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter of 10 microns diameter and smaller (PM_{10}), particulate matter of 2.5 microns diameter and smaller ($PM_{2.5}$), reactive organic gases (ROGs), and sulfur dioxide (SO_2), compared to the No Action Alternative. Past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Methodology*, may have cumulative effects on air quality as well, to the extent that they could increase regional emissions. The cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for special status species whose special status in many cases constrains water supply delivery operations. The projects described in Appendix Y could increase emissions through the same mechanisms as the action alternatives: increases in grid power generation, groundwater pumping, and use of construction equipment and vehicles. The emissions from Alternative 1 are expected to be relatively small compared to the emissions from past, present, and reasonably foreseeable projects. Consequently, the emissions from Alternative 1, when combined with emissions from past, present, and reasonably foreseeable projects, are not expected to result in pollutant concentrations that would lead to new exceedances of the CAAQS or NAAQS or to worsen existing exceedances. Therefore, the cumulative air quality contribution of Alternative 1 would be not considered cumulatively considerable.

Alternatives 2 and 3 would have cumulative effects similar to those of the Alternative 1. As with Alternative 1, the cumulative air quality effects of Alternatives 2 and 3 along with past, present, and reasonably foreseeable projects are not expected to lead to new exceedances of the CAAQS or NAAQS or to worsen existing exceedances. Therefore, the cumulative air quality effect of Alternatives 2 and 3 would not be considered cumulatively considerable.

Alternative 4 would lead to decreases in regional emissions compared to the No Action Alternative. Because emissions would decrease under Alternative 4, the cumulative air quality effects of Alternative 4 along with past, present, and reasonably foreseeable projects are not expected to lead to new exceedances of the CAAQS or NAAQS or to worsen existing exceedances. Therefore, the cumulative air quality effect of Alternative 4 may be considered beneficial when considered along with the and past, present, and reasonably foreseeable projects. .

5.20.7 Greenhouse Gas Emissions

5.20.7.1 *No Action Alternative*

The No Action Alternative would not result in any changes to operations of existing facilities or construction of new facilities and so would not have impacts on GHG emissions. Thus, no cumulative effects of the project on GHG emissions would occur under the No Action Alternative.

5.20.7.2 *Alternatives 1, 2, 3, and 4*

As described in Section 5.7, *Greenhouse Gas Emissions*, Alternative 1 would lead to increases in regional emissions of GHGs compared to the No Action Alternative. Past, present, and reasonably foreseeable projects, described in Appendix Y, may have cumulative effects as well, to the extent that they could increase regional emissions. The cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for special status species whose special status in many cases constrains water supply delivery operations. The projects described in Appendix Y could increase GHG emissions through the same mechanisms as the action alternatives: increases in grid power generation, groundwater pumping, and use of construction equipment and vehicles. The impacts of Alternative 1, when combined with those of past, present, and reasonably foreseeable projects, would add incrementally to the global effects of GHG emissions on climate. However, the GHG emissions from Alternative 1 are expected to be relatively small compared to the emissions from past, present, and reasonably foreseeable projects. Consequently, the cumulative impact on GHG emissions would not be considered cumulatively considerable The cumulative effects of Alternatives 2 and 3 would be similar to those of Alternative 1 and would not also not be considered cumulatively considerable

Alternative 4 would lead to decreases in regional emissions of GHGs compared to the No Action Alternative. Because GHG emissions would decrease under Alternative 4, the cumulative GHG emission effects of Alternative 4, may be considered beneficial when considered along with the and past, present, and reasonably foreseeable projects.

5.20.8 Visual Resources

5.20.8.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Continued tidal restoration actions could lead to adverse effects; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to a cumulative effect on visual resources.

5.20.8.2 *Alternatives 1, 2, 3, and 4*

Alternatives 1, 2, 3, or 4, would have little to no adverse effects on visual resources and visual quality. , These small changes to visual resources and visual quality are not considered cumulatively considerable when considered along with the contribution made by past, present, and reasonably foreseeable project,

5.20.9 Aquatic Resources

5.20.9.1 *No Action Alternative*

The No Action Alternative would generate no changes to water operations compared to existing conditions. As such, there would be no change to the aquatic biological resource conditions that currently contribute to the aquatic resource conditions in the study area. Continued restoration actions under the No Action Alternative could lead to beneficial aquatic resource effects. However, the extent would be dependent on habitat design and locations. Thus, the No Action Alternative would not result in a cumulatively considerable effect on aquatic resources.

5.20.9.2 *Alternatives 1, 2, 3, and 4*

As described in Section 5.9, Aquatic Resources, Alternative 1 would lead to changes in aquatic resources compared to the No Action Alternative. The changes in Trinity River flows for Alternative 1 would result in lower water temperatures from December through May but higher water temperatures in September and November. While maximum September water temperatures would exceed recommended criteria for spawning and egg incubation, little salmonid spawning occurs in the Trinity River in September and adverse effects are not expected. Flows in Clear Creek would be similar between the No Action Alternative and Alternative 1. Changes in Sacramento River flows would generally improve water temperatures for salmonids under Alternative 1, while lower flows in some fall months of wet and above normal years would reduce habitat quality. Spawning and rearing habitat restoration under Alternative 1 would improve conditions for salmonids and steelhead. Changes in Feather and American River flows and temperatures for all the action alternatives would have minor effects on fish. Changes in operation on the Stanislaus River under Alternative 1 would be modest. These changes would result in reductions in suitable habitat for juvenile salmonids. Restoration under Alternative 1 would increase food production and provide protection from predators. Changes in San Joaquin River flows under all action alternatives would be minimal. In the Bay-Delta, changes to water project operation have the potential to increase the risk of entrainment, but would increase flow in the Sacramento River mainstem, which would increase survival and reduce routing into the interior Delta where survival is often lower regardless of flows. Changes in water operations under Alternative 1 could potentially increase Delta Smelt entrainment risk, reduce food availability, and reduce habitat extent. Summer-fall habitat operations under Alternative 1 may increase habitat extent, and food subsidy studies and habitat restoration may provide benefits under Alternatives 1 as well. Reintroduction of captive-bred Delta Smelt under Alternative 1 could potentially increase population abundance. Changes in water operations under Alternative 1 potentially could negatively affect Longfin Smelt abundance and increase south Delta entrainment risk.

Past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Methodology*, may have effects on aquatic resources in the study area that are related to the effects of the proposed actions of Alternative 1 described above, including positive and negative effects. The cumulative projects include actions that affect the timing and magnitude of flow releases and seasonal water temperatures and actions that improve habitat of spawning, rearing, and migrating fish in the study area. Flow and temperature effects of completed projects are generally accounted for in the operational modeling of the No Action Alternative. Of the water supply and water quality projects that have not been completed, those most likely to have cumulative effects related to the flow and water temperature effects of Alternative 1 are the Shasta Lake Water Resources Investigation (Shasta Dam Raise Project), the SWRCB Bay-Delta Water Quality Control Plan Update, and the Sites Reservoir Project.

Given the mixture of potential negative and positive effects from the actions in Alternative 1 and those of the past, present, and reasonably foreseeable projects, there is some uncertainty in how Alternative 1 would ultimately affect the cumulative condition. However, in consideration of the likely positive effects of many of the cumulative projects, as well as the benefits of the non-operations-related programmatic actions included in Alternative 1, Alternative 1's contribution to adverse cumulative effects would not be substantial.

Alternative 2 would change Trinity River flows similar to Alternative 1. Flows in Clear Creek under Alternatives 2 would be lower, resulting in reduced habitat quality and quantity for salmonids, and Pacific lamprey in all months. Water temperatures in Clear Creek under Alternative 2 would be higher during key life stages (July through October) for Spring-Run Chinook Salmon and steelhead. Changes in Sacramento River flows would adversely increase water temperatures for salmonids under Alternative 2. Changes in operation on the Stanislaus River under Alternative 2 would have substantially reduced flows. These changes would result in reductions in suitable habitat for juvenile salmonids. Changes in Bay-Delta water operations and risk of entrainment would be similar, but somewhat greater than Alternative 1. Since Alternative 2 does not include the benefits of the non-operations-related programmatic actions included in Alternative 1, Alternative 2's contribution to adverse cumulative effects could be substantial.

Under Alternative 3, modeled maximum November water temperatures in the Trinity River would increase substantially and exceed the recommended criterion, likely resulting in adverse effects on Fall-Run Chinook Salmon, Spring-Run Chinook Salmon, and Coho Salmon spawning success. Flows and temperatures in Clear Creek would be similar to those of Alternative 2. Changes in Sacramento River flows would also be similar to Alternative 2. Spawning and rearing habitat restoration under Alternative 3 would improve conditions for salmonids and steelhead. Changes in operation on the Stanislaus River under Alternative 3 would be similar to those of Alternative 2. These changes would result in reductions in suitable habitat for juvenile salmonids. Restoration under Alternative 3 would increase food production and provide protection from predators. Changes in the Bay-Delta would be similar to Alternatives 1 and 2 in that Alternative 3 could potentially increase Delta Smelt entrainment risk, reduce food availability, and reduce habitat extent. Food subsidy studies and habitat restoration may provide benefits and reintroduction of captive-bred Delta Smelt could potentially increase population abundance. Changes in water operations under Alternative 3 potentially could negatively affect Longfin Smelt abundance and increase south Delta entrainment risk. In consideration of the likely positive effects of many of the cumulative projects, as well as the benefits of the non-operations-related programmatic actions included in Alternative 3, Alternative 3's contribution to adverse cumulative effects would not be substantial.

Alternative 4 would have similar changes in Trinity River, Clear Creek, and Sacramento River flows and temperatures to those described for Alternative 1. Changes in operation on the Stanislaus River under Alternative 4 would be similar to Alternative 1. Changes in water operations under Alternative 4 could potentially decrease entrainment risk under Alternative 4. In consideration of the likely positive effects of many of the cumulative projects, Alternative 4's contribution to adverse cumulative effects would not be substantial.

5.20.10 Terrestrial Resources

5.20.10.1 *No Action Alternative*

Under the No Action Alternative, Reclamation and DWR would continue with current operations of the CVP and SWP. The overall direction of these past, present, and reasonably foreseeable programs and policies that influence land conversion and land management in the study area would continue to work toward maintaining the mix of agricultural, recreational, water management, and wildlife uses in the study area. Given that the No Action Alternative would not change CVP and SWP operations and would change flow rates or increased land conversion or land management activities, the No Action Alternative will not contribute to a cumulative effect on terrestrial biological resources.

Climate change is expected to result in changes to terrestrial resources in the study area. The most significant changes would include a gradual rise in sea level, increasing water and air temperatures, more frequent drought and extreme rainfall events, and changes in the hydrologic patterns of the rivers and the Bay-Delta channels that influence the terrestrial and aquatic habitats used by terrestrial plants and wildlife. Physical changes to conditions in the study area could change the distribution and value of habitats. For example, climate change could result in a gradual loss of tidal marshes; low-lying upland grassland and riparian areas that border the study area waterways could be gradually converted to tidal marsh; existing wildlife corridors could change; population numbers of riparian, grassland, and tidal marsh species would be likely to decrease; and population distribution would be altered. Land subsidence, sea level rise, gradual or catastrophic levee failure, or a combination of these conditions, should they occur, would result in flooding and inundation that could significantly damage existing facilities and infrastructure, uproot and kill vegetation to an unknown extent, permanently flood Bay-Delta islands, and drastically alter the salinity of Bay-Delta waterways and wetlands. These negative elements of global climate change would be a contributing factor to any cumulative effects of implementing the projects and programs that are part of the No Action Alternative.

5.20.10.2 *Alternatives 1, 2, 3, and 4*

This cumulative analysis discusses Action Alternatives 1, 2,3, and 4, all of which will result in slight increases in flows throughout the study area. Action Alternatives 1 and 3 also include restoration and other construction-related activities that could result in impacts on terrestrial biological resources. However, these changes would have little or no negative effect on the terrestrial biological resources of concern in the study area, and are expected to improve the long-term viability of special-status species and their habitats. The positive effects of implementing Alternative 1 and Alternative 3 are similar, while Alternatives 2 and 4 includes no additional restoration activities but will change flow regimes in the project area. There will be relatively small variations in the acres affected by flow regime changes across the alternatives but larger variations in the acres affected by restoration; thus, restoration has the greatest potential to modify natural communities and affect special-status plants and wildlife.

The past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Methodology,* may have effects on terrestrial biological resources. The cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for special status species whose special status in many cases constrains water supply delivery operations.

Collectively, these cumulative projects would have short-term effects but benefit terrestrial biological resources over the long-term. While flow changes, construction activities, and restoration activities in the short-term period of cumulative projects could temporarily or permanently remove natural communities and modeled habitat for special-status plant and wildlife species, the short-, mid- and long-term result of construction and restoration activities would replace, enhance and in most cases expand habitat acres and value for these species; therefore the action alternatives' contribution would not be substantial.

In addition, Alternatives 1, 2, 3, and 4, the avoidance and minimization measures presented are sufficient to avoid cumulative effects from the combined losses due to flow changes, construction, and restoration.

5.20.11 Regional Economics

5.20.11.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Although continued tidal restoration actions could lead to adverse effects, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to the cumulative changes to regional economic activity attributable to other projects occurring within the study area.

5.20.11.2 *Alternatives 1, 2, 3, and 4*

Alternatives 1 through 3 would increase water supply deliveries to North of Delta and South of Delta contractors. Alternatives 1, 2 and 3 would help M&I contractors meet their existing and future demands without alternate water supply projects. Increased water supply to agricultural contractors could also increase agricultural production and, in turn, the agricultural revenues generated within the study area. Alternative 4 would decrease M&I water supply deliveries to North of Delta and South of Delta contractors. Implementation of Alternative 4 could increase the supply gap and require M&I contractors to invest in alternate water supply projects to meet their demands. Alternative 4 would also decrease water supply to agricultural contractors and decrease agricultural production and revenue.

Appendix Y*, Cumulative Methodology* describes past, present, and reasonably foreseeable projects that may have effects on regional economics as well, as they would improve water supply and reliability. These cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity and reoperation of existing water supply infrastructure - including surface water reservoirs and conveyance infrastructure. Cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for special status species that could limit water supply deliveries to contractors.

Alternatives 1 through 3 would contribute to cumulatively beneficial impacts to regional economy due to an overall increase in water supply that would reduce water rates to customers and increase disposable income and spending in the project area. Alternatives 1 through 3 would also result in an overall increase in water supply that would increase agricultural production and revenue in the project. Alternative 4 would decrease water supply and increase water rates to customer, which would contribute water supply shortages under the cumulative condition.

Collectively, implementation of these cumulative projects is expected to directly or indirectly improve water supply reliability to water contractors in California. Alternatives 1 through 3's contribution would be cumulatively beneficial. Alternative 4 would contribute to increased water rates under the cumulative condition.

5.20.12 Land Use and Agricultural Resources

5.20.12.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Although continued tidal restoration actions could lead to adverse effects, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to cumulative changes in land use or irrigated agriculture.

5.20.12.2 *Alternatives 1, 2, 3, and 4*

Alternative 4 would contribute to cumulative changes in land use, namely the ability of local jurisdictions to implement their general plans with respect to M&I water availability, as a result of changes in flows and water use efficiency measures.

Alternatives 1 and 3 would contribute to cumulative changes in irrigated agriculture, namely conversion of agricultural land to nonagricultural use, as a result of habitat restoration activities. Alternative 4 would contribute to cumulative changes in irrigated agriculture, namely conversion of agricultural land to nonagricultural use, as a result of changes in flows and water use efficiency measures.

Past, present, and reasonably foreseeable projects may have effects on land use and irrigated agriculture. The cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, the reoperation of existing water supply infrastructure, and habitat restoration/ecosystem improvements. Collectively these cumulative projects would both benefit land use and agriculture by improving water supply reliability and potentially adversely affect land use and agriculture by increasing water flows for fish (with corresponding reductions in water deliveries), increasing water use efficiency measures, and locating ecosystem restoration projects on agricultural lands.

The potential for increasing the reliability of water supplies to local jurisdictions and agricultural users under Alternatives 1, 2, and 3 would be beneficial and as such would not contribute to the adverse cumulative effects attributable to other projects. Under Alternative 4, the decrease in water supply and increased water use efficiency measures would potentially contribute to adverse cumulative effects related to a reduced ability of local jurisdictions to implement their general plans as well as in conversion of some agricultural land to nonagricultural use.

Alternatives 1, and 3 are anticipated to result in the permanent conversion of agricultural lands when the ecosystem restoration actions are implemented . The amount of agricultural lands converted under Alternatives 1 and 3 would be considered cumulatively considerable when compared to the actions included in the cumulative list of projects that would include activities requiring the likely conversion of agricultural lands.

Collectively, the cumulative projects and Alternative 4 could potentially adversely affect land use by decreasing M&I water deliveries resulting in a cumulative impact. The alternative's contribution to this cumulative impact would be substantial. Alternatives 1, 2, and 3 would not result in a cumulatively considerable contribution to land use.

Collectively, the cumulative projects and Alternatives 1, 3, and 4 could potentially adversely affect agriculture by increasing water flows for fish or acquiring agricultural land for habitat restoration, simultaneously decreasing water availability for agriculture, resulting in a cumulative impact. The alternatives' contribution to this cumulative impact would be substantial. Alternative 2 would not result in a cumulatively considerable contribution to cumulative impacts on agricultural resources.

5.20.13 Recreation

5.20.13.1 *No Action Alternative*

Under the No Action Alternative, current recreational conditions for activities such as boating, camping, day use, and recreational fishing would remain the same so long as there are no major changes to seasonal variations. Continued tidal restoration actions could lead to adverse effects; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to cumulative changes in recreation conditions.

5.20.13.2 *Alternatives 1, 2, 3, and 4*

In the short term, the implementation of Alternatives 1 and 3, resource management plans, and restoration measures could have cumulative construction impacts on recreation in the surrounding area when taken into account with past, present, and reasonably foreseeable projects, especially if construction of multiple projects occurs at the same time and in the same general area. Potential cumulative construction effects from Alternatives 1 and 3 would be minor, localized, and short-term because project construction would be dispersed throughout the project area, and BMPs would be implemented to reduce construction effects.

Depending on the location and season, Alternatives 1 through 4 could cause minor beneficial and/or adverse effects on recreation. Therefore, effects from Alternatives 1 through 4 could have minor contributions to beneficial and/or adverse cumulative impacts on recreation. In the long term, Alternatives 1 and 3 would likely contribute to beneficial cumulative effects on recreation and fishing in the action area by restoring vegetation and habitat and increasing the population and health of recreationally fished species. Because Alternative 3 would restore more habitat than Alternative 1, the contribution of Alternative 3 to the adverse cumulative effect would be greater. Alternative 4 could also contribute to beneficial cumulative effects on recreational fishing opportunities by implementing water use efficiency measures. No mitigation measures would be required for the implementation of Alternatives 1 through 4, as no substantial overall adverse impacts on recreation are expected to occur.

5.20.14 Environmental Justice

5.20.14.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Continued tidal restoration actions could lead to adverse effects; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to a cumulative effect on minority or low-income communities.

5.20.14.2 *Alternatives 1, 2, 3, and 4*

Changes in CVP and SWP operations under Alternative 1 through 3 would increase water deliveries to both M&I and agricultural users in the regions. Increases in M&I water deliveries could result in lower water costs with resulting economic benefit to water users, including minority and low-income populations. Modeling shows that increases in agricultural water deliveries would translate to higher agricultural employment within the agricultural and commercial fisheries economic sectors and result in an economic benefit to minority and low-income workers employed within those sectors. The positive cumulative economic benefits to minority and low-income communities would be expected to be greater under Alternatives 2 and 3 because these alternatives would potential delivery more water to M&I and agricultural users than under Alternative 1.

Alternatives 1, 2, and 3 would also result in adverse effects on minority and low-income communities as a result of converting agricultural lands for ecosystem restoration purposes. The amount of agricultural lands converted under each alternative would not be considered cumulatively considerable when compared to the actions included in the cumulative list of projects that would include activities requiring the likely conversion of agricultural lands. In addition, this adverse impact could be offset by the increase in water supplied for M&I and agricultural uses, which would benefit economic activity affecting minority and low-income communities.

5.20.15 Power

5.20.15.1 *No Action Alternative*

Regional development anticipated under general plans in combination with projects included in the cumulative project list are anticipated to reduce carryover storage in reservoirs and changes in streamflow patterns in a manner that could reduce hydroelectric generation in the summer and fall months. Reduced CVP and SWP water deliveries south of the Delta would also reduce CVP and SWP electricity use.

5.20.15.2 *Alternatives 1, 2, 3, and 4*

Alternatives 1, 2, and 3 are anticipated to increase water deliveries in the regions that receive water from the CVP and SWP, and Alternative 4 is expected to decrease water deliveries. As water becomes more available, it is expected that energy use for conveyance of CVP and SWP water supplies also would increase. Conversely, a decrease in water deliveries would reduce the energy used to convey CVP and SWP water supplies. When compared with the total amount of energy used to convey water within the study area, the additional energy demands to convey the additional water that would become available under each of the action alternatives is not expected to be cumulatively considerable. The incremental cumulative effect attributable to each of the action alternatives is reflective of the estimated amount of water that could be delivered. As indicated in Appendix H, the greatest increase in water deliveries would occur under Alternative 3, followed by Alternatives 2 and 1. Accordingly, it is expected that the greatest cumulative effect on power would occur under Alternative 3, with lesser effects occurring under Alternative 2 followed by Alternative 1. With decreased water deliveries, Alternative 4 would result in additional power availability, and a potentially positive cumulative effect on power.

5.20.16 Noise

5.20.16.1 *No Action Alternative*

The No Action Alternative would not result in any changes to water operations or additions to the proposed restoration actions. Continued tidal restoration actions could lead to adverse effects; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative would not contribute to a cumulative noise effect on sensitive receptors.

5.20.16.2 *Alternatives 1, 2, 3, and 4*

Temporary and permanent equipment noise and vibration levels for project-level actions would be the same as the No Action Alternative; therefore, there would be no project-level cumulative effects.

Construction of programmatic action under Alternatives 1, 3, or 4 simultaneously with other planned projects may result in a temporary cumulative increase in noise levels, where projects are located within 0.5 mi of one another. The timing and location of many program-level projects is unknown; however, the cumulative effect of simultaneous construction projects could result in a cumulative increase in noise and vibration levels if the timing of construction of two or more projects overlap. If a cumulative impact is likely, coordination of construction phasing of simultaneous projects would minimize construction-related noise impacts. Therefore, Alternatives 1, 3, or 4 are not expected to contribute to cumulative construction-related noise impacts. Alternative 2 has no program-level construction actions and therefore, no cumulative construction-related noise impacts.

5.20.17 Hazards and Hazardous Materials

5.20.17.1 *No Action Alternative*

Under the No Action Alternative, Reclamation would continue with current operations of the CVP. The proposed operational changes, facility improvements, or intervention measures, as well as some habitat restoration, under the action alternatives would not occur under the No Action Alternative. While there would be construction or operation and maintenance of any CVP or SWP projects that are planned or currently under way under the No Action Alternative, each project implemented under the No Action Alternative would require its own separate environmental compliance process. Compliance with applicable laws pertaining to hazards and hazardous materials, combined with the implementation of project-specific mitigation measures, would minimize the potential cumulative impacts of the No Action Alternative related to hazards and hazardous materials. However, tidal habitat restoration under the No Action Alternative could create conditions resulting in increased methylation of mercury within the Delta and therefore increased mercury bioaccumulation in fish tissues. Because the Delta is already impaired with regard to mercury, tidal habitat restoration under the No Action Alternative would contribute to the adverse cumulative condition for methylmercury in the Bay-Delta region.

5.20.17.2 *Alternatives 1, 2, 3, and 4*

Alternatives 2 and 4 would not involve any project-level actions related to habitat restoration, which would result in an increased potential for public and environmental hazards. Therefore, there would be no cumulative effect on this resource from implementation of Alternatives 2 and 4.

Alternatives 1, 3, and 4, in conjunction with the past, present, and reasonably foreseeable projects included in the cumulative project list could result in an increase in public and environmental hazards.

Alternatives 1 and 3 include implementation of tidal and floodplain habitat that has the potential to increase mosquito-borne diseases in the study area; create conditions that would result in increased methylation of mercury within the Delta, which in turn could increase the potential for human exposure to mercury via fish consumption; and attract waterfowl and other birds, which could lead to an increase in the potential for bird-aircraft strikes if the habitat locations are in proximity to existing airport flight zones. Construction and/or operation and maintenance of facilities under Alternatives 1, 3, and 4, could result in short-term potential for hazards to the public or environment through the transport, use, accidental release, or disposal of hazardous materials, as well as through damage to existing hazardous infrastructure (e.g., natural gas pipelines). Overall, because Alternative 3 would restore more habitat than Alternative 1, the contribution of Alternative 3 to the adverse cumulative effect would be greater. Under Alternative 4 there would be an overall reduction in irrigated agricultural land in the San Joaquin River region of approximately 0.1% in average water years and 0.3% in dry/critical years. Although Coccidioides is endemic to the San Joaquin Valley, it is unlikely that this reduction in irrigated agricultural land would substantially contribute to the adverse cumulative effect of Valley fever risk because the irrigated acreage reduction is relatively nominal in all water year types. However, there could be a small contribution to the cumulative Valley Fever risk if the reduction in irrigated land were to result in long-term fallowing or idling because this could make conditions more conducive to Coccidioides growth.

Compliance with applicable laws pertaining to hazards and hazardous materials, combined with the implementation of project-specific mitigation measures (HAZ-1, HAZ-2, HAZ-3, AG-1, and WQ-1), would minimize the potential cumulative impacts of Alternatives 1, 3, and 4. Therefore, there would be no cumulative adverse effects.

5.20.18 Geology and Soils

5.20.18.1 *No Action Alternative*

The No Action Alternative would not result in changes to water operations or additions to the proposed restoration actions. Continued tidal restoration actions could lead to adverse effects to geology and soils through activities requiring ground-disturbing actions; however, the extent of these effects is uncertain and would be dependent on habitat design and locations. Therefore, the No Action Alternative is not likely to contribute to cumulative effects on geology and soils that may occur as result of other projects within the study area; however, there is potential for an effect dependent upon habitat design and location.

5.20.18.2 *Alternatives 1, 2, 3, and 4*

The past, present, and reasonably foreseeable projects may have effects on geology and soils by enhancing surface water supplies and implementing ecosystem restoration actions. Enhancing surface water supplies may result in reduction in agricultural land fallowing as shifting water supplied for agricultural and M&I purposes from groundwater to surface water. When combined with other water supply programs and projects, this shift could result in a cumulative beneficial effect on geology and soils by reducing agricultural land fallowing and land subsidence. Conversely, Alternatives 1, 2, and 3 may result in adverse impact on geology and soils through those activities that require ground-disturbing actions to implement (i.e., ecosystem restoration, hatchery construction, etc.). However, the extent of these land disturbing activities, when compared to the probable projects included in the analysis would not be considered cumulatively considerable. Alternative 4 would result in increased releases largely from Sacramento Valley tributaries and result in lowered deliveries for San Joaquin River and Delta water users. Total Delta deliveries would reduce overall, but the general trend of deliveries is similar to the No Action Alternative. The reductions will result in some shortages of water deliveries and increased groundwater usage. Reductions in crops will follow the reduced water deliveries and may result in increased erosion. Conversion of ag land and increased storage long term may alleviate some of the potential impact.

Chapter 6 Other NEPA Considerations

6.1 Irreversible and Irretrievable Commitment of Resources

NEPA requires that an EIS include a discussion of the irreversible and irretrievable commitments of resources that may be involved should an action be implemented. An irreversible commitment of resources is the permanent loss of a resource that cannot be replaced (or restored over a long period of time). An irretrievable commitment of resources is a loss of production or use of natural resources. The operational components of the action alternatives would result in irretrievable impacts on power resources, as discussed in Section 5.15, Alternatives 1 and 3 involve construction actions that would result in the irretrievable commitment of construction materials, nonrenewable energy, and land area. These components are currently analyzed at a program level of detail in Chapter 5.

6.2 Relationship between Short-term Uses and Long-term Productivity

NEPA requires that an EIS consider “the relationship between short-term uses of man’s environment and the maintenance and enhancement of long-term productivity.” In the short term, the action alternatives would use power resources to operate the CVP and SWP. Alternatives 1, 3, and 4 would include short-term uses of capital, labor, fuels, and construction materials. Construction would result in short-term construction-related effects such as interference with local traffic and increased air emissions, ambient noise levels, dust generation, and disturbance of wildlife. Construction would increase demand for construction and technical services. In the long term, Alternatives 1 and 4 would improve conditions for biological resources. Alternatives 1, 2, and 3 would increase water deliveries, which would increase economic productivity. Alternatives 1, 2, and 3 would reduce net energy generation on the CVP side, and Alternatives 1 through 4 would reduce net energy generation on the SWP side.

6.3 Growth Inducing Impacts

NEPA requires that an EIS consider indirect effects of a project, which can be the result of growth inducement. This Project would not directly induce growth through the construction of infrastructure, housing, or commercial development. Alternatives 1, 2, and 3 would increase water deliveries, and inadequate water supplies can be a barrier to growth. However, these increased deliveries are to portions of the CVP and SWP where deliveries have been severely constrained in recent years. The action alternatives would not increase deliveries above past deliveries (or existing contract amounts).

6.4 Consultation and Coordination

Reclamation has worked to coordinate with many different parties that may have an interest in the development of this EIS. Reclamation has been meeting with stakeholders and interested parties since consultation was reinitiated in August 2016.

6.4.1 Tribal Consultation

Reclamation conducted separate in-person meetings with the Yurok Tribe and Hoopa Valley Tribe. On December 12, 2017, Reclamation, NMFS, and USFWS met with the tribes separately to explain the project scope and hear concerns and thoughts. Reclamation met with the Yurok Tribe on March 28, 2018 to provide an update. On September 14 and 19, 2017, there were government-to-government meetings with the Hoopa Valley Tribe and Yurok Tribe, respectively, that included the reinitiation of consultation as a topic of discussion. In addition to tribal meetings, Reclamation presented information to the Trinity Management Council (that includes the Yurok Tribe and Hoopa Valley Tribe) on March 28, 2018, September 5, 2018, December 6, 2018, and April 3, 2019. The Hoopa Valley Tribe also participated in review of the Administrative Draft EIS.

6.4.2 Resource Agencies

Reclamation recognized the importance of coordination with the resource agencies that have responsibility for sensitive species. Reclamation worked to coordinate with USFWS, NMFS, and CDFW during development of this EIS through meetings every 2-3 weeks for the first 2 years of the project, in addition to brainstorming meetings and workshops. Appendix Z includes a list of coordination meetings with resource agencies and water users.

6.4.3 Water Users

Reclamation has been meeting with interested parties since 2017, including CVP and SWP water contractors. Reclamation held monthly water user forums in 2018 and 2019 for CVP and SWP water users and DWR. In addition, Reclamation met with water users in small groups, and held quarterly meetings per WIIN Act 4004(c) that included water users as well as other interested parties. The water contractors provided information about potential alternatives, the scope of the analysis, and water supply issues for consideration in this EIS. For this EIS, a number of water agencies are also Cooperating Agencies under NEPA, including City of Folsom, CCWD, East Bay Municipal Utility District, El Dorado Irrigation District, Friant Water Authority, Glenn-Colusa Irrigation District, Grasslands Water District, Kern County Water Agency, Metropolitan Water District of Southern California, San Juan Water District, San Joaquin River Exchange Contractors Water Authority, San Luis & Delta-Mendota Water Authority, Santa Clara Valley Water District, Solano County Water Agency, Tehama-Colusa Canal Authority, and Westlands Water District. In addition to the water users, other Cooperating Agencies included DWR, and Northern California Power Agency. These entities reviewed administrative drafts of the EIS to provide input on their areas of expertise. Appendix Z includes a list of coordination meetings with resource agencies and water users.