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.

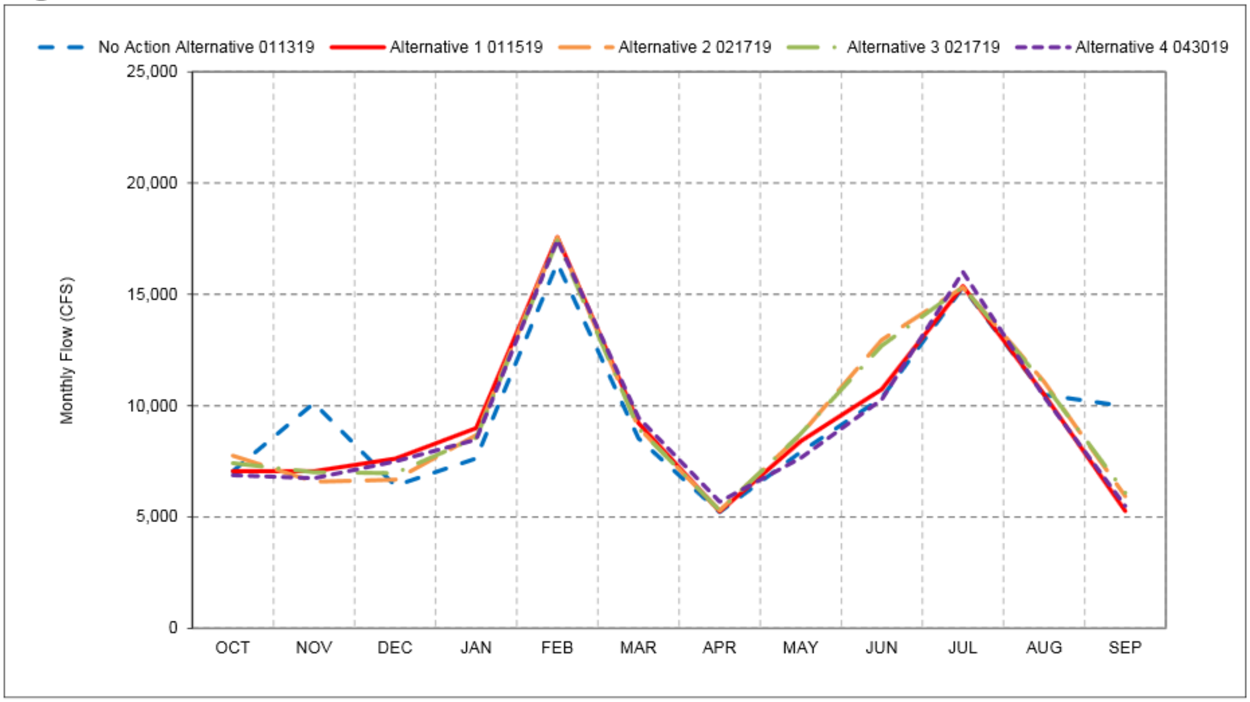
5.2.1 Project-Level Effects

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.

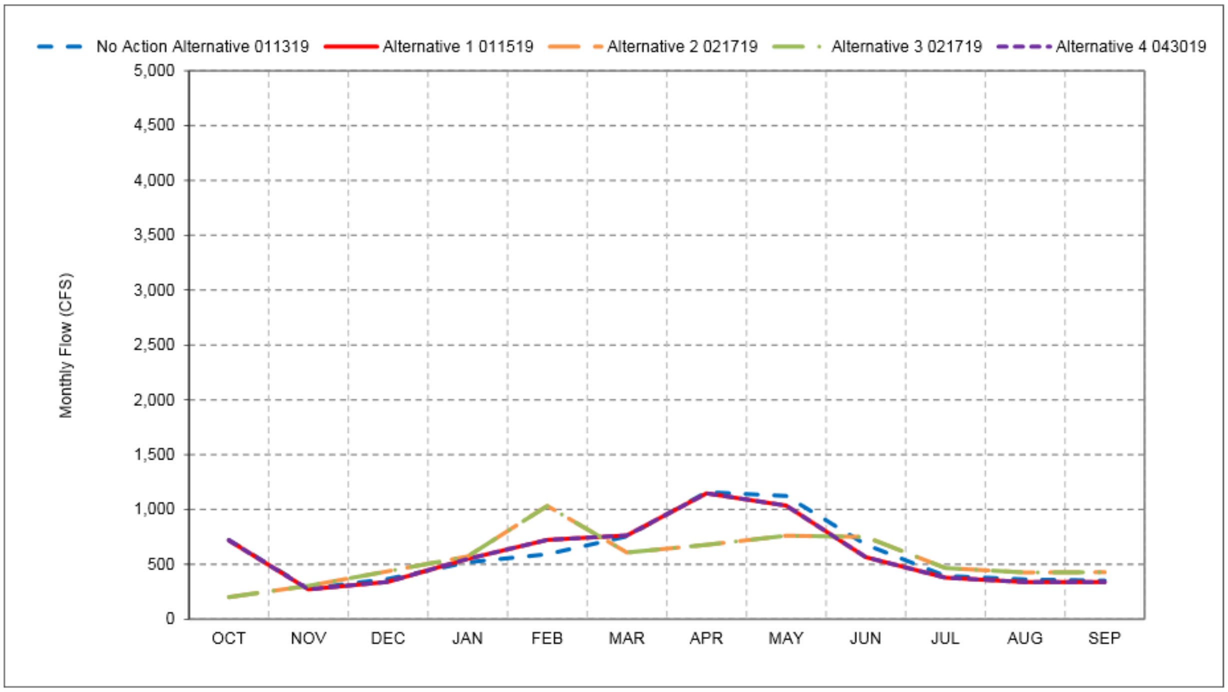
Figure 5.2-1. Sacramento River Flow Downstream of Keswick Reservoir, Above Normal Year Average Flow

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.

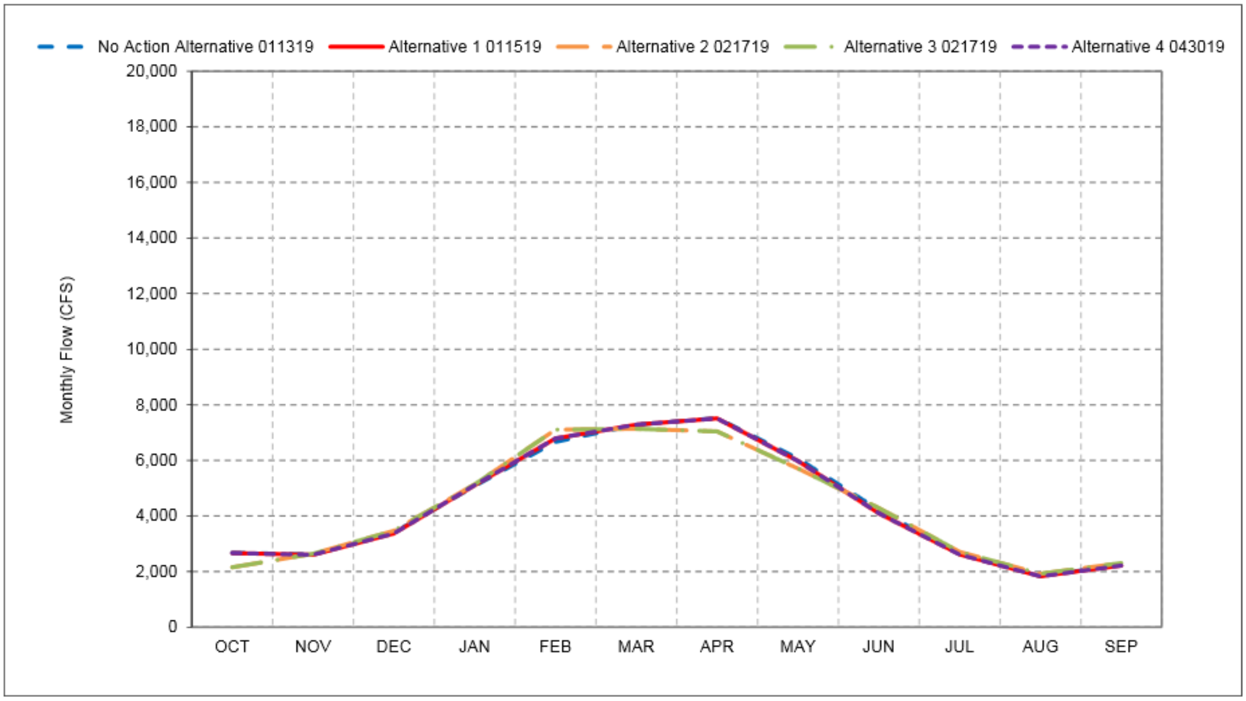
Flows in the San Joaquin River at Vernalis would remain similar between the No Action Alternative and the action alternatives. Figure 5.2-3, San Joaquin River at Vernalis, Long-Term Average Flow illustrates long-term average flows across the model record for all alternatives at the San Joaquin River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

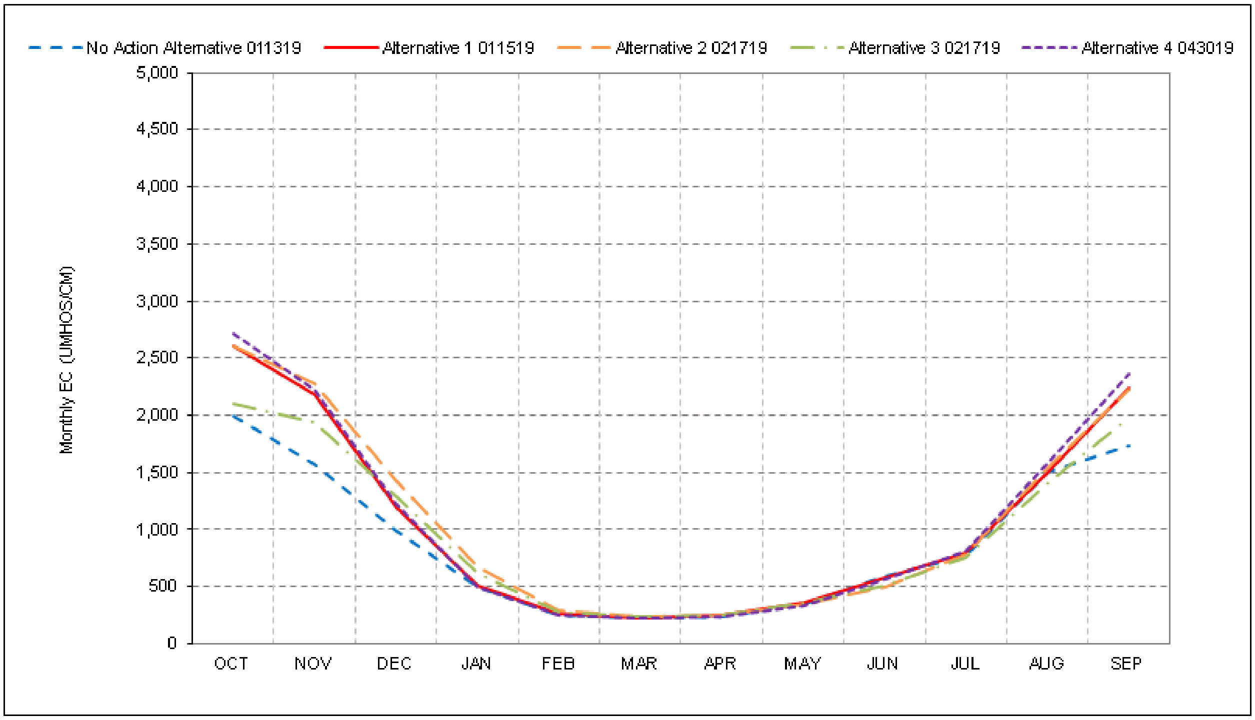


Figure 5.2-4. Long-Term Monthly Average EC for the Sacramento River at Emmaton for Water Years 1922–2003

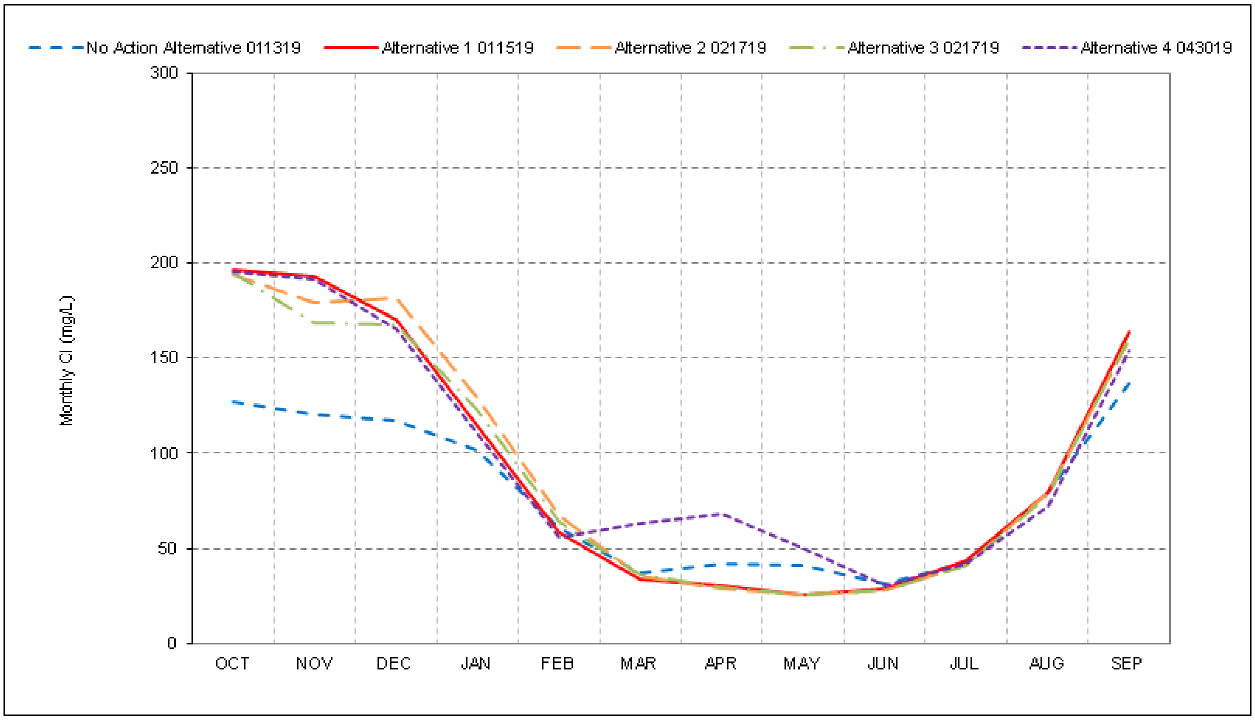


Figure 5.2-5. Long-Term Average Chloride at Contra Costa Pumping Plant #1 for Water Years 1922–2003

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%.

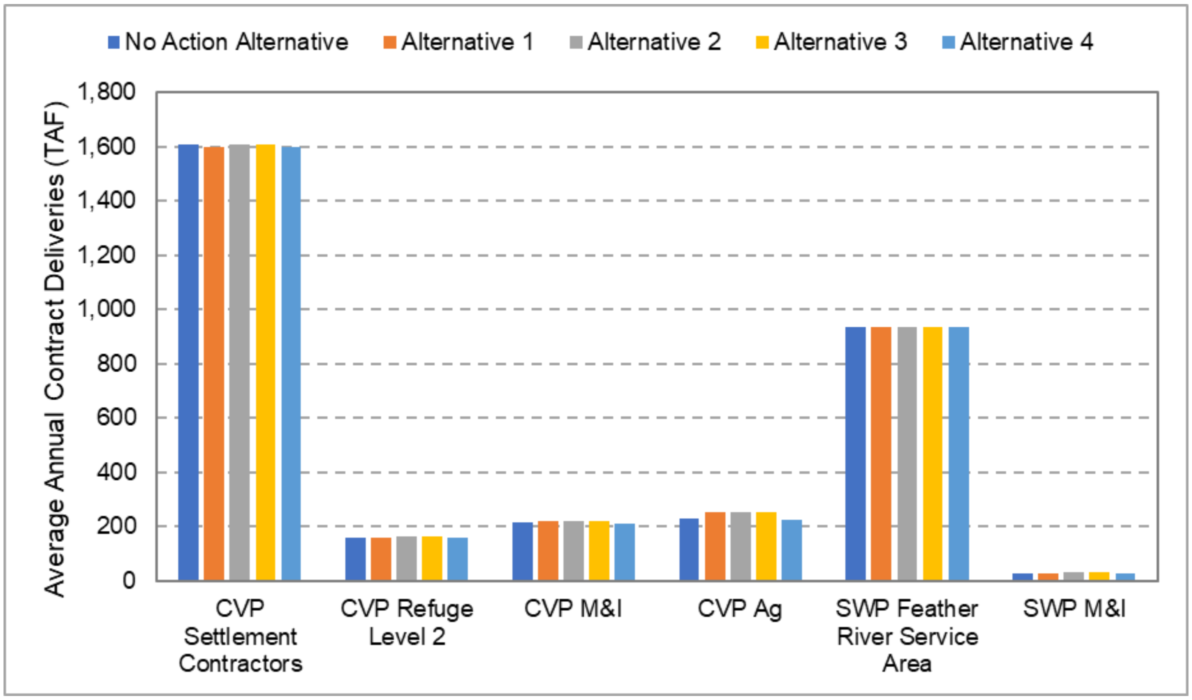


Figure 5.3-1. Sacramento River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

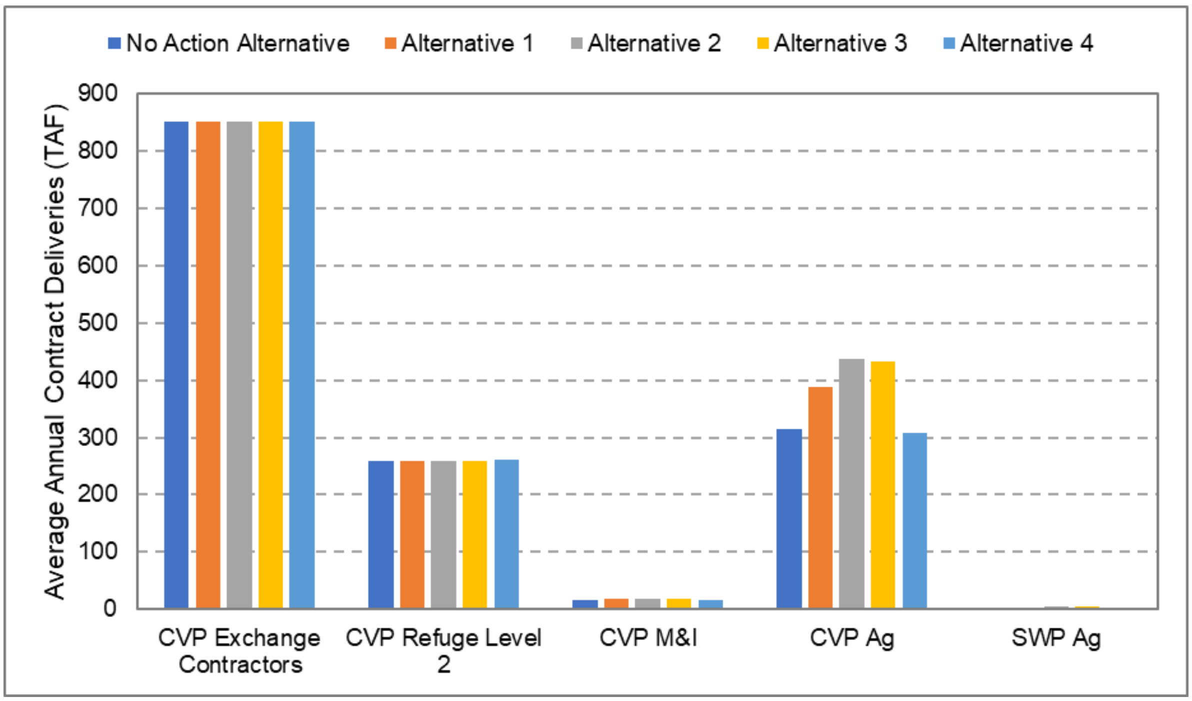


Figure 5.3-2. San Joaquin River Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

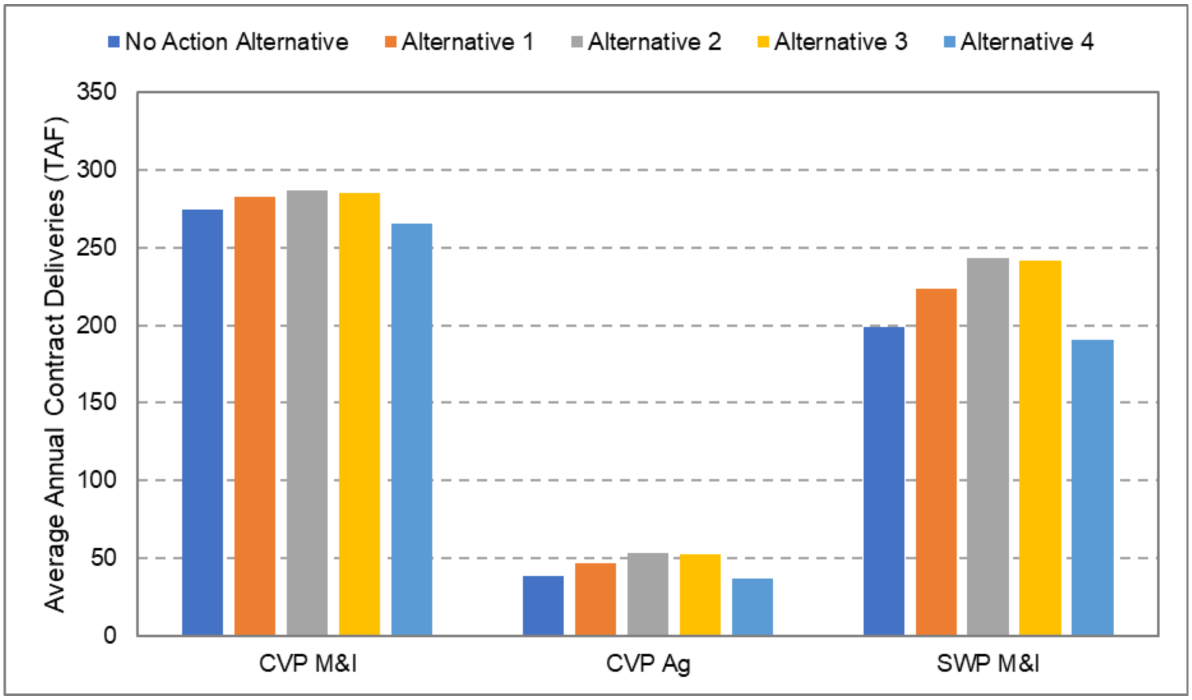


Figure 5.3-3. San Francisco Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

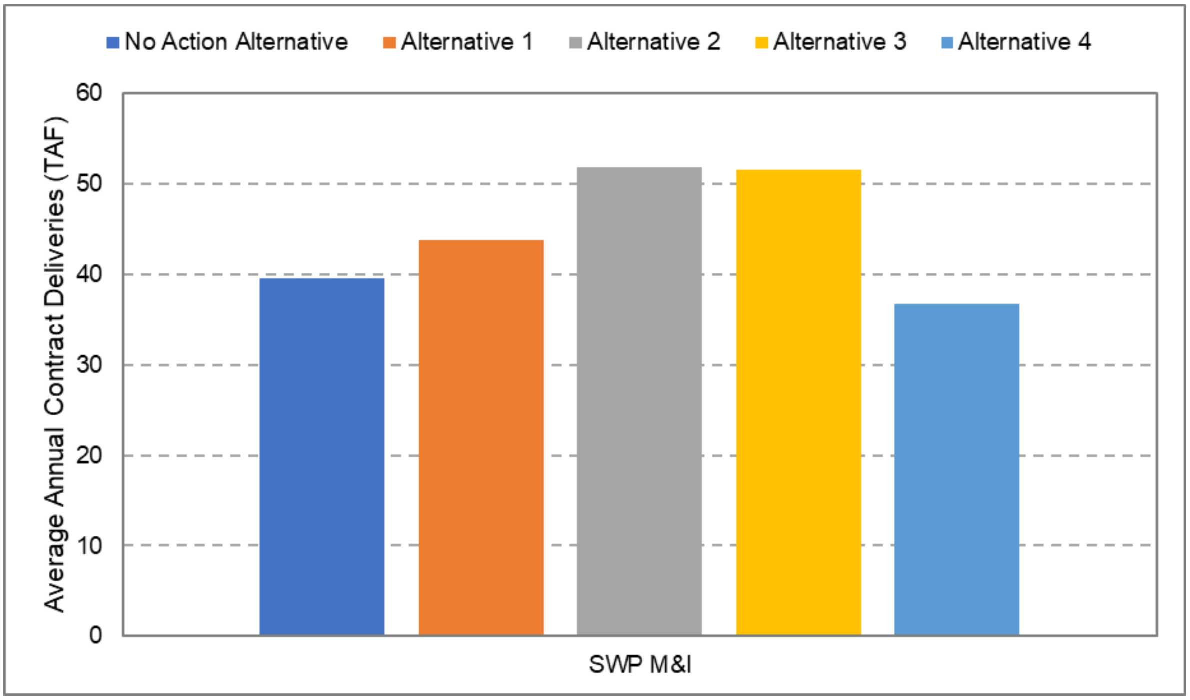


Figure 5.3-4. Central Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

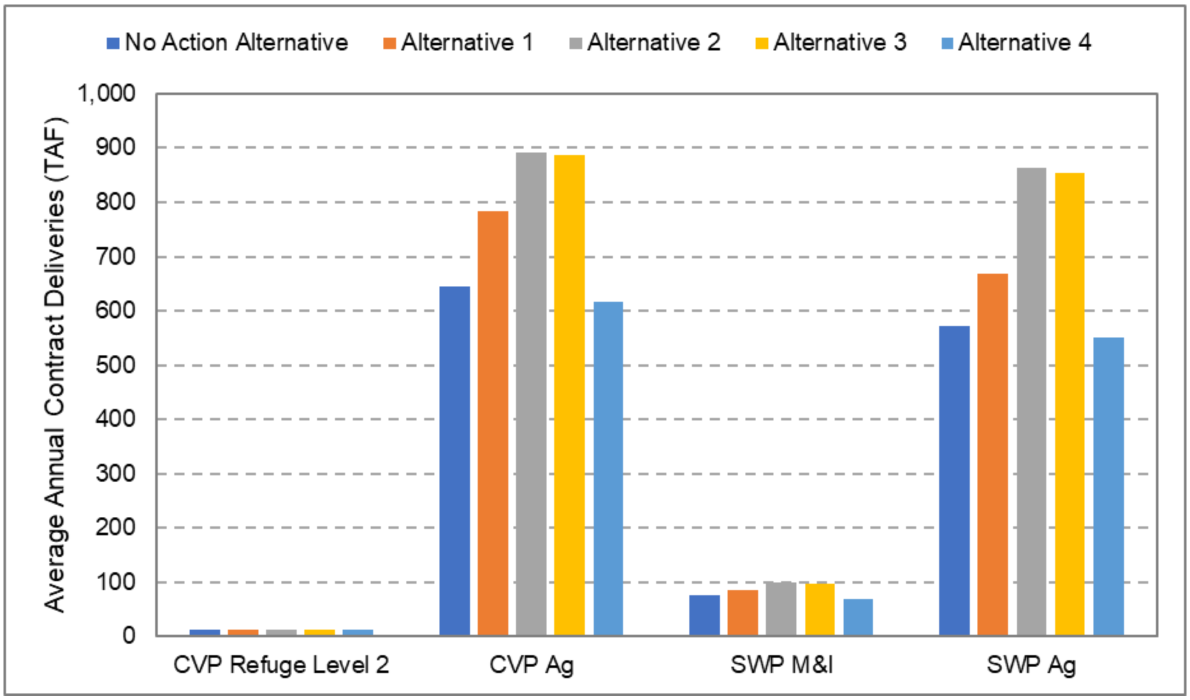


Figure 5.3-5. Tulare Lake Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

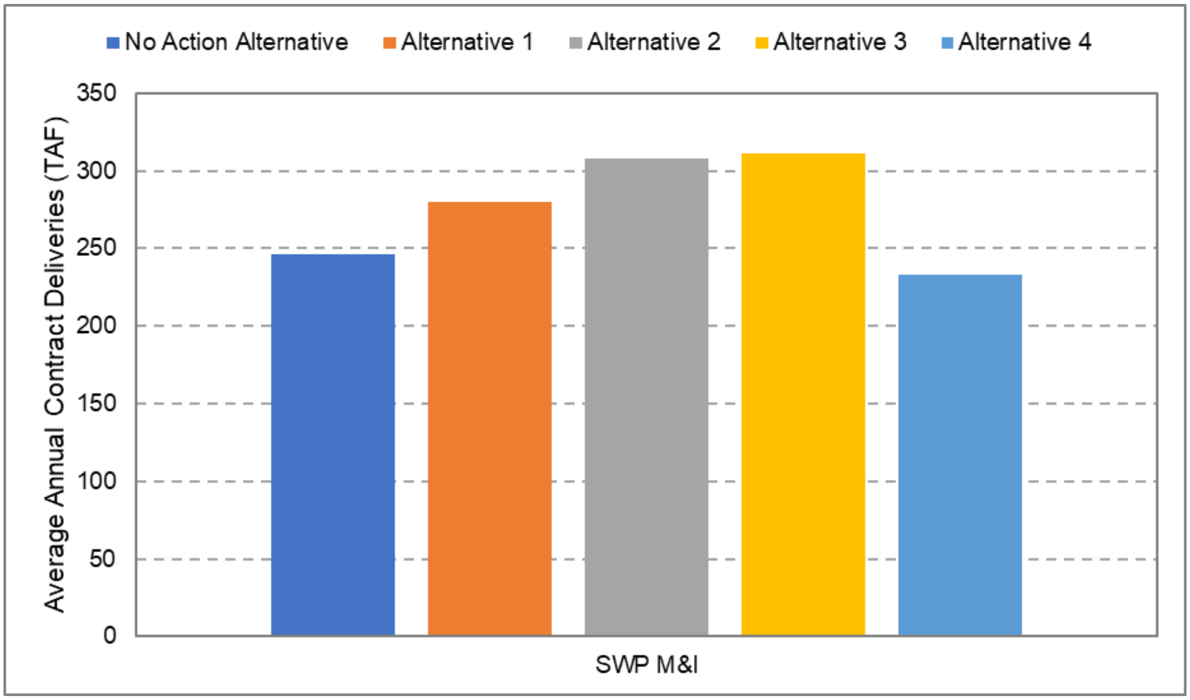


Figure 5.3-6. South Lahontan Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

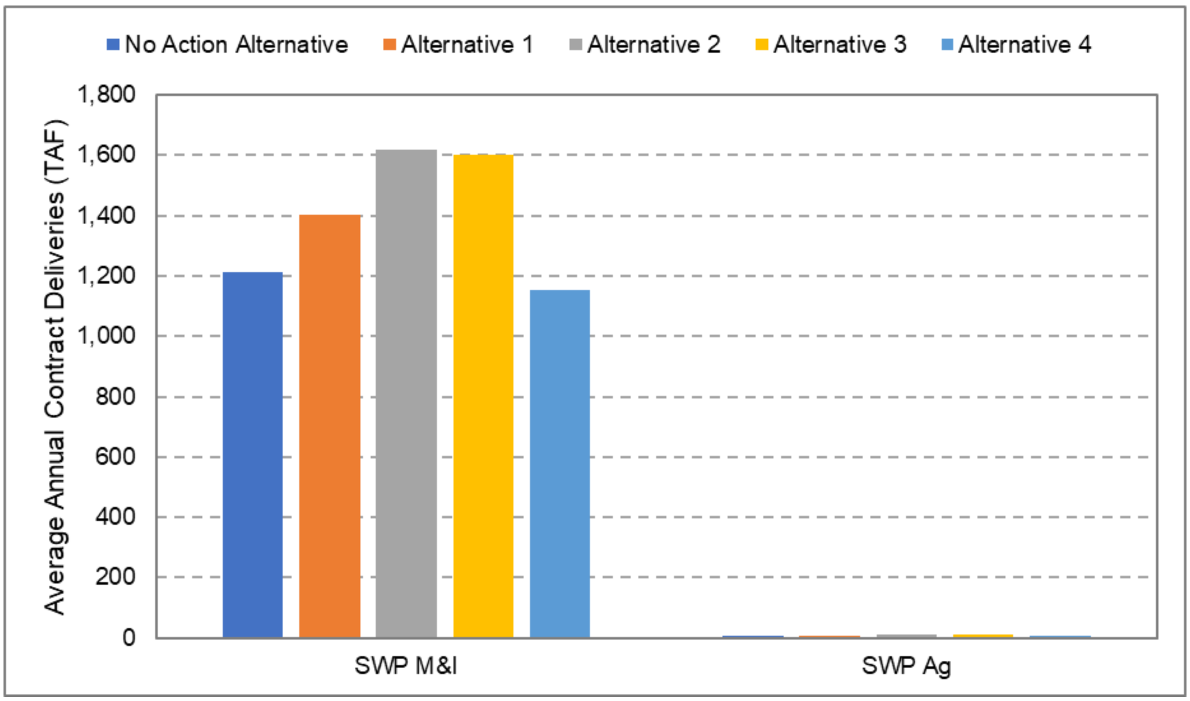


Figure 5.3-7. South Coast Hydrologic Region Average Annual Contract Deliveries under All Water Year Types

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.

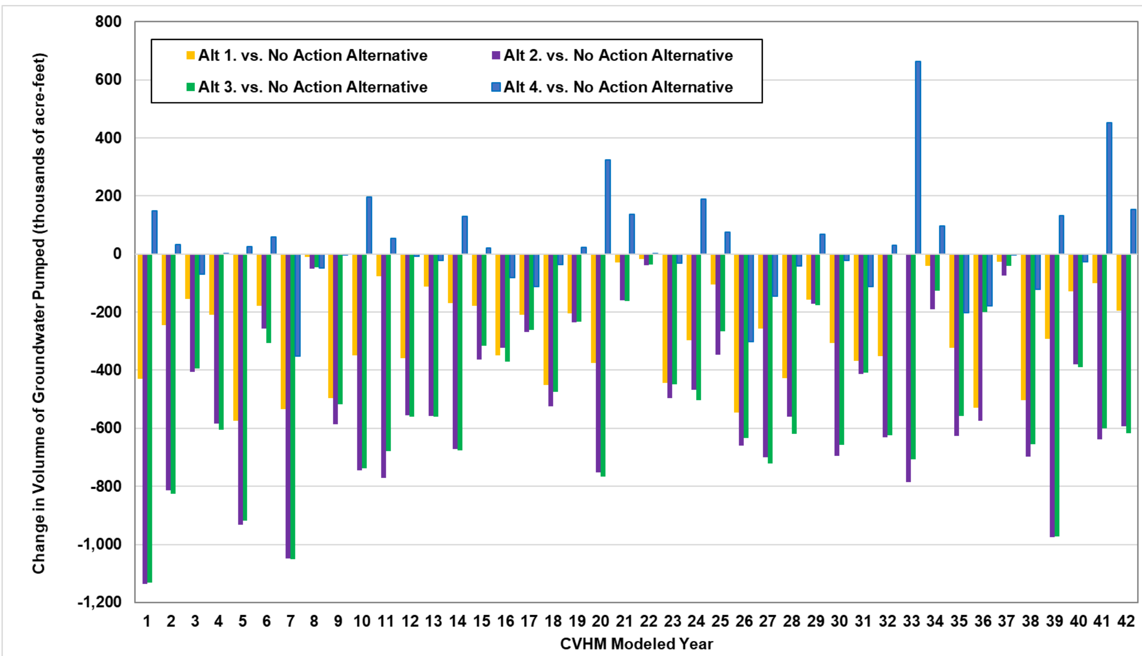


Figure 5.4-1. Change in Groundwater Pumping Resulting from Alternatives 1 through 4 Compared to the No Action Alternative

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.

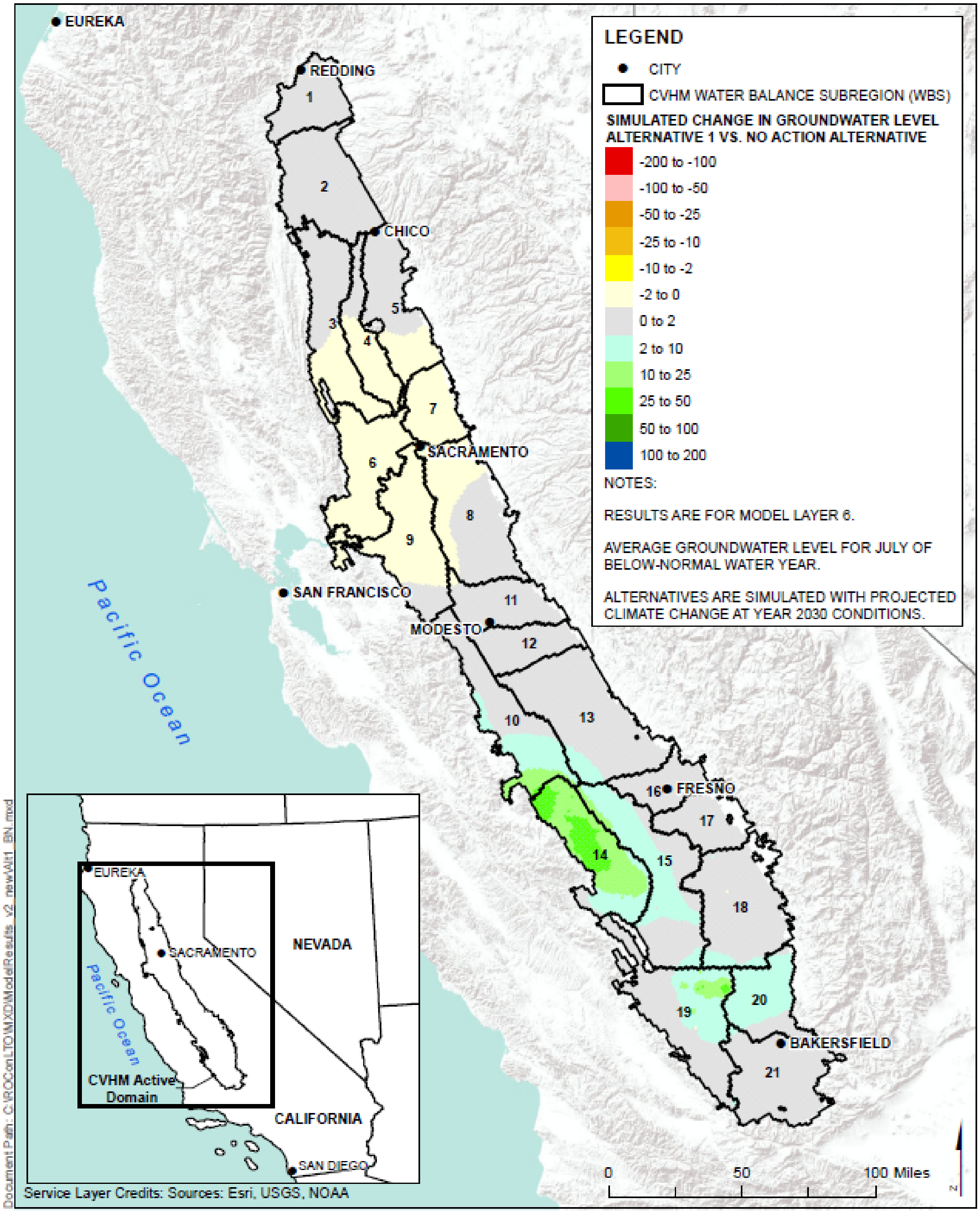


Figure 5.4-2. Simulated Change in Groundwater Level for all July of Below Normal Water Years, Alternative 1 versus No Action Alternative

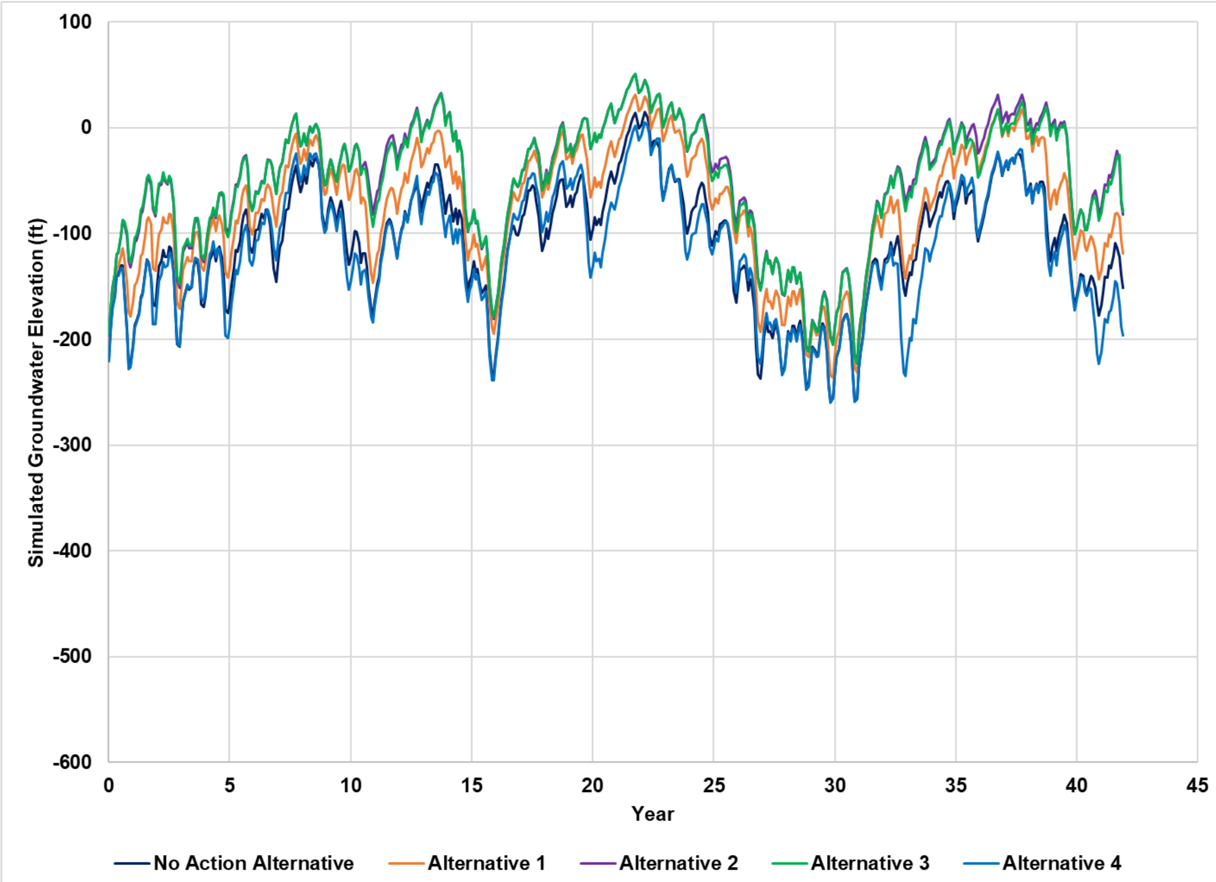


Figure 5.4-3. Simulated Groundwater Elevation in CVHM Area 14, No Action Alternative and Alternatives 1 through 4

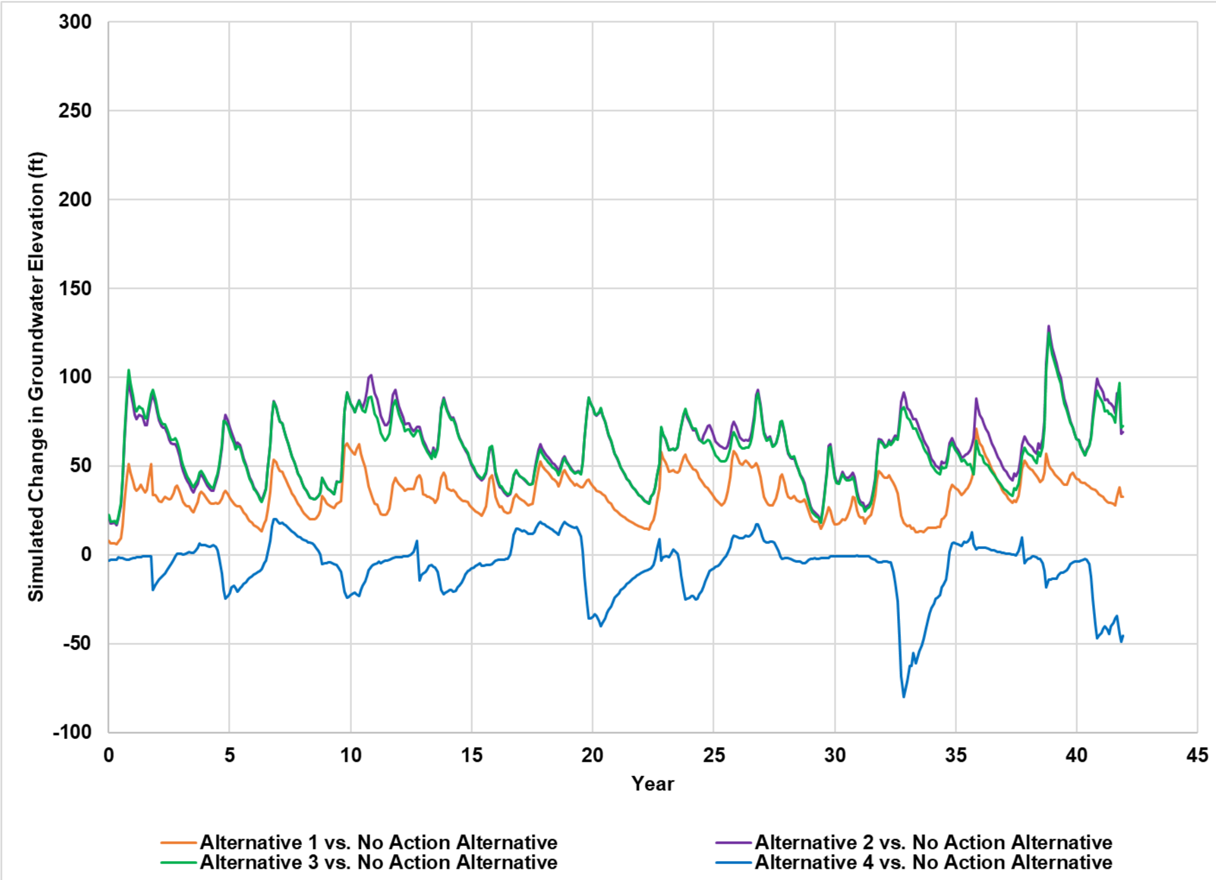


Figure 5.4-4. Simulated Change in Groundwater Level in CVHM Area 14, Alternatives 1 through 4 versus No Action Alternative

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.

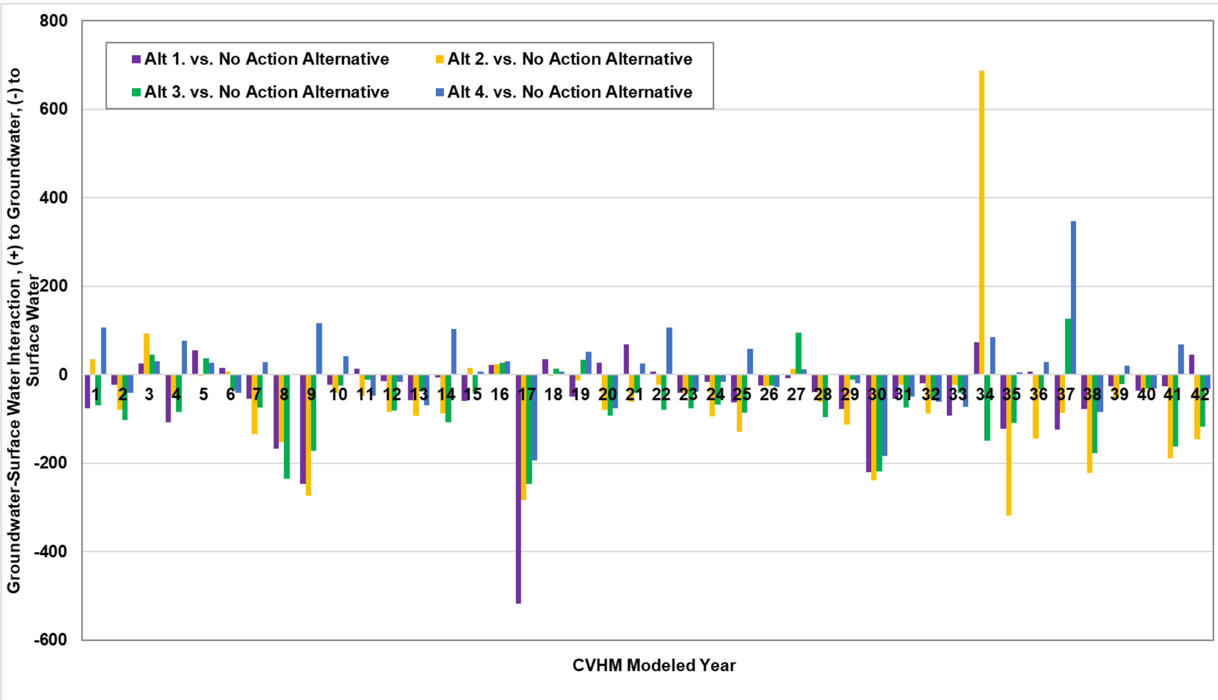


Figure 5.4-5. Change in Groundwater-Surface Water Interaction Flow for Alternatives 1 through 4 Compared to the No Action Alternative

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

Pollutant	Emissions (U.S. tons per average year)[1, 2]				
	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

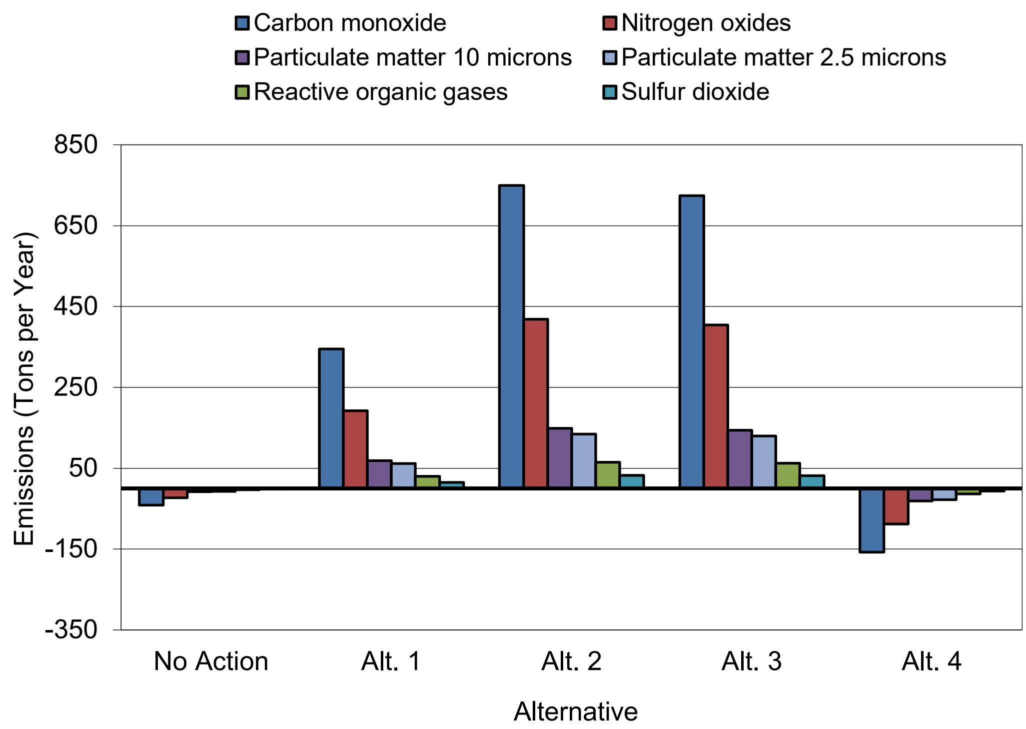


Figure 5.6-1. Emissions from Grid Power Generation

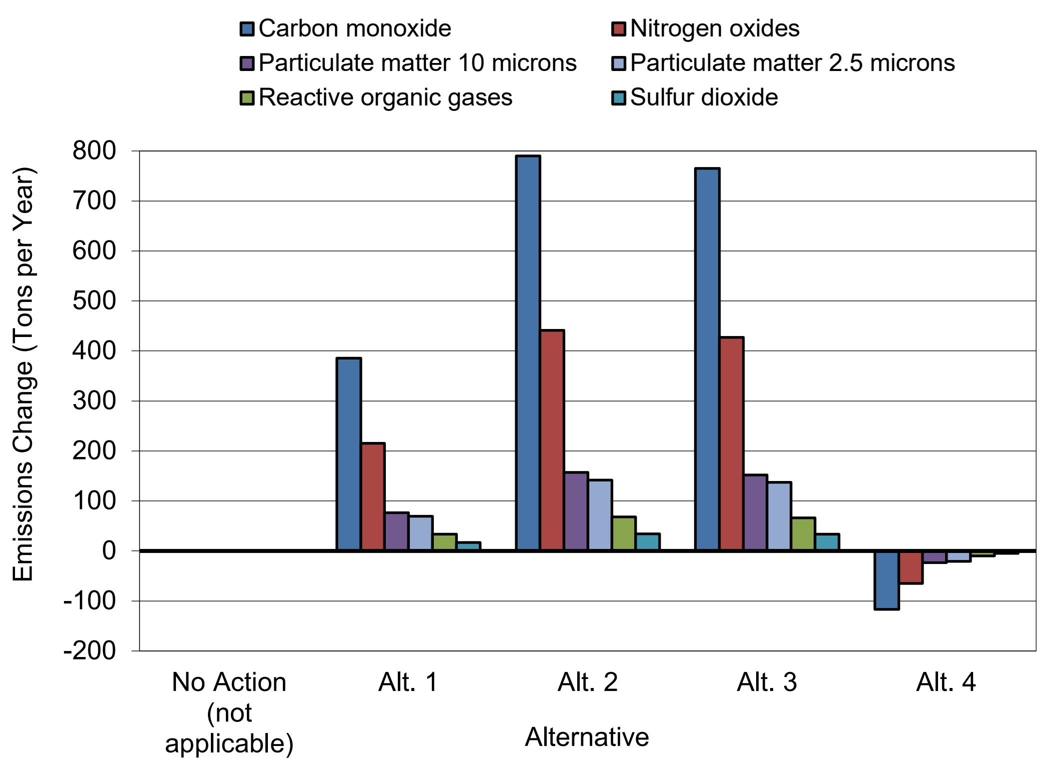


Figure 5.6-2. Emissions from Grid Power Generation Compared to the No Action Alternative

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

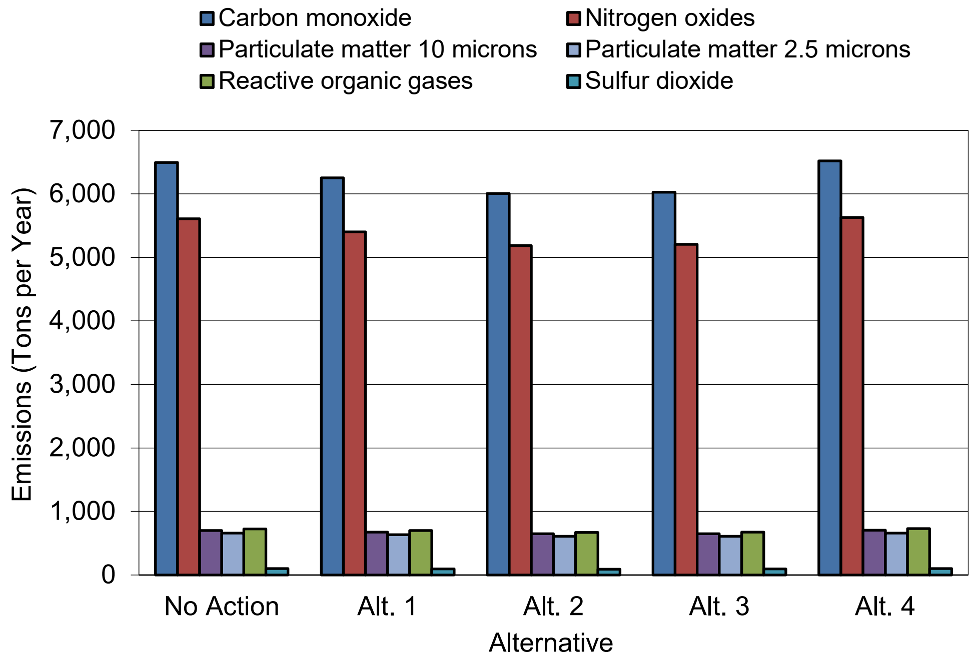


Figure 5.6-3. Emissions from Groundwater Pumping

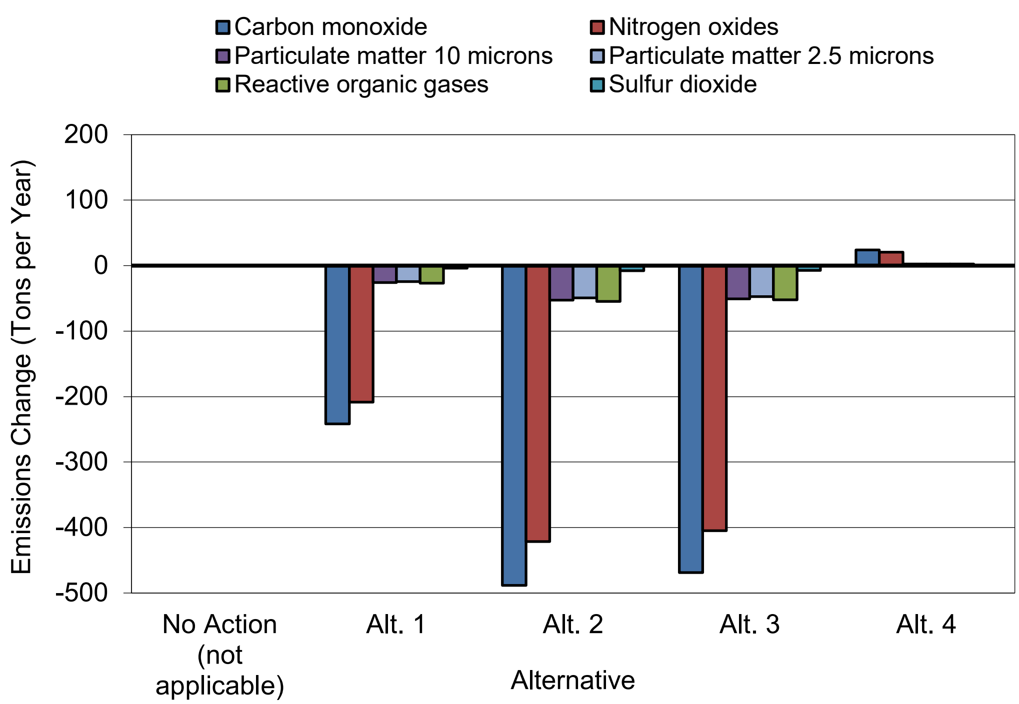


Figure 5.6-4. Changes in Emissions from Groundwater Pumping Compared to the No Action Alternative

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

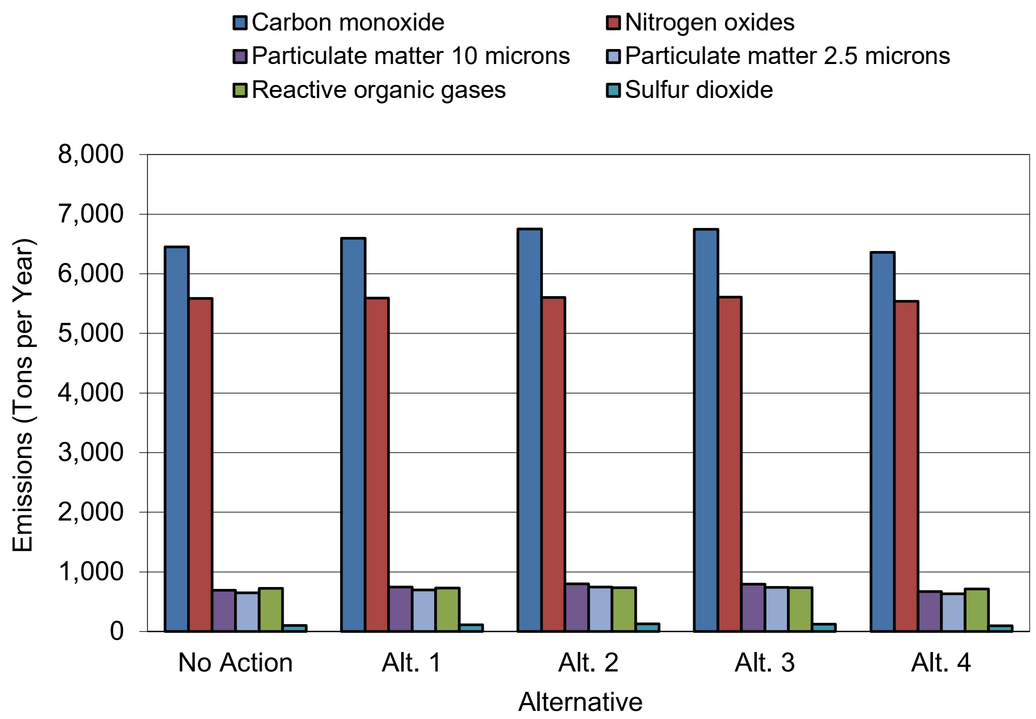


Figure 5.6-5. Emissions from All Sources

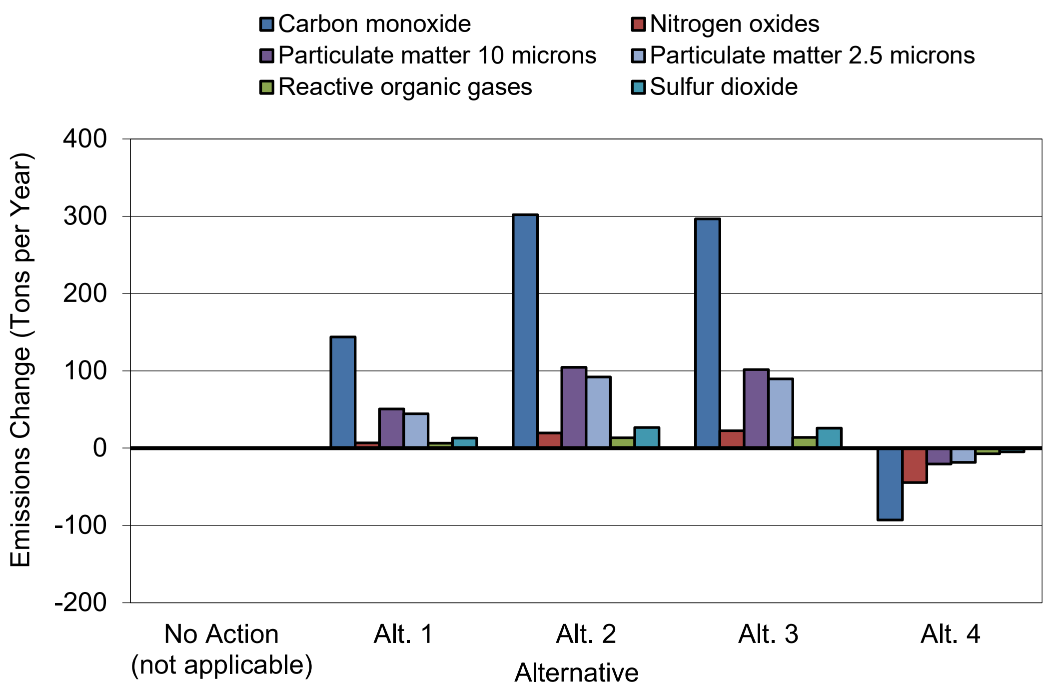


Figure 5.6-6. Changes in Emissions from All Sources Compared to the No Action Alternative

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

Source of Emissions	CO_2e Emissions (Metric tons per average year)				
	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

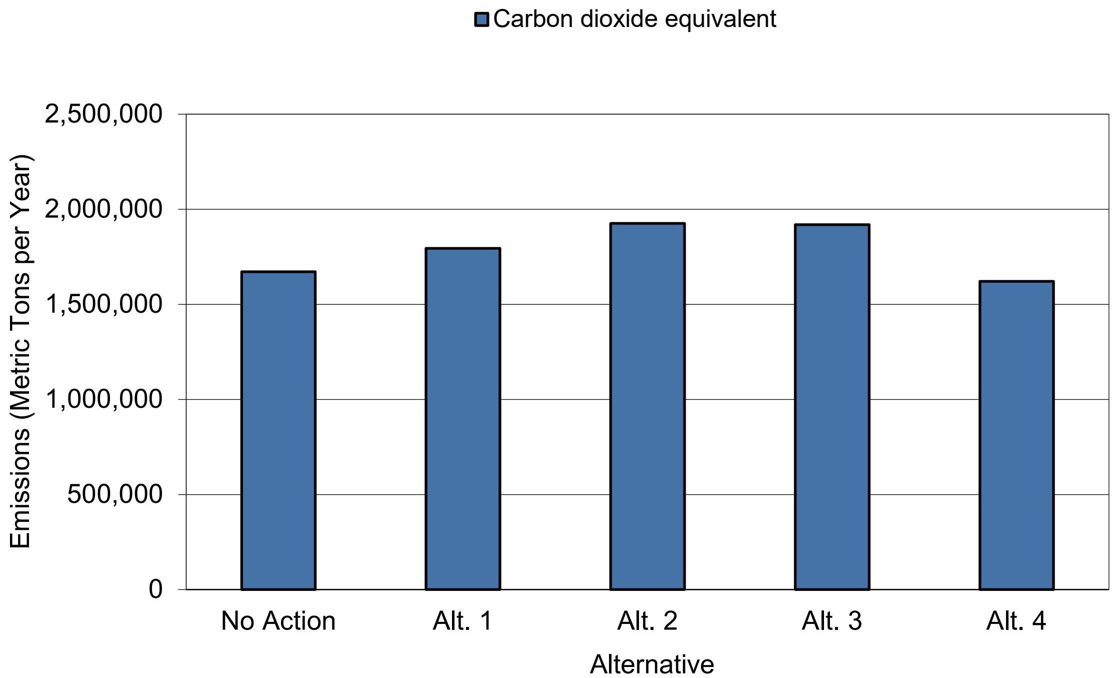


Figure 5.7-1. GHG Emissions Associated with the Action Alternatives

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 <u>Trinity River below Lewiston</u>

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).

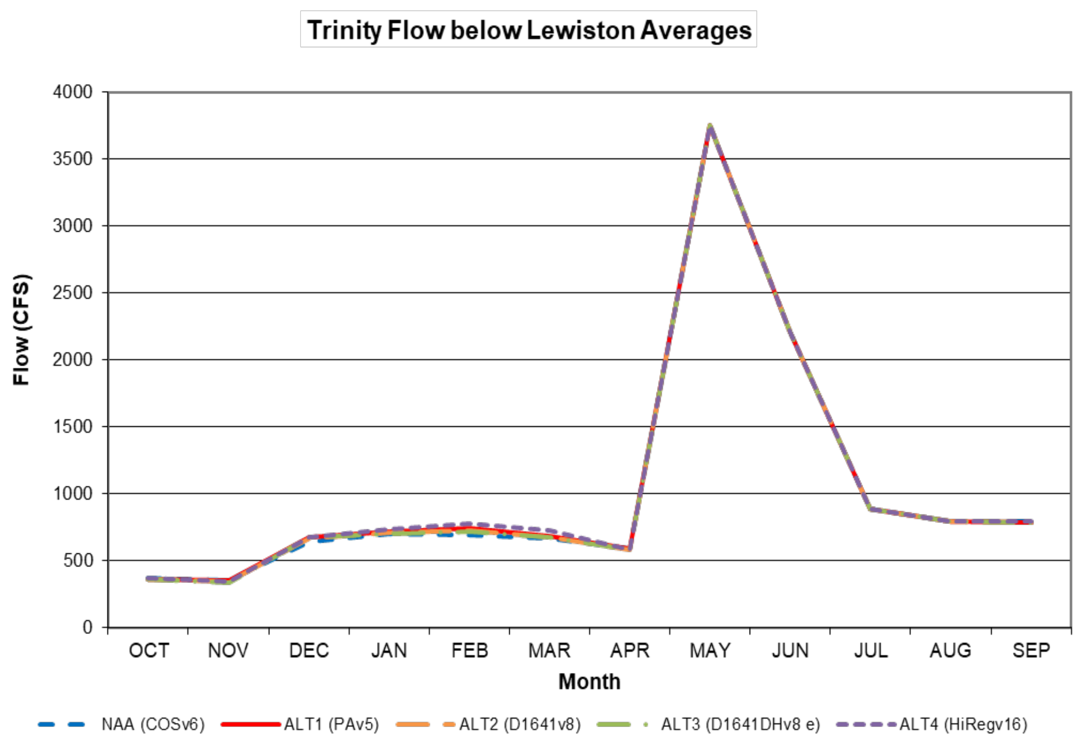


Figure 5.9-1. Average Trinity River Flow below Lewiston Dam for the Period October–September, Average of All Water Year Types

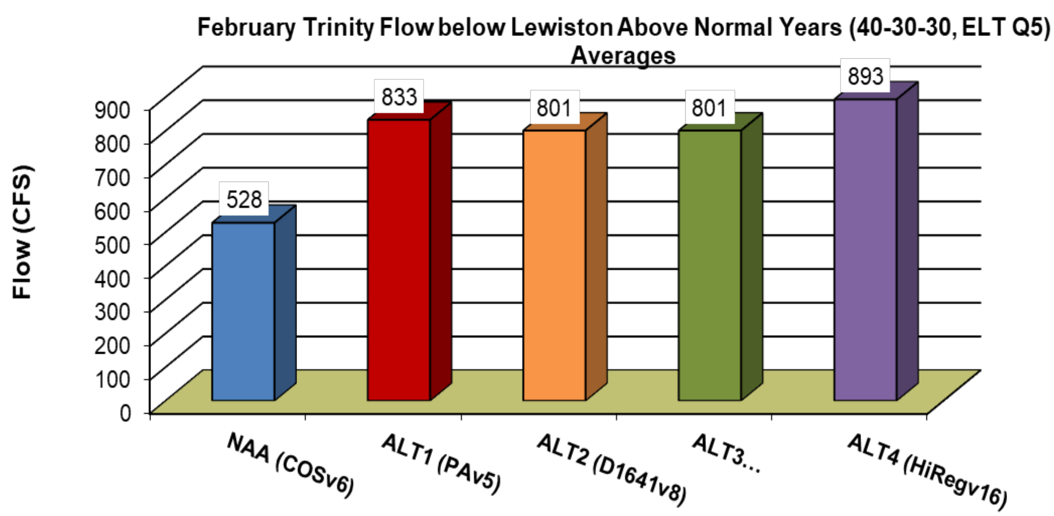


Figure 5.9-2. Average Trinity River Flow below Lewiston Dam during February in Above Normal Water Years

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.

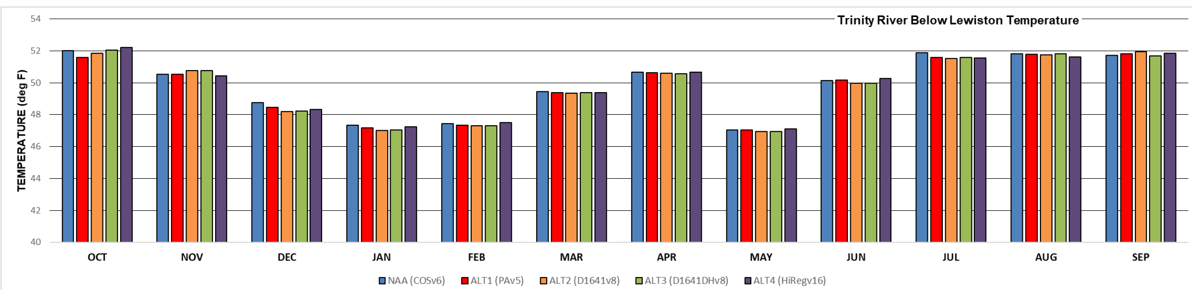


Figure 5.9-3. Average Monthly Trinity River Water Temperatures below Lewiston Dam, Average of All Water Year Types

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).

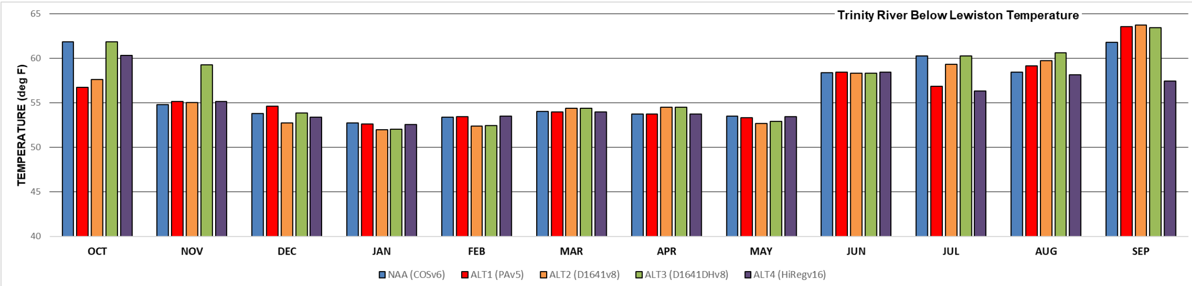


Figure 5.9-4. Maximum Trinity River Water Temperatures below Lewiston Dam for the Period October–September, Average of All Water Year Types

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.

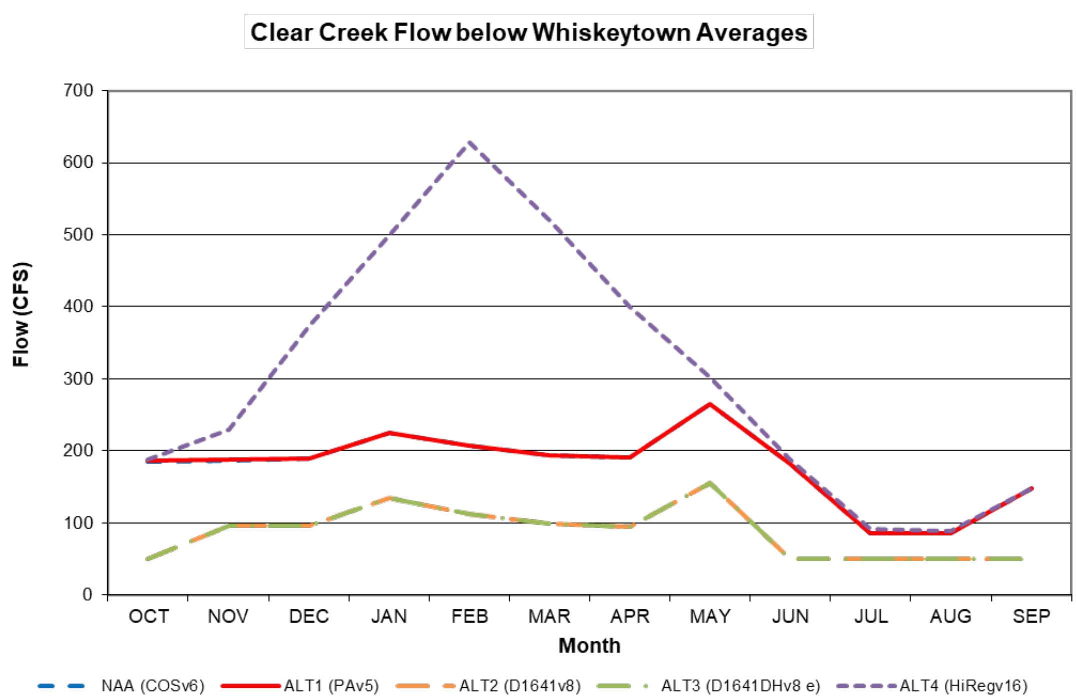


Figure 5.9-5. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Average of all Water Year Types

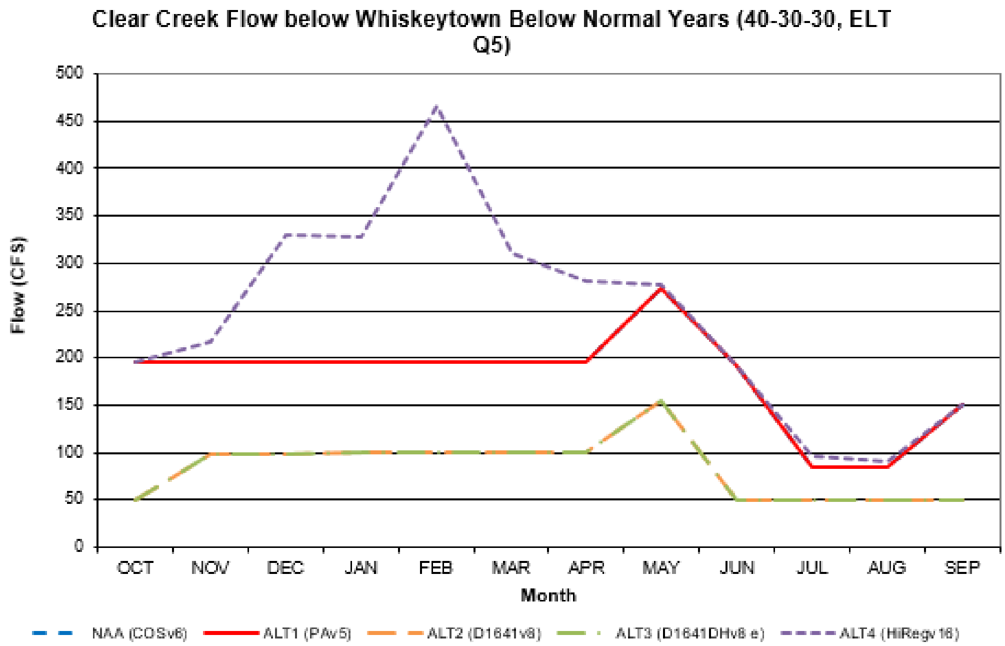


Figure 5.9-6. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Below Normal Water Years

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.

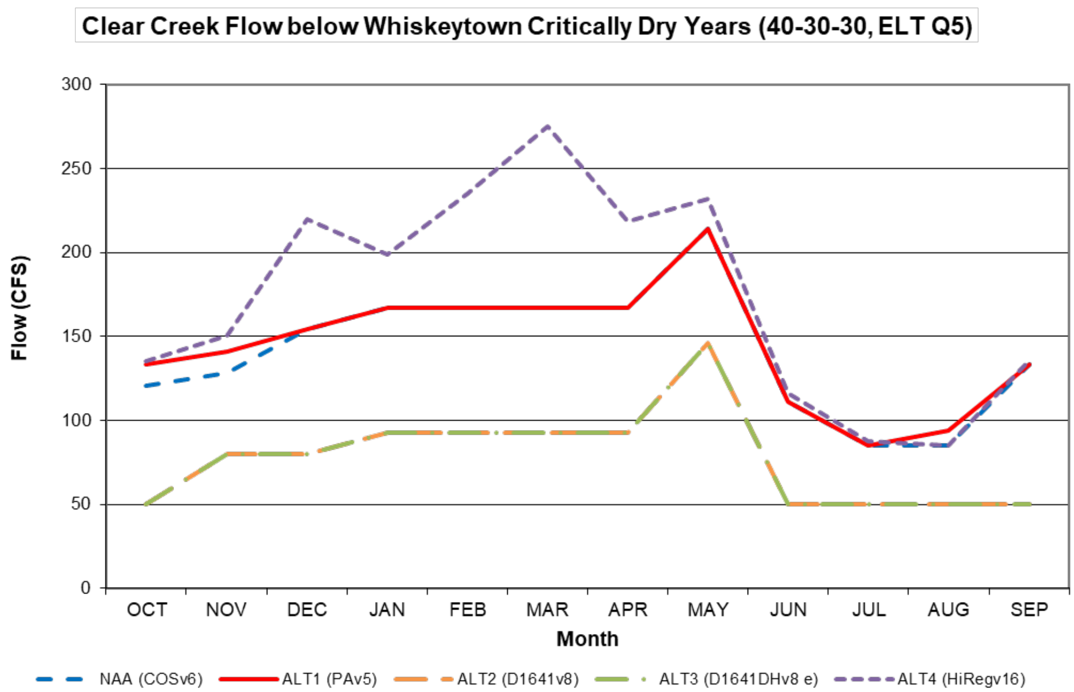


Figure 5.9-7. Modeled Average Flow in Clear Creek below Whiskeytown Dam for the Period October–September, Critically Dry Water Years.

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.

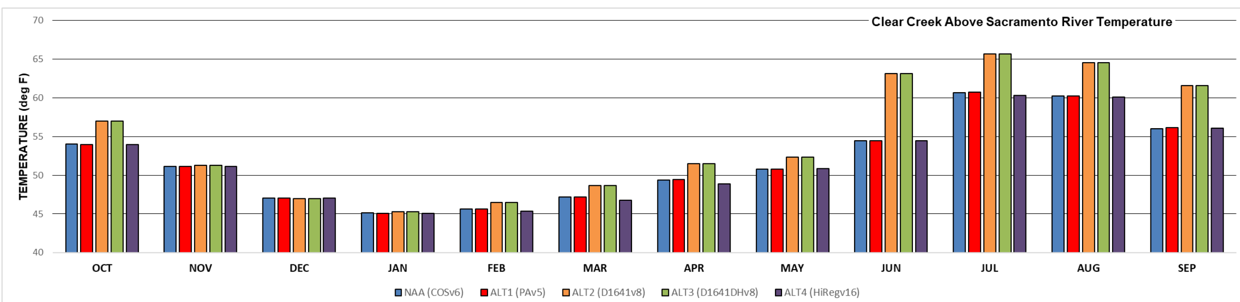


Figure 5.9-8. Modeled Average Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of All Water Year Types

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.

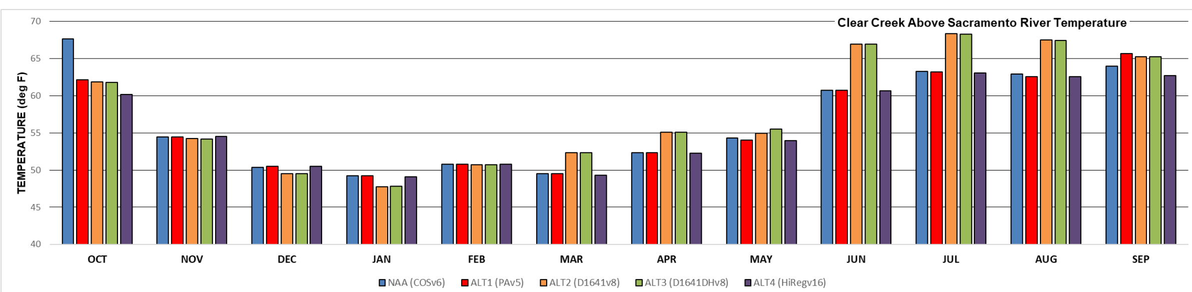


Figure 5.9-9. Modeled Maximum Water Temperatures in Clear Creek above the Sacramento River for the Period October–September, Average of all Water Year Types

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.

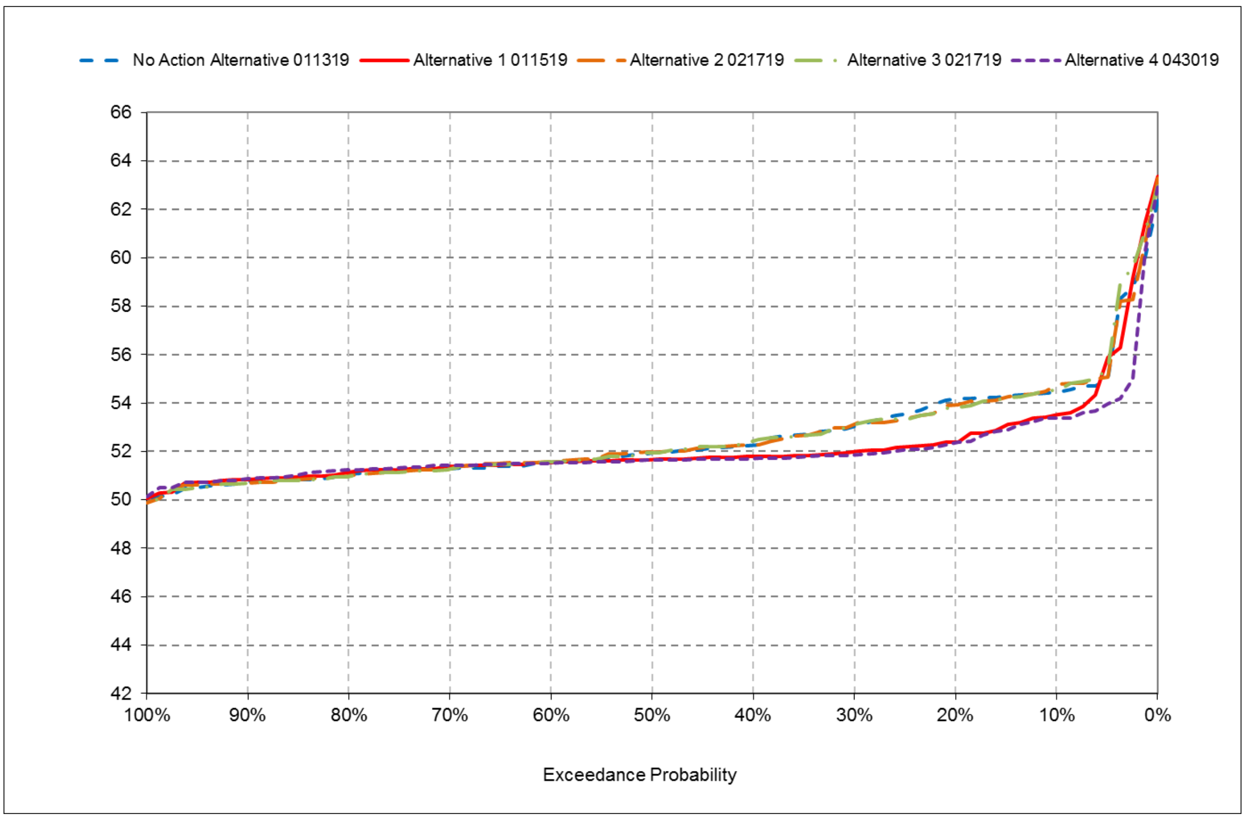


Figure 5.9-10. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the No Action Alternative, Alternative 1, Alternative 2, Alternative 3 and Alternative 4; August

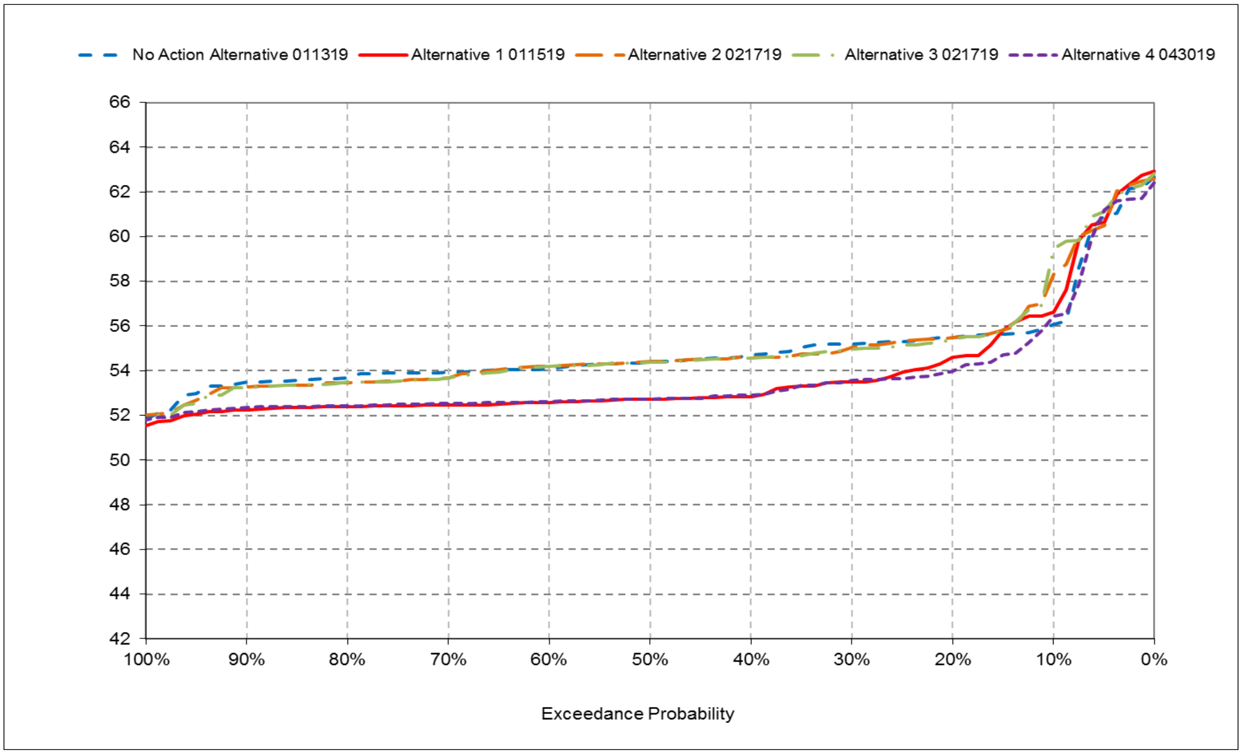


Figure 5.9-11. HEC-5Q Sacramento River Water Temperatures at Keswick Dam under the No Action Alternative, Alternative 1, Alternative 2, Alternative 3 and Alternative 4; October

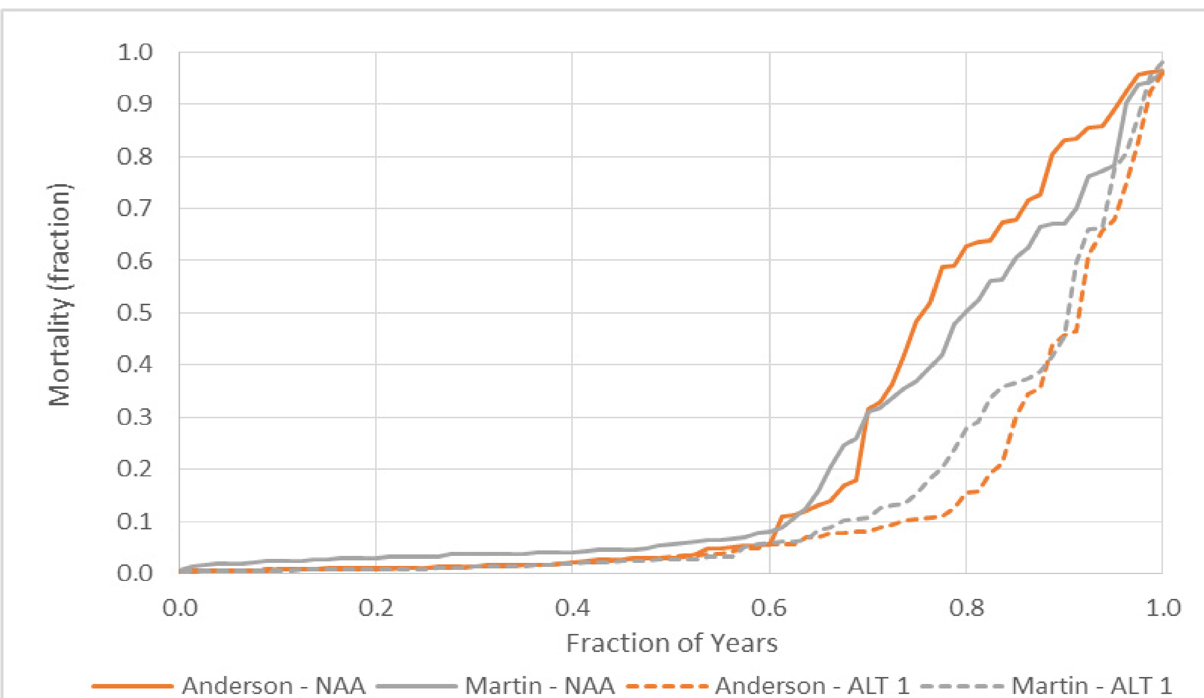


Figure 5.9-12. Exceedances of Winter-run Chinook Salmon Temperature-Dependent Egg Mortality, Alternative 1 vs. No Action Alternative; All Water Year Types.

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).

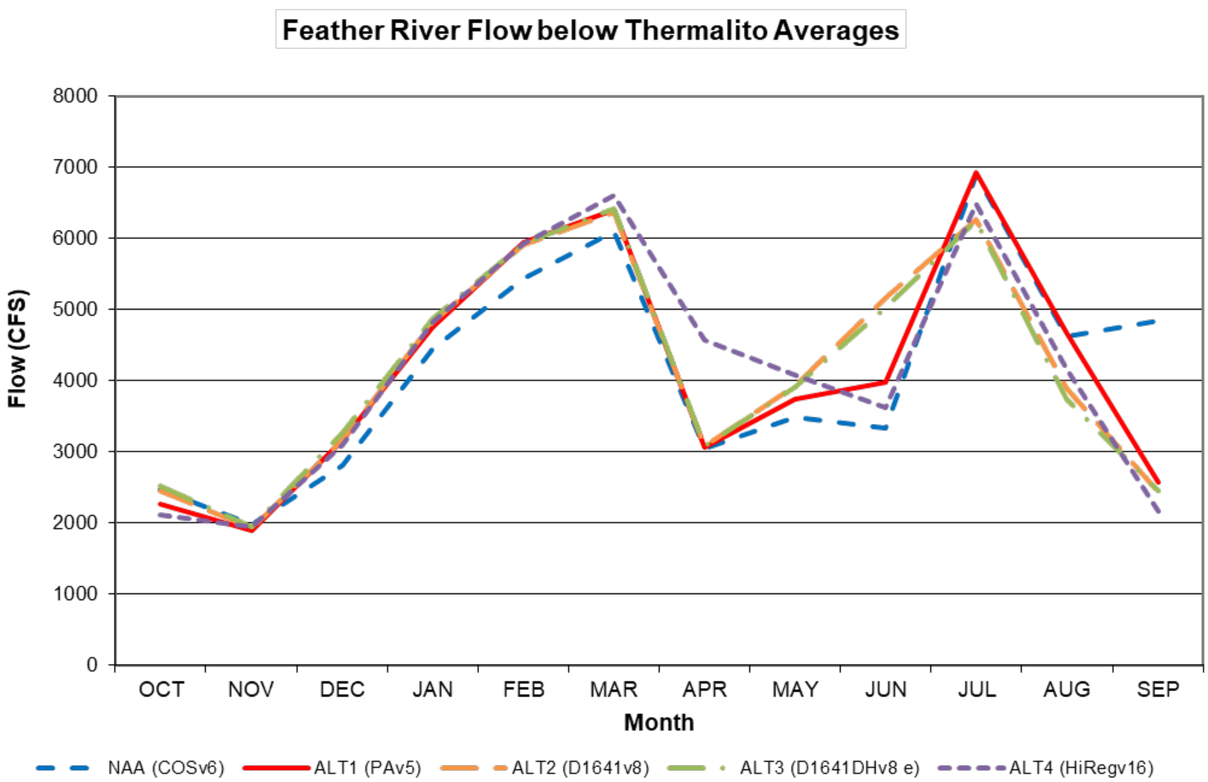


Figure 5.9-13. Average Feather River Flow below Thermalito Afterbay for the Period October–September, Average of All Water Year Types

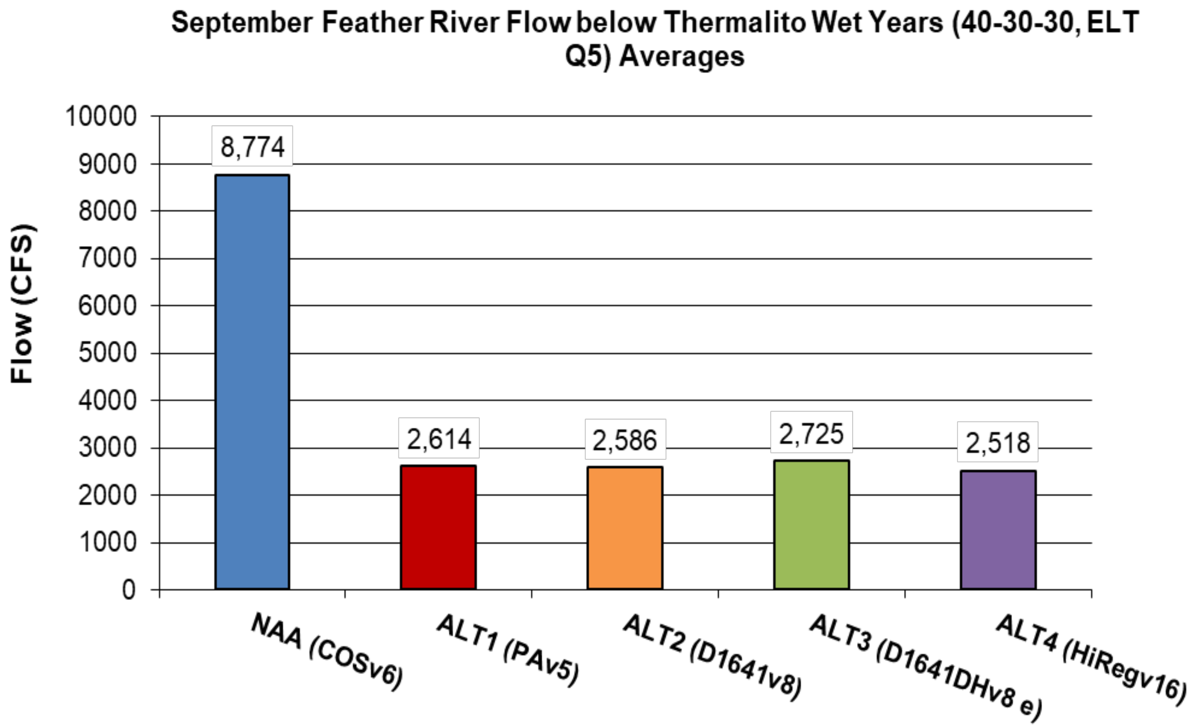


Figure 5.9-14. Average Feather River Flow below Thermalito Afterbay during September in Wet Water Years

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.

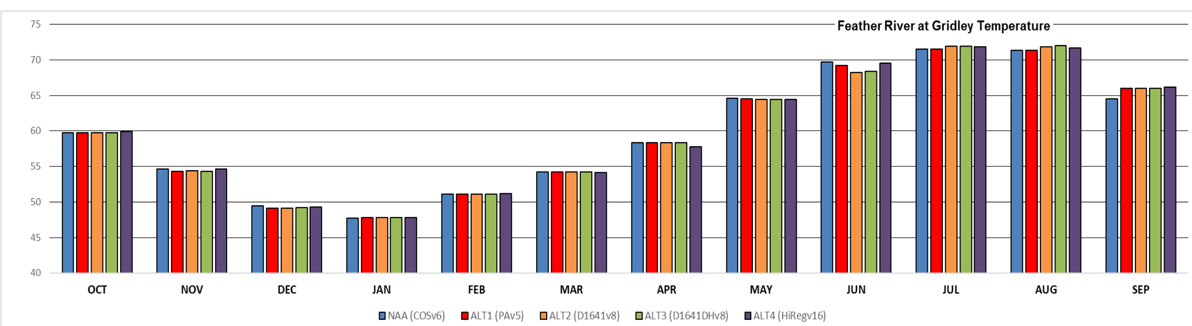


Figure 5.9-15. Average Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types

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.

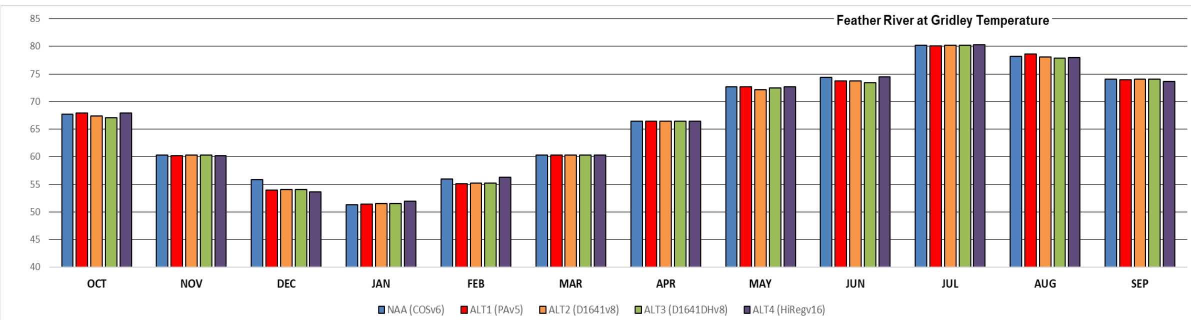


Figure 5.9-16. Maximum Feather River Water Temperatures at Gridley Bridge for the Period October–September, Average of All Water Year Types

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.

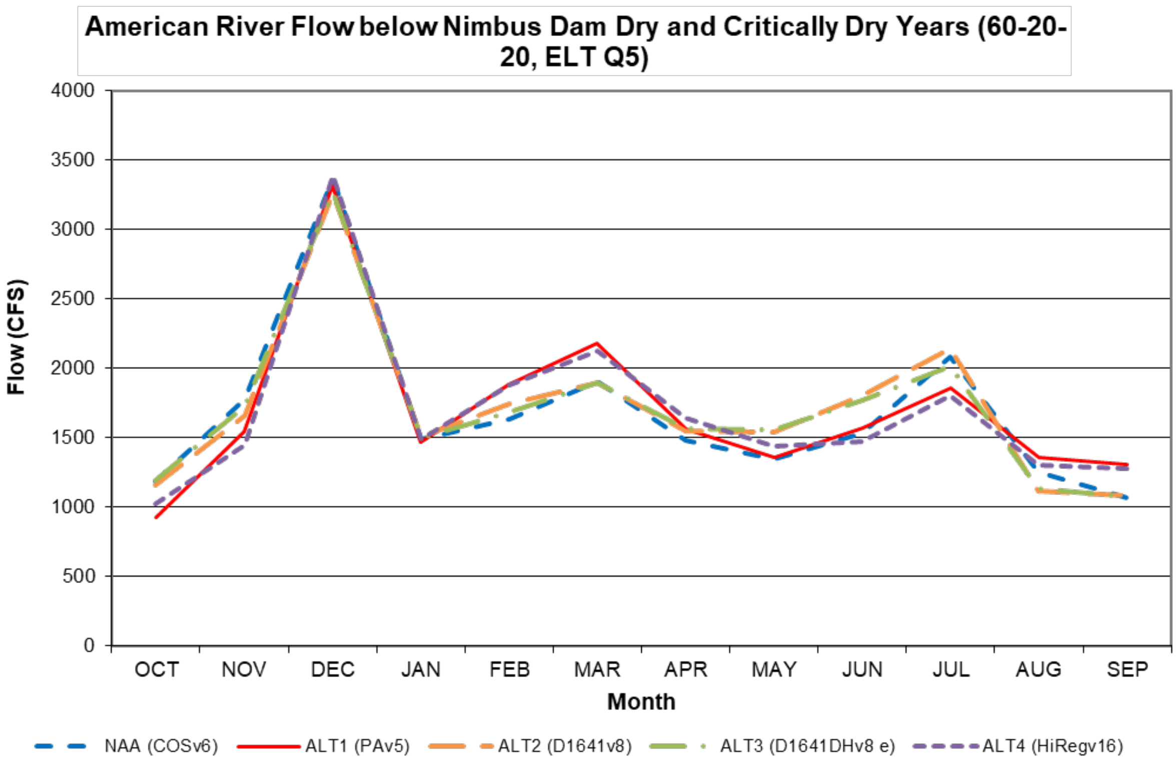


Figure 5.9-17. Flows in the American River below Nimbus Dam in Dry and Critically Dry Years

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.

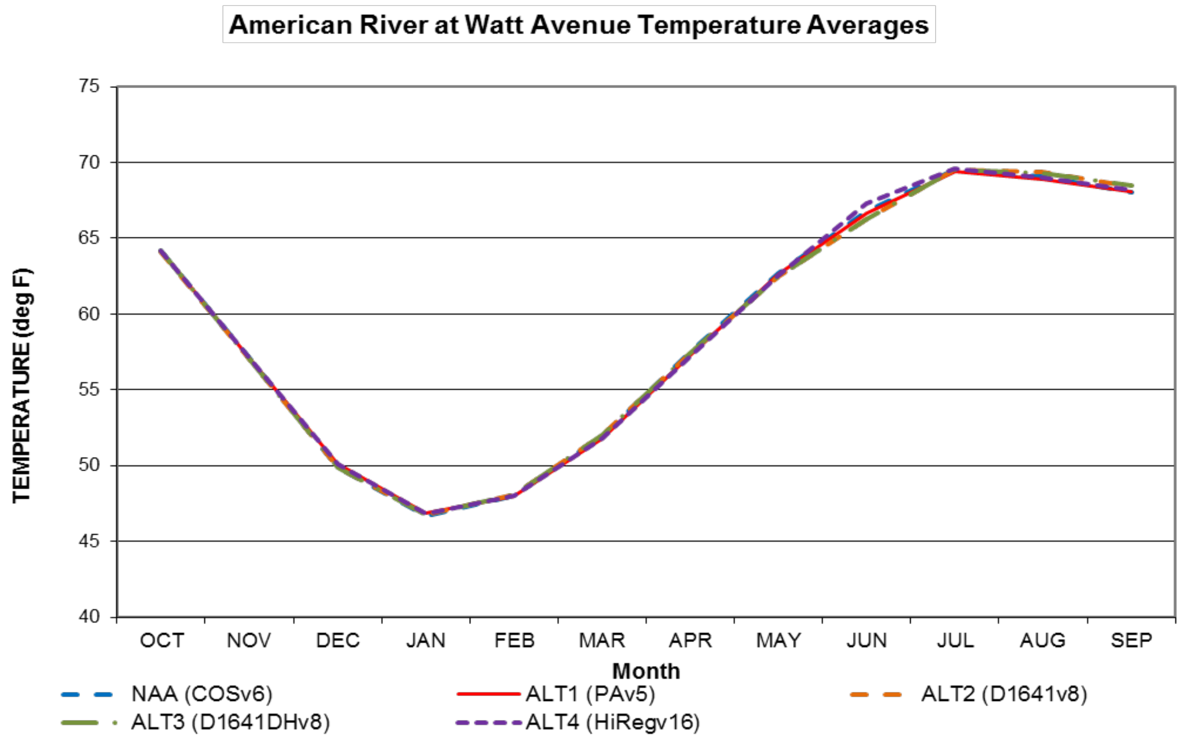


Figure 5.9-18. Average Temperatures at Watt Avenue on the American River

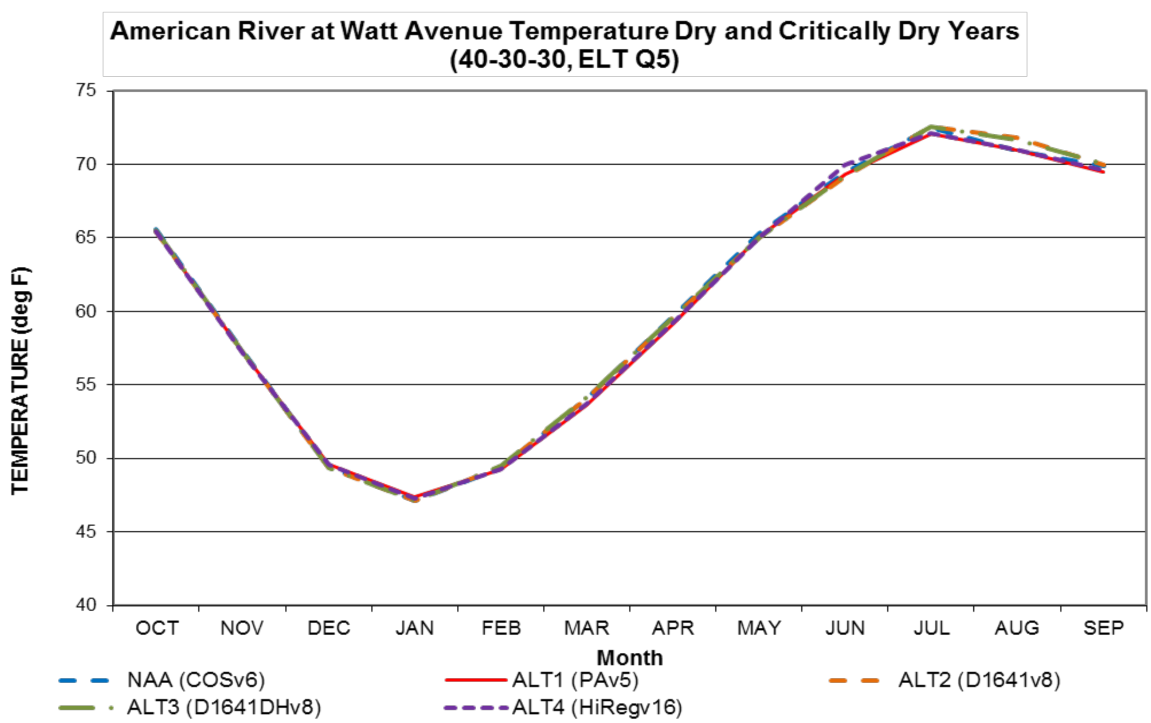


Figure 5.9-19. Average Temperatures at Watt Avenue on the American River in Dry and Critically Dry Years

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.

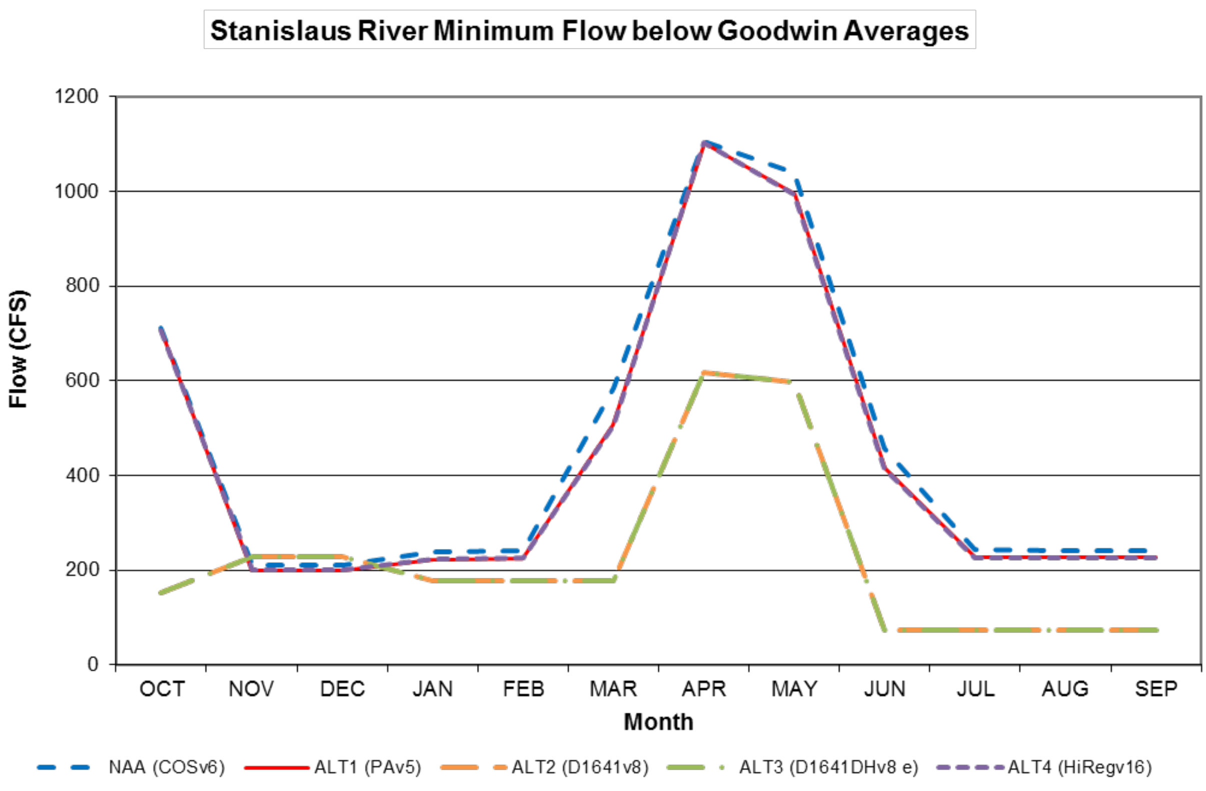


Figure 5.9-20. Stanislaus River Average Minimum Flow below Goodwin Dam.

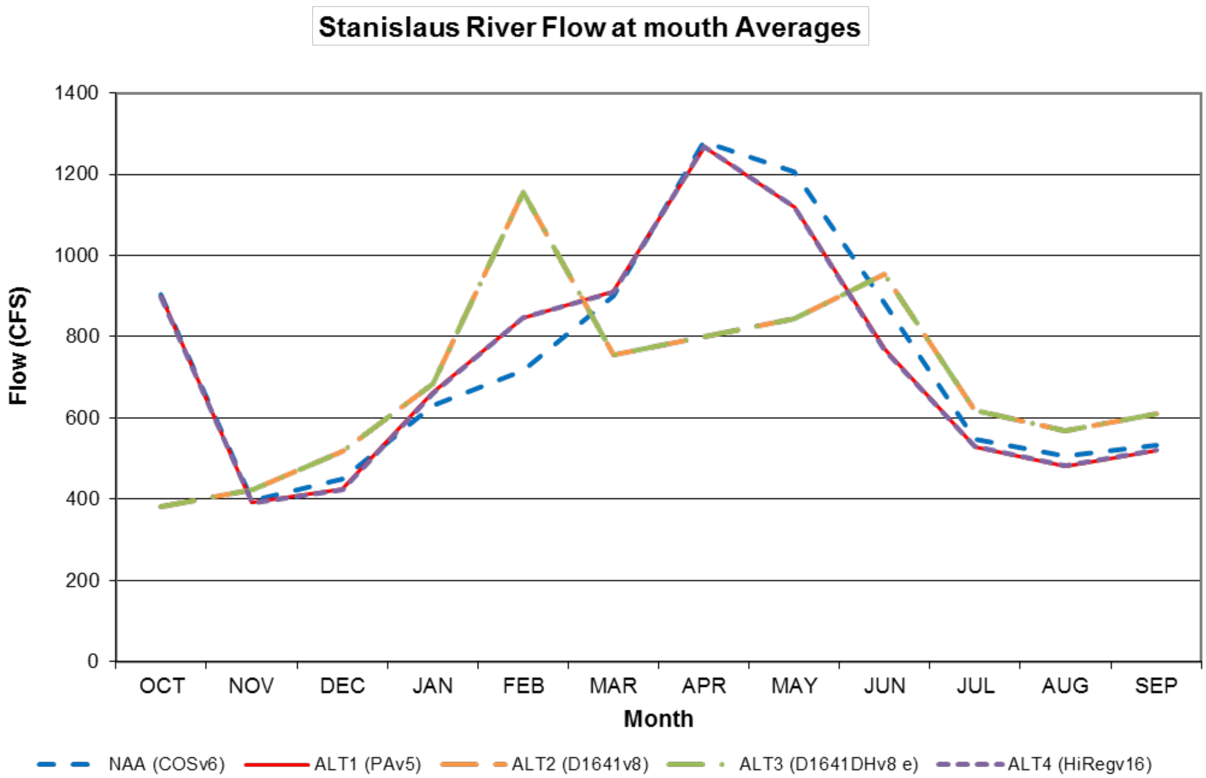


Figure 5.9-21. Average Monthly Flow at the Mouth of the Stanislaus River.

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.

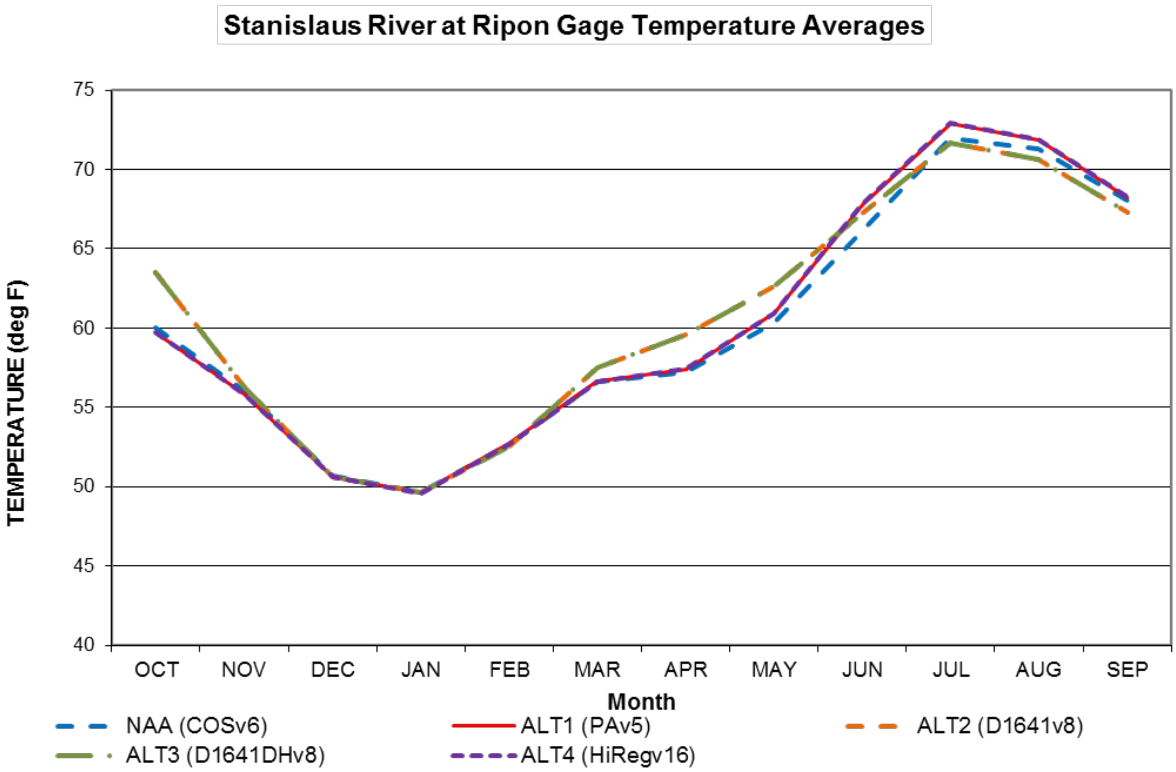


Figure 5.9-22. Average Monthly Temperature at Ripon on the Stanislaus River

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.

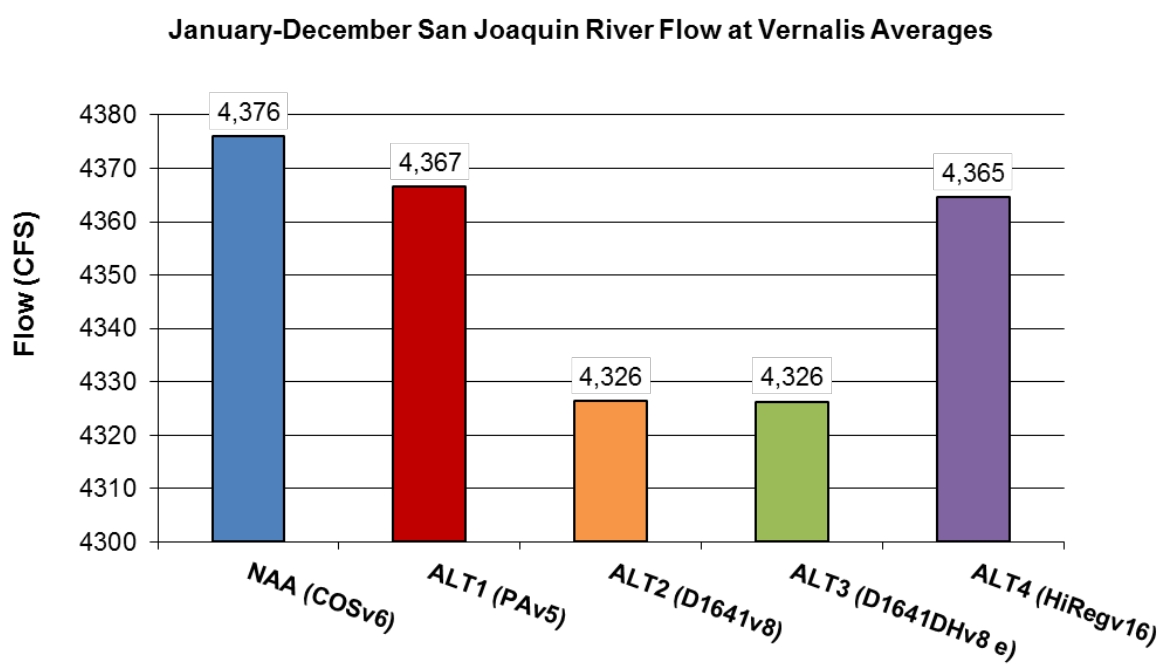


Figure 5.9-23. January–December San Joaquin River Flow at Vernalis Averages.

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).

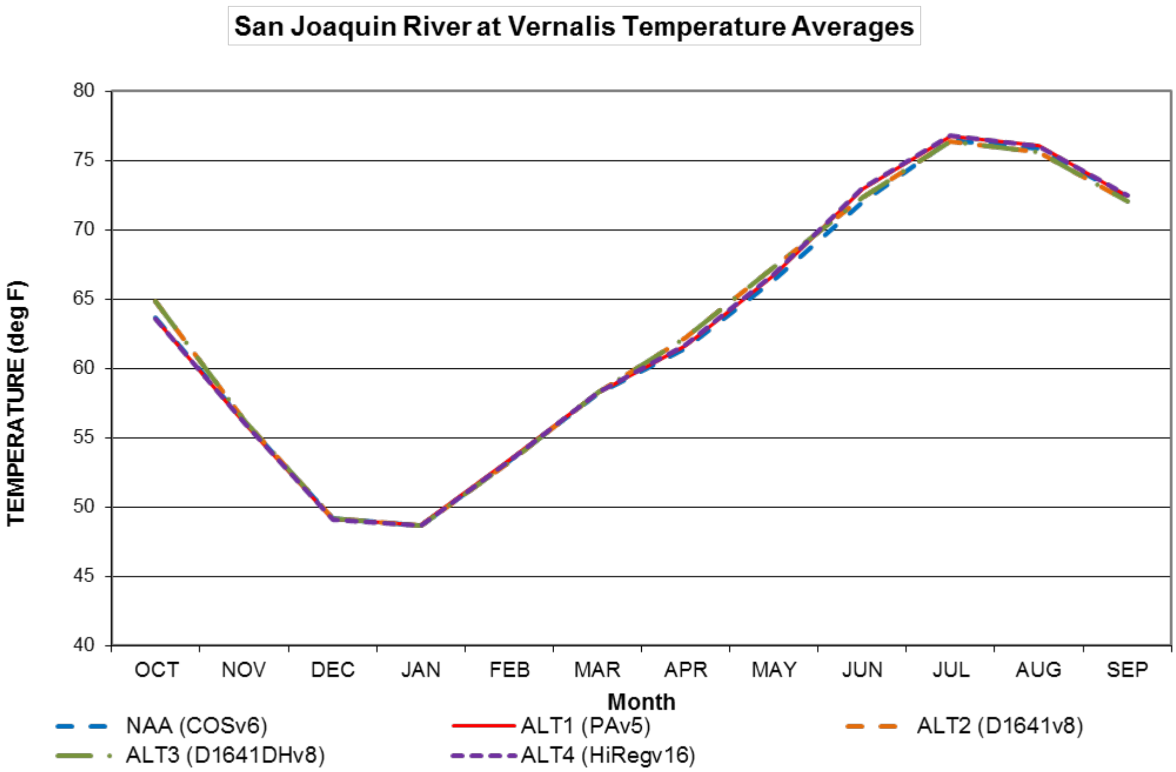


Figure 5.9-24. Average Monthly Water Temperature at Vernalis by Project Alternative.

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

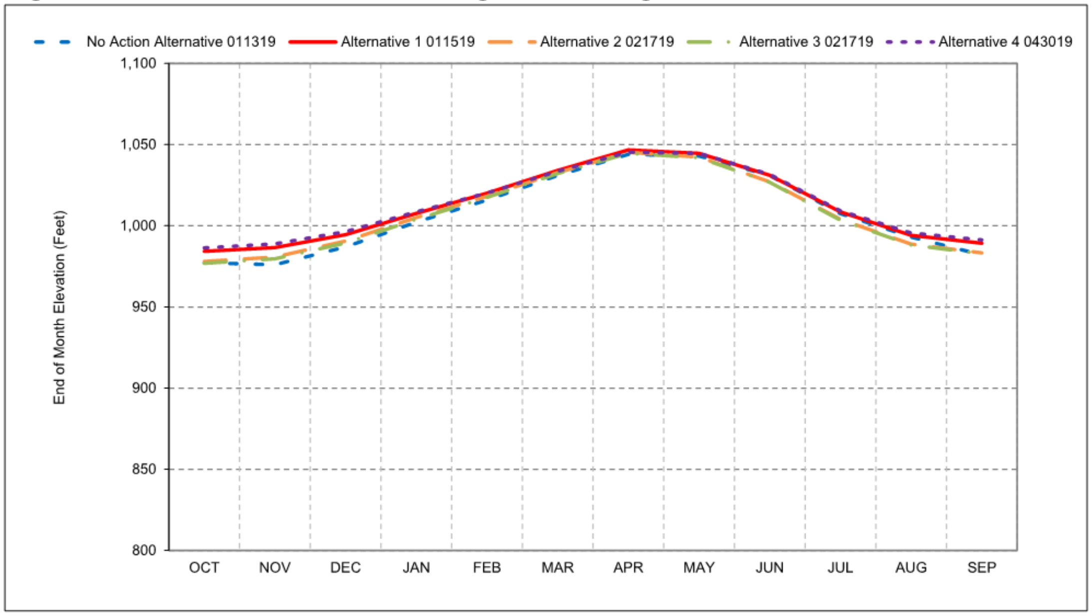
This impact assessment is based on the technical analysis documented in Appendix S, *Recreation Technical Appendix*, which includes additional information on recreation existing conditions and technical analysis of the effects of each alternative. The analysis is based on CalSim II model results.

5.13.1 Project-Level Effects

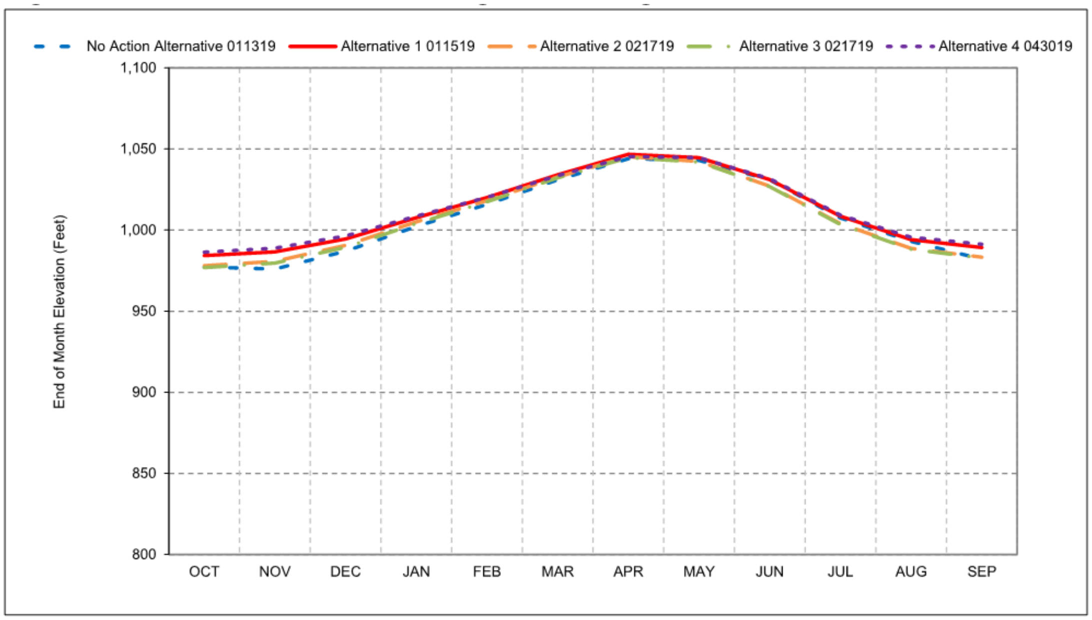
Potential changes to recreational opportunities

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.

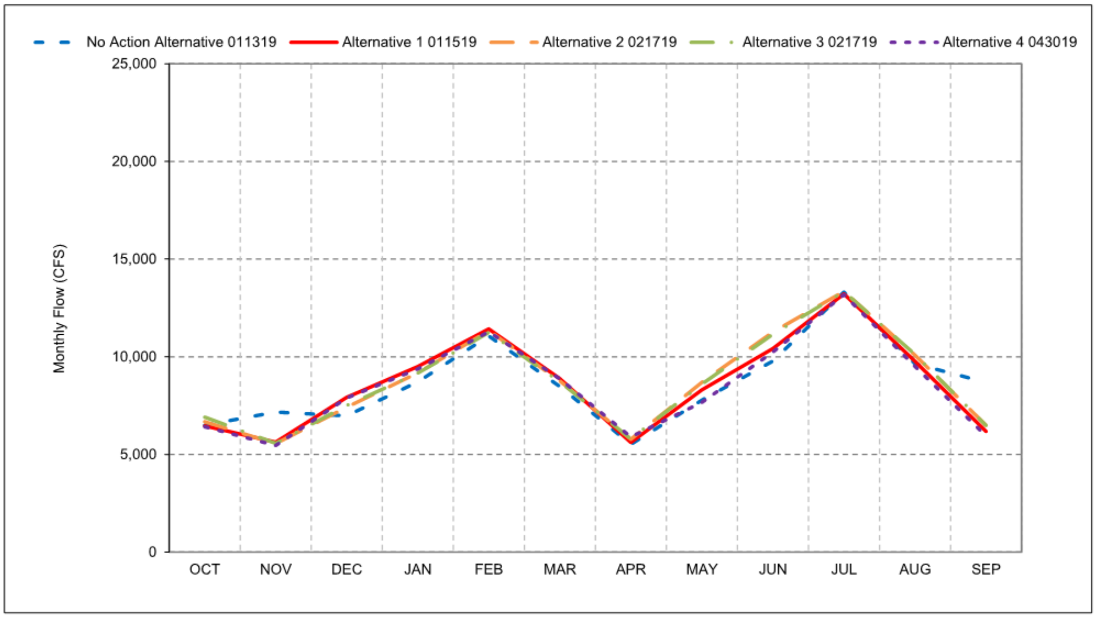


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft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

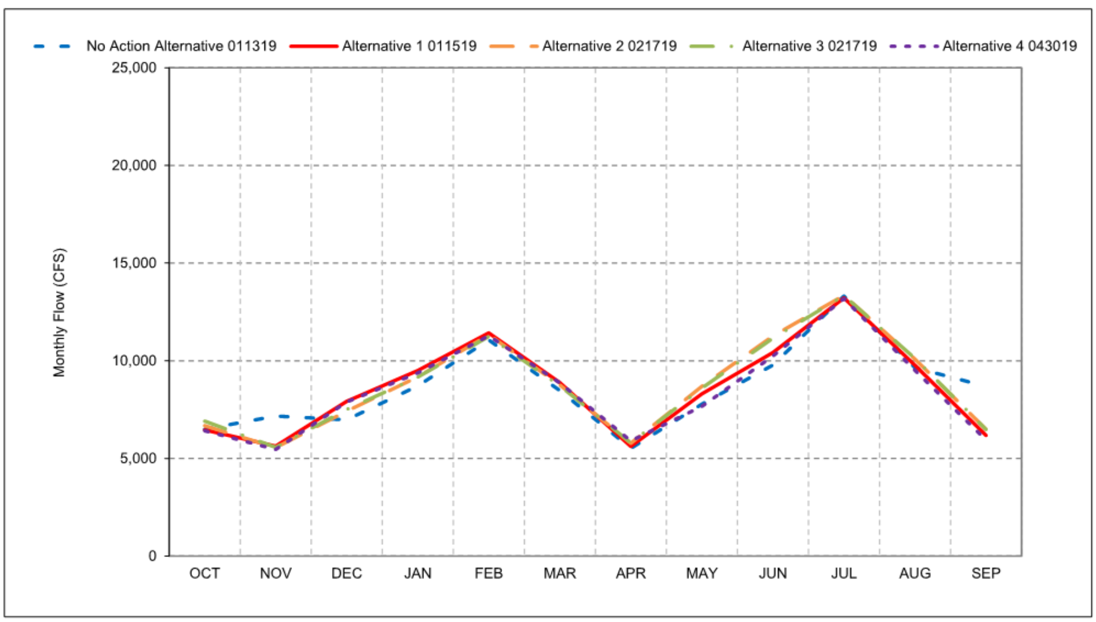


*As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
*These results are displayed with calendar year - year type sorting.
*All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.
*These are draft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

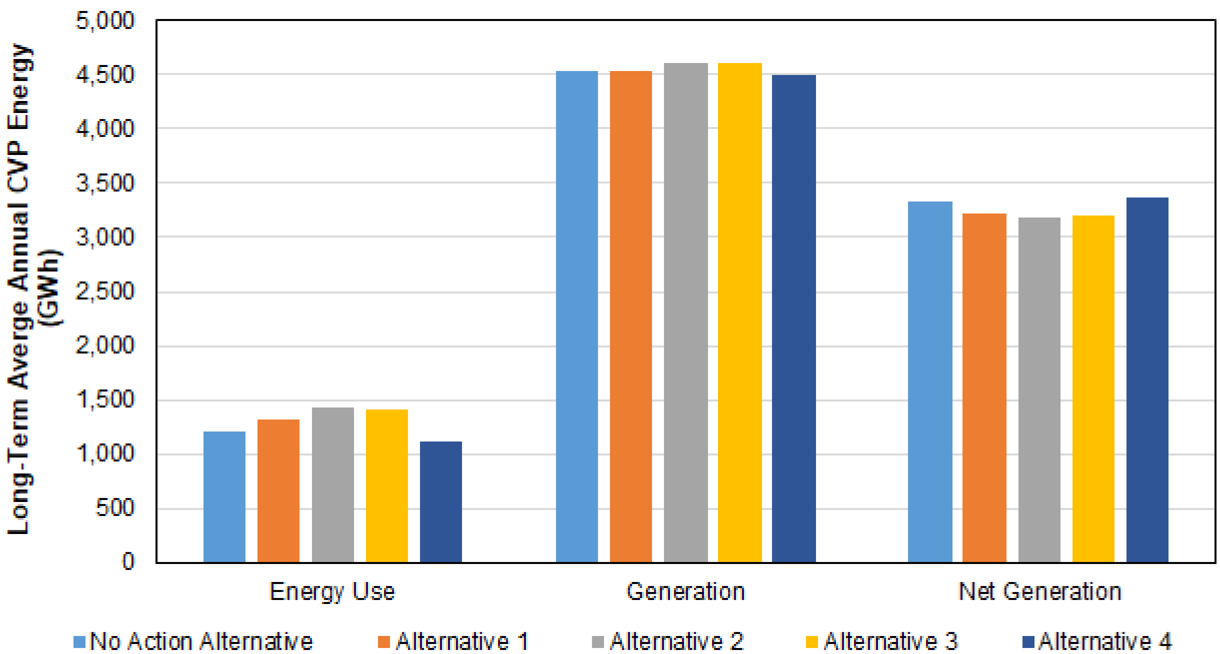


Figure 5.15-1. Comparison of Simulated Long-Term Average Annual CVP Energy Use, Generation, and Net Generation

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.

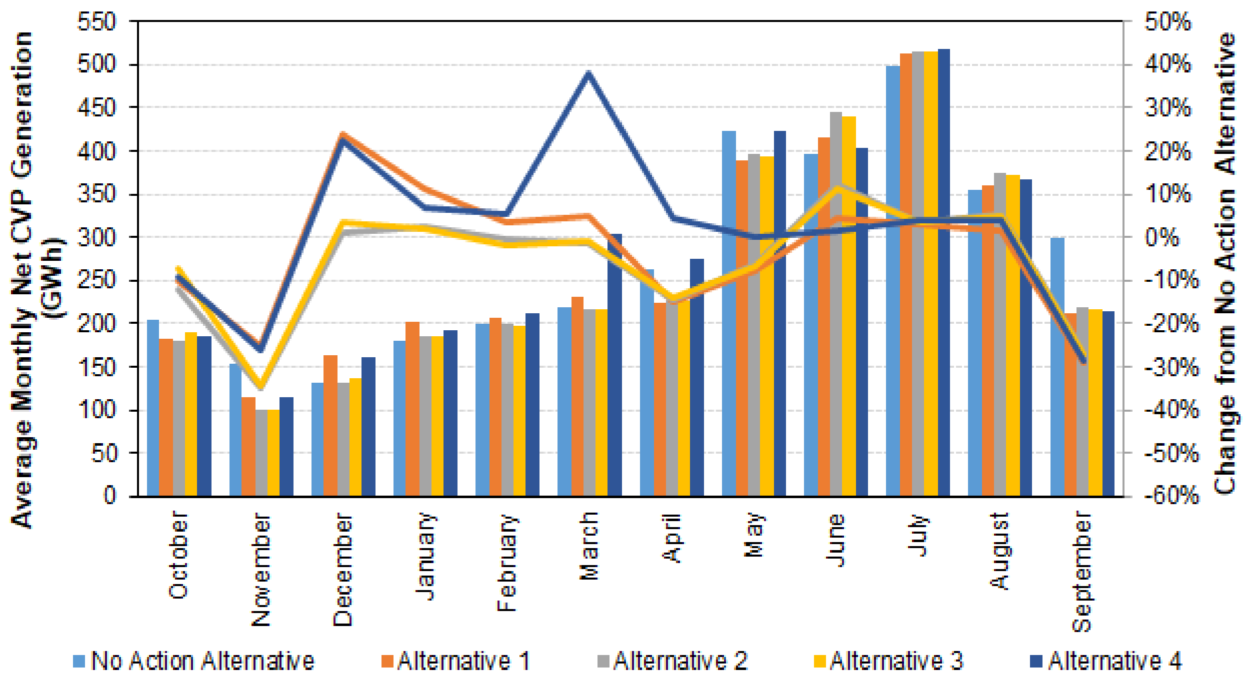


Figure 5.15-2. Comparison of Simulated Long-Term Monthly CVP Net Generation and Percent Change in Net Generation from the No Action Alternative

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.

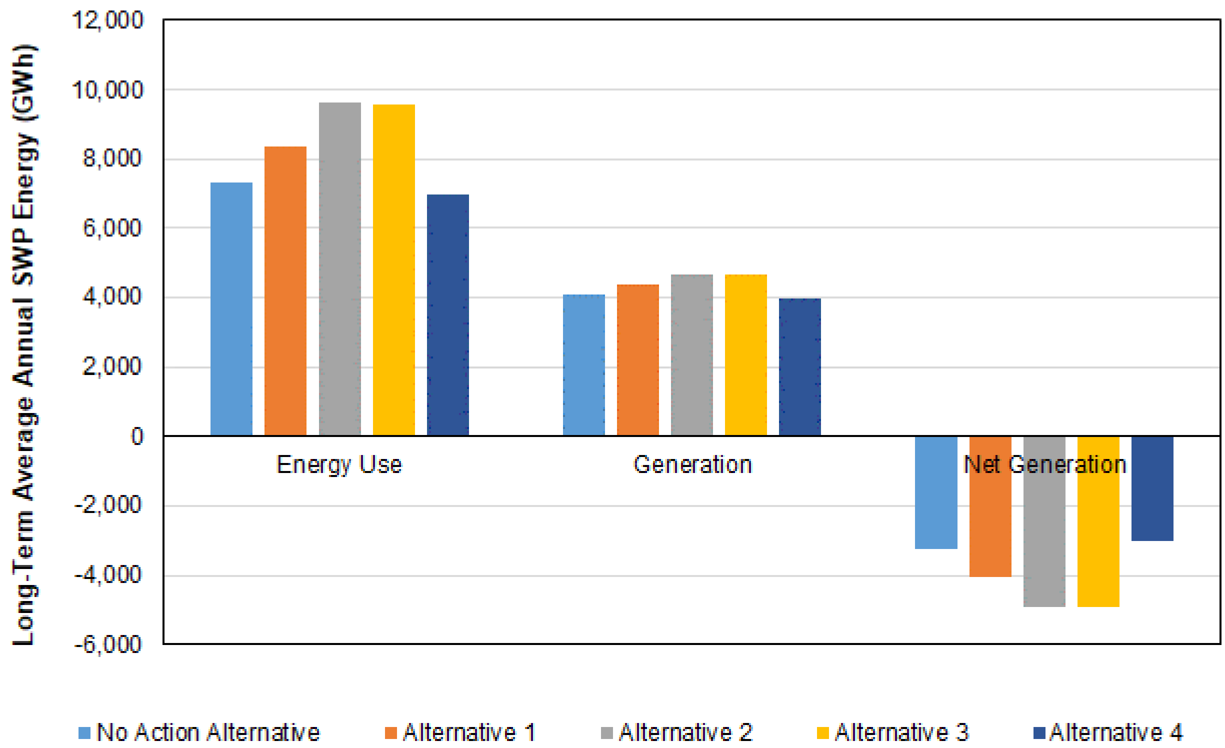


Figure 5.15-3. Comparison of Simulated Long-Term Average Annual SWP Energy Use, Generation, and Net Generation

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.

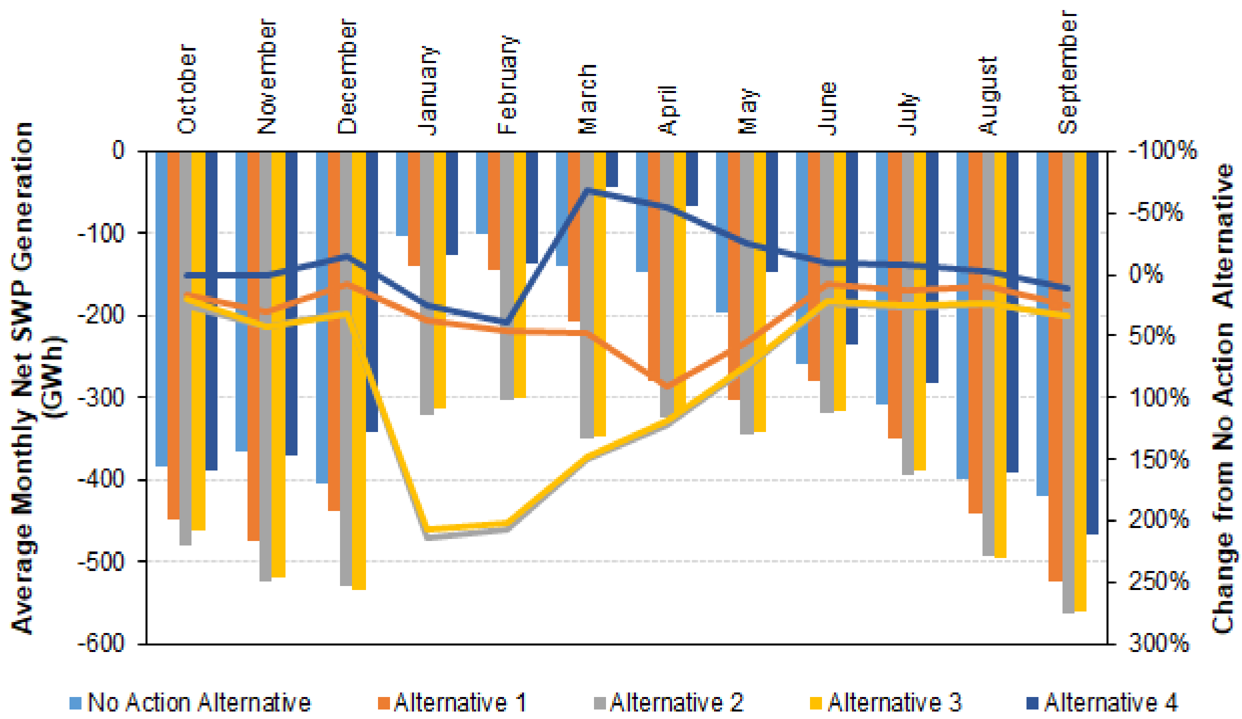


Figure 5.15-4. Comparison of Simulated Long-Term Monthly SWP Net Generation and Percent Change in Net Generation from the No Action Alternative

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.