Chapter 1 Summary

1.1 Purpose of this Environmental Impact Statement

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

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

1.2 Project Background

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

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

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

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

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

1.3 Major Conclusions

1.3.1 Alternatives

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

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

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

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

1.3.2 Analysis Overview

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

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

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

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

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

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

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

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

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

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

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

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

1.4 Areas of Controversy

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

1.4.1 Delta Smelt and Longfin Smelt

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

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

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

1.4.1.1.2 Delta outflow as a driver of Longfin Smelt population dynamics

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

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

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

1.4.1.3 *Distribution of Longfin Smelt and spawning locations*

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

1.4.1.3.1 Potential benefits of tidal habitat restoration

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

1.4.1.3.2 Factors influencing food availability

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

1.4.2 Salmonids

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

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

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

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

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

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

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

1.4.2.1.1 Navigational Cues for Juvenile Salmonids in the Tidal Delta

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

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

1.5 Scope of Analysis for Resource Areas

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

1.6 Selection of Preferred Alternative

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

1.7 Issues to be Resolved

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