UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

Refer to NMFS No: WCRO-2016-00077

January 24, 2020

Mr. Ernest Conant
Regional Director
U.S. Bureau of Reclamation
Mid-Pacific Region
2800 Cottage Way
Sacramento, California 95825

Re: Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Long Term Operations of the Central Valley Project and State Water Project

Dear Mr. Conant:

Thank you for your request for consultation with NOAA's National Marine Fisheries Service (NMFS) on essential fish habitat (EFH) for the Long Term Operations of the Central Valley Project (CVP) and State Water Project (SWP). The NMFS reviewed the proposed action for potential effects on EFH designated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), including conservation measures and any determination made in the Biological Assessment regarding the potential effects of the action. This review was pursuant to section 305(b) of the MSA (16 U.S.C. 1855(b)), implementing regulations at 50 CR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation.

Based on the best available information, NMFS has determined that the proposed action would adversely affect EFH for Pacific coast salmon, Pacific coast groundfish, and coastal pelagic species. Therefore, in the enclosed, NMFS provides Conservation Recommendations.

As required by Section 305(b)(4)(B) of the MSA, Reclamation must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative timeframes for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

Reclamation must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(1)].

We appreciate your consideration of our Conservation Recommendations. If you wish to discuss this consultation further or have questions concerning our recommendations, please contact Kimberly Clements at kimberly.clements@noaa.gov or at (916) 930-5646.

Sincerely,

Maria Rea
Assistant Regional Administrator
California Central Valley Office

Enclosure

cc: File: ARN #151422WCR2016SA00300

NATIONAL MARINE FISHERIES SERVICE

MAGNUSEN-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the Magnuson-Stevens Act (MSA) directs Federal agencies to consult with the NOAA's National Marine Fisheries Service (NMFS) on all actions or proposed actions that may adversely affect essential fish habitat (EFH). The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

Background

NMFS completed this EFH consultation on the proposed long-term operation of the Central Valley Project (CVP) and State Water Project (SWP), in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

NMFS has completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository. A complete record of this consultation is on file at NMFS' California Central Valley Office.

Consultation History

- On August 2, 2016, the U.S. Bureau of Reclamation (Reclamation) provided a letter to NMFS requesting re-initiation of consultation on the long-term operations of the CVP and SWP (ROC on LTO) pursuant to the Endangered Species Act (ESA) section 7 and EFH.

- On January 31, 2019, Reclamation issued a biological assessment (BA) to initiate formal section 7 consultation pursuant to the ESA. Within the transmittal was an EFH assessment.

- On October 17, 2019, Reclamation issued a revised BA with changes to the Proposed Action (PA).(U.S. Bureau of Reclamation 2019).

- On October 21, 2019, NMFS issued a Biological Opinion on the effects of the ROC on LTO on listed species and their designated critical habitats (NMFS 2019). NMFS deferred completion of the EFH consultation.

Proposed Action and Action Area

Proposed Action

The purpose of the PA is to continue the operation of the CVP in coordination with the SWP, for their authorized purposes, in a manner that enables Reclamation and California Department of Water Resources (DWR) to maximize water deliveries and optimize marketable power generation consistent with applicable laws, contractual obligations, and agreements; and to augment operational flexibility by addressing the status of listed species. Conservation measures were included to avoid and minimize or compensate for CVP and SWP effects, and include actions that benefit listed species. For a full description of the PA, please see Chapter 4 of Reclamation's final Biological Assessment (BA) for the ROC on LTO, issued on October 17, 2019. In addition, a more detailed description of the proposed action is provided in the effects and conservation recommendations section separated by watershed.

Action Area

The action area for this consultation is the same as for the ESA section 7 consultation, which includes all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. Specifically, the action area is (1) Shasta and Keswick reservoirs, and the Sacramento River from Keswick Reservoir downstream to and including the Sacramento–San Joaquin Delta; (2) Whiskeytown Reservoir, and Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (3) Folsom Reservoir, Lake Natoma, and the American River from Lake Natoma downstream to its confluence with the Sacramento River; (4) New Melones Reservoir, and the Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (5) San Joaquin River from the confluence of the Stanislaus River downstream to and including the Sacramento–San Joaquin Delta; and (6) San Francisco Bay and Suisun Marsh. The action area also includes Battle Creek, Deer Creek, and Spring Creek Reservoir, Debris Dam and Spring Creek, where restoration and water quality actions are proposed.

Essential Fish Habitat Affected by the Proposed Action

This EFH analysis is based, in part, on the EFH assessment provided by Reclamation, and descriptions of EFH for various species and life stages of Pacific Coast Salmon (specifically Chinook salmon) [Pacific Fishery Management Council (PFMC) 2016b], Pacific Coast Groundfish (PFMC 2016a), and Coastal Pelagic Species (PFMC 1998) contained in the fishery management plans (FMPs) and that occur in the action area. These FMPs were developed by the PFMC and approved by the Secretary of Commerce. Table 1 provides details associated with this EFH analysis. This consultation also describes conservation measures Reclamation proposes in their BA to avoid, minimize, or otherwise offset potential adverse effects resulting from the PA on EFH.

Table 1. Fishery Management Plans and effects by the Proposed Action in the action area.

Fishery Management Plan That Identifies EFH in the Action Area	Does Action Have an Adverse Effect on EFH?	Does Action Have an Adverse Effect on HAPC?	Are EFH Conservation Recommendations Provided?	Action Area
Pacific Coast Salmon (PFMC 2016b)	Yes	Yes	Yes	Sacramento River, Clear Creek, Deer Creek, Battle Creek, American River, Stanislaus River, San Joaquin River, SR-SJR Delta, Suisun Bay and San Francisco Bay
Pacific Coast Groundfish (PFMC 2016a)	Yes	Yes	Yes	SR-SJR Delta, Suisun Bay and San Francisco Bay
Coastal Pelagic Species (PFMC 1998)	Yes	No	Yes	SR-SJR Delta, Suisun Bay and San Francisco Bay

All evolutionarily significant units of Chinook salmon in the Central Valley [Sacramento River winter-run Chinook salmon, Central Valley (CV) spring-run Chinook salmon, and CV fall and late fall-run Chinook salmon] are managed under the Pacific Coast Salmon FMP, and all occur within the action area.

EFH for Chinook salmon means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. Freshwater EFH for Chinook salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC), and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

In the estuarine and marine areas, Chinook salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone [(EEZ) 200 miles or 370.4 km] offshore of Washington, Oregon, and California north of Point Conception

EFH for Pacific coast groundfish is defined as the aquatic habitat necessary to allow groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. Descriptions of groundfish EFH for each of the 83 species and their life stages result in more than 400 EFH identifications. Species most likely to occur in the action area include starry flounder (*Platichthys stellatus*) and English sole (*Pleuronectes vetulus*). When these EFHs are taken together, the groundfish EFH includes all waters from the mean higher high water line, and the upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon, and California, and seaward to the boundary of the EEZ.

EFH for coastal pelagic species is described in Amendment 8 to the Coastal Pelagic Species FMP and explains the habitat requirements of five pelagic species: Northern anchovy, Pacific sardine, Pacific (chub) mackerel, jack mackerel and market squid. These four finfish and market squid are treated as a single species complex because of similarities in their life histories and habitat requirements. Species most likely to occur in the action area include Northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*). EFH for coastal pelagic species is defined as follows. The east-west geographic boundary of EFH for coastal pelagic species is defined as all marine and estuarine waters from the shoreline along the coasts of California, Oregon and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10^{o} C to 26^{o} C. The southern boundary is the U.S.-Mexico maritime boundary. The northern boundary is more dynamic, and is defined as the position of the 50^{o} F isotherm, which varies seasonally and annually.

Along the West Coast, the PFMC identifies habitats that fall within "Habitat Areas of Particular Concern" (HAPC) and recommends these to NMFS consistent with the MSA. HAPCs are considered high priority areas for conservation, management, or research because they are important to ecosystem function, sensitive to human activities, stressed by development, or are rare. These areas provide important ecological functions and/or are especially vulnerable to degradation and can be designated based on either specific habitat types or discrete areas. HAPCs are a discrete subset of EFH. This EFH consultation focuses on addressing any adverse effects the PA may incur in the following designated HAPCs:

- HAPCs for Chinook salmon are: complex channel and floodplain habitat, spawning habitat, thermal refugia, estuaries, and submerged aquatic vegetation as described in Appendix A to the Pacific Coast Salmon FMP (PFMC 2014).

- HAPCs for Pacific coast groundfish are: estuaries, rocky reefs, canopy-forming kelp, seagrasses, and "areas of interest" as described in Amendment 19 to the Pacific coast groundfish FMP (PFMC 2016a).

Effects on Essential Fish Habitat and EFH Conservation Recommendations

This section provides information by watershed and includes a brief description of the PA, adverse effects to EFH, and conservation recommendations. The PA includes conservation measures to avoid and minimize or compensate for CVP/SWP effects and include actions that benefit listed species. For a full description of the PA, please refer to Chapter 4 of Reclamation's October 17, 2019, final BA.

Sacramento River/Shasta Division

The PA for the Sacramento River includes a number of new operating procedures (Table 2). Reclamation intends to divert and store water consistent with obligations under water rights and decisions by the State Water Resources Control Board (SWRCB); use Shasta critical determinations and allocations to water service and water repayment contractors; and implement the 2018 revised Coordinated Operations Agreement. For the upper Sacramento River, the PA includes modified seasonal operations, spring pulse flows, Shasta cold water pool management,

and fall and winter refill and redd maintenance. The PA also includes conservation measures to minimize potential negative effects (Table 3). A detailed list of the PA and its project components can be found in the Chapter 4 of the ROC on LTO BA.

Within the upper Sacramento River, Reclamation operates Shasta and Keswick dams year-round in coordination with the other facilities of the CVP and SWP. These operations are seasonal in their nature, as Reclamation operates in the winter for flood control, including both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. Releases for flood control will vary dependent upon the current storage, the forecasted inflow, and the flow in the mainstem Sacramento River at Bend Bridge where flows are held below 100,000 cfs. When not operating for fall and winter flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows both down the Sacramento River and in the Delta. During the winter to spring period, there are natural accretions (flows from unregulated creeks) into the Sacramento River below Shasta Dam. In wetter year types, Reclamation may be able to operate mostly for flood control and minimum instream requirements because of the large volumes of accretions to the Sacramento River. In drier years, these accretions may be lower and, therefore, require Reclamation to release a higher level of releases from the upstream reservoirs to meet state permit requirements as well as project exports in the Delta.

In the spring, reservoir releases are relatively stable until flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements. When Delta regulatory constraints are relaxed, exports can increase during periods of excess flow and Reclamation can build additional storage south of the Delta, in San Luis Reservoir, without increasing releases from upstream reservoirs. An overarching goal for Reclamation when operating the CVP is to fill the reservoirs as much as possible by the end of the flood control season (end of May), while still meeting all other authorized project purposes. A new action component in the PA is the inclusion of spring pulse releases, where under certain hydrological conditions, Reclamation will make reservoir releases to simulate natural springtime freshets events that stimulate and facilitate juvenile salmonid emigration.

During the summer, operational considerations are mainly flows sufficient to meet Delta outflow requirements, instream demands, temperature control, and exports. A particularly challenging aspect of summer operations is the Cold Water Pool Management in Shasta Reservoir, where during summer months Reclamation releases large volumes of water to meet downstream agricultural demands while also providing suitable temperatures for winter-run Chinook salmon spawning and incubation. To meet these competing demands, Reclamation proposed to use a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. Temperature management continues into the fall, and by late fall, the remaining cold-water pool in Shasta Reservoir is usually very limited.

In the fall and with decreasing agricultural demands, Reclamation reduces its reservoir releases, to begin again the process of building storage for the following summer. However, early in the fall, upper Sacramento River flows cannot be too low, as there are still significant instream diversion demands on the mainstem between Keswick Dam and Wilkins Slough, and depending on conditions, SWRCB Delta requirements may require upstream reservoir releases. This

necessitates maintaining higher releases to support the instream demands until they fall off later in the season. To manage that change between higher early-fall releases with the lower releases in the late fall and winter, Reclamation will consider the potential for dewatering redds with a risk analysis of the remaining winter-run Chinook salmon redds and the probability of sufficient cold water in a subsequent year.

The PA also includes a number of conservation measures intended to avoid and minimize or otherwise compensate for CVP and SWP project effects as well as contribute to the recovery and enhancement of species and their habitats (Table 3). These conservation measures include non-flow actions that benefit listed species.

Table 2. Comparison of Action Components between the Current Operation and Proposed Action for the Sacramento River.

Action Component	Current Operation	Proposed Action
Seasonal operations	Reclamation operates Shasta and Keswick dams year-round in coordination with the other facilities of the CVP and SWP. Seasonal operations follow a set of objectives, which include building storage in the fall, winter and spring, and to meet summer temperature targets.	Reclamation will operate to a similar set of seasonal constraints and objectives that include a modified outflow requirement and increased flexibility in export operations.
Spring pulses	No spring pulses	Spring pulse(s) up to 150 thousand acre-feet (TAF) if projected May 1 storage >4 million acre-feet (MAF).
Cold Water Pool Management	NMFS reasonable and prudent alternative (RPA) Action I.2.1-I.2.4: Shasta Temperature Management, water rights order 90-5 downstream temperature targets	Reclamation will address cold-water management utilizing a tiered strategy that allows for strategically selected temperature objectives, based on projected total storage and cold-water pool, meteorology, Delta conditions, and habitat suitability for incoming fish population size and location. This action component includes additional commitments and performance metrics.

Action Component	Current Operation	Proposed Action
Fall and Winter Refill and Redd Maintenance	Based on real-time operations. No explicitly proposed fall and winter refill and redd maintenance.	Reclamation will establish minimum winter and spring flows based on end of September storage in Shasta. Reclamation will consider the potential for dewatering redds with a risk analysis of the remaining winter-run Chinook salmon redds, the probability of sufficient cold water in a subsequent year, and conservative distribution and timing of subsequent winter-run Chinook salmon redds.
Operation with Shasta Dam Raise	No Dam Raise	Reclamation would not change operations described in the PA until the Shasta Dam Raise Record of Decision (ROD) and separate ESA consultations are completed.

Table 3. Proposed Conservation Measures for the Sacramento River

Conservation Measure	Description of Activity
Rice Decomposition Smoothing	Reclamation proposes to coordinate diversions to lower peak rice decomposition demand by lowering late October and early November flows. Early reductions (late October – early November) would balance the potential for dewatering of Chinook salmon redds, and stranding adults.
Spring Management of Spawning Locations	Reclamation will coordinate with NMFS as part of adaptive management to establish experiments to determine if providing colder water earlier induces earlier spawning, or if keeping April/May Sacramento River temperatures warmer induces later spawning, to refine the state of the science.
Temperature Modeling Platform	Reclamation will continue as part of a collaborative model development effort to develop a new temperature model for the Upper Sacramento River.
Shasta Temperature Control Device (TCD) Performance Evaluation	Reclamation will coordinate with NMFS to study whether there are problems or limitations with the function of the TCD under low storage conditions, and, if necessary, identify potential actions and/or modification for improving operational efficiency of the TCD.

Conservation Measure	Description of Activity
Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan	Reclamation will provide funding for an additional ten years towards reintroduction of winter-run Chinook salmon to Battle Creek and will accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project, which is intended to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries.
Lower Intakes near Wilkins Slough	Reclamation would provide grants to senior water right holders to install new diversions and screens that would operate at the lower flows, which may allow Reclamation to have greater flexibility in managing Sacramento River flows and temperatures
Spawning Habitat Restoration	Reclamation proposes to create additional spawning habitat by injecting approximately 15,000 – 40,000 tons of gravel annually into the Sacramento River to 2030, using the following sites: Keswick Dam
Rearing Habitat Restoration	Reclamation, in coordination with the Sacramento River Settlement Contractors proposes to create 40–60 acres of side channel and floodplain habitat at 10 sites in the Sacramento River by 2030.
Deer Creek Irrigation District (DCID) Dam Fish Passage	Reclamation will provide funding towards this fish passage project to construct a fishway downstream of the DCID's dam, providing spring-run Chinook salmon and Central Valley steelhead with unimpeded access to 25 miles of prime spawning habitat.
Small Screen Program	Reclamation and DWR propose to continue to work within existing authorities to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.
Knights Landing Outfall Gates	Reclamation will provide funding towards reconstruction of the Knights Landing Outfall Gates to reduce the potential for fish straying into the Colusa Basin Drain.
Winter-Run Conservation Hatchery Production (Tier 4 Intervention Measure)	Reclamation proposes to increase production of winter-run Chinook salmon. Increased production during drought could help populations continue over multiple years. Increased production would aim to offset temperature-dependent mortality on the Sacramento River.
Adult Rescue	Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds.

Conservation Measure	Description of Activity
Juvenile Trap and Haul (Tier 4 Intervention Measure)	Reclamation proposes implementation of a downstream trap and haul strategy for the capture and transport of juvenile salmonids in the Sacramento River watershed in drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream migration and survival.

Effects on Essential Fish Habitat in the Sacramento River

Chinook salmon EFH affected by the PA includes the Sacramento River from Keswick Dam to the Delta (301 miles). This stretch of the Sacramento River provides three general habitat functions essential to one or more life stages, including freshwater spawning and egg incubation, juvenile rearing, and juvenile and adult migration for Chinook salmon. The relative value of these habitats is based on the condition of the habitat itself and the functions that they provide. With regard to the PA, and where the specific action components are expected to cause a change in habitat conditions, the changes are identified based on flow, water temperature and the availability of spawning, rearing and migration habitats.

The Chinook salmon HAPCs that occur within the Sacramento River include complex channels and floodplains, thermal refugia, and spawning habitat. Based on the best available information, NMFS concludes that the following adverse effects on EFH designated for Chinook salmon are reasonably certain to occur:

Effect SR-1: Seasonal operations (Complex Channels and Floodplain Habitats, and Spawning Habitat HAPC)
Seasonal operation of Shasta and Keswick dams, as described by the PA, include controlling flow and water temperatures in the upper Sacramento River where all runs of Chinook salmon spawn. The seasonal flows modeled under the PA in the Sacramento River at Keswick Dam are very similar to the observed flows under current operations, which both show high summer and early fall flows with lower managed flows in the winter and spring. Current operations, and modeling of the PA from January to May have reduced discharges, while discharges in the remaining months are augmented or unchanged. Depending on the time of year, higher flows may negatively impact spawning and egg/alevin incubation. If flows are too high, they may result in depths and flow velocities in excess of suitable flows for constructing redds, and for redds that were previously built, which may be at risk of being scoured from the bed (NMFS 2017). In addition, adults may construct redds under high flow conditions and in areas that are later dewatered or isolated from the main river channel when the flows decline.

Likewise, low flow conditions during the late fall and winter in the spawning reaches of the upper Sacramento River, would have a number of negative effects on spawning, egg incubation, and alevins. As described by Windell et al. (2017), potential adverse effects of low flows on eggs and alevins include:

- An insufficient area of riverbed with suitable attributes to accommodate redds for all spawning-ready fall-run/late fall-run Chinook salmon adults.

- Inadequate flow velocities to flush sediments from the redds.

- Insufficient flow to maintain adequate levels of dissolved oxygen in contact with eggs and alevins in the redds and to flush metabolic wastes from the redd.

- Insufficient water depths for redds, such that minor reductions in flow result in redd stranding and dewatering.

Overall, NMFS considers the effects of seasonal operations on EFH as being both positive and negative. Seasonal operations where Reclamation builds storage enables Reclamation to make summer releases at a suitable temperature for winter-run Chinook salmon spawning and incubation. Conversely, reducing releases in the fall, winter, and spring can limit the available spawning and rearing habitat for fall-run and late fall-run Chinook salmon, negatively impacting EFH.

Effect SR-2: Spring pulses (Complex Channels and Floodplain Habitats, and Spawning Habitat HAPC)
Reclamation proposes to implement a spring pulse flow under certain hydrologic conditions to improve the survival of out-migrating juvenile salmonids, specifically CV spring-run Chinook salmon. In the PA, Reclamation assessed the volume of water in Shasta Reservoir that could be used to create a spring pulse flow while keeping storage above 4.0 MAF on May 1. Based on its analysis, a pulse flow (of 150 TAF) can be released in 53 percent of years. As proposed, a spring pulse flow occurring between March 1 and May 15 is expected to result in increased survival of juvenile salmonids by mimicking the natural hydrologic cues that trigger salmonid outmigration (Kjelson et al. 1981). Spring pulse flows would likely result in some increased turbidity, which would provide a level of cover from predators for outmigrating juveniles that may not occur without a spring pulse. NMFS considers this action component to provide a benefit to Chinook salmon EFH, as it would increase survival of outmigrating juveniles by improving the migration corridor function of the mainstem Sacramento River.

Effect SR-3: Cold Water Pool Management (Thermal Refugia, and Spawning Habitat HAPC)
The effects of temperature, associated with implementation of the tiered strategy are described according to the likelihood of Reclamation operating in a particular tier (based on the modeled May 1 storage). While this section describes the modeled likelihood of Reclamation operating to a particular "tier" of summer cold water pool management, unforeseen events (e.g., reduced solar radiation from cloud or smoke cover, unusual Delta salinity conditions) can result in a change in tier within a year. NMFS relies on the modeled characterization of May 1 storage and temperature management conditions. NMFS used the frequency of exposure to temperatures in the summer to characterize the following effects:

- Tier 1: CalSimII modeling of May 1 Shasta storage indicates that Tier 1 operations would apply to summer temperature management in approximately 68 percent of years. This is generally consistent with the frequency of Shasta storage greater than or equal to 4.1

MAF on May 1. HEC-5Q modeling of the proposed action indicates that during the temperature management season in Tier 1 years, the 53.5°F threshold at the CCR California Data Exchange Center gage is exceeded 23.3 percent of days from May 15 to October 31 (about 39 days total).

- Tier 2: CalSimII modeling of May 1 Shasta storage indicates that Tier 2 operations would apply to summer temperature management in approximately 17 percent of years. This is generally consistent with the frequency of Shasta cold-water pool greater than or equal to 2.3 MAF but less than 2.8 MAF on May 1. HEC-5Q modeling of the proposed action indicates that during the temperature management season in Tier 2 years, the 53.5°F threshold is exceeded 33.1 percent of days from May 15 to October 31 (about 56 days total).

- Tier 3: CalSimII modeling of May 1 Shasta storage indicates that Tier 3 operations would apply to summer temperature management in approximately 7 percent of years when cold water pool less than 2.3 MAF but total storage is above 2.5 MAF. HEC-5Q modeling of the proposed action indicates that during the temperature management season in Tier 3 years, the 53.5°F threshold is exceeded 65 percent of days from May 15 to October 31 (about 110 days total).

- Tier 4: CalSimII modeling of May 1 Shasta storage indicates that Tier 4 operations would apply to summer temperature management in approximately 7 percent of years. This is based on modeled May 1 Shasta storage less than or equal to 2.5 MAF. HEC-5Q modeling of the proposed action indicates that during the temperature management season in Tier 4 years, the 53.5°F threshold is exceeded 86 percent of days from May 15 to October 31 (about 145 days total).

NMFS acknowledges that the limited cold-water pool is maximized each year to ensure that suitable spawning and incubation conditions are available to endangered winter-run Chinook salmon in the upper Sacramento River May 15 – October 31. Relative to current operations, the PA and the Cold Water Pool Management action component would provide a benefit to winter-run Chinook salmon and Chinook salmon EFH generally during the time that Reclamation is able to provide suitable temperatures. However, the use of cold-water reserves for winter-run Chinook salmon through the summer would impact those Chinook salmon spawning later in the season in October and beyond, since the cold water is typically used up by the end of the temperature management season. Further, in all but Tier 1 years, Reclamation's proposed operation would target higher temperatures outside of the period identified as critical to egg development. The effect of the Cold Water Pool Management on Chinook salmon EFH is both positive and negative, where Reclamation is able to selectively improve access to spawning habitat and thermal refugia during the specific periods winter-run Chinook salmon spawning, but where other periods would be subject to reduced access and degraded thermal refugia.

Effect SR-4: Fall and Winter Refill and Redd Maintenance (Thermal Refugia, and Spawning Habitat HAPC)

Under the PA, Reclamation proposes to adjust fall flows based on Shasta Reservoir storage to avoid dewatering winter-run Chinook salmon redds and cold-water pool impacts. Higher flows

during the October – November period could increase the available spawning habitat that would benefit fall-run Chinook salmon redds. Currently, Reclamation lowers flows in the early fall period in order to conserve water for spring cold-water pool. This can result in dewatering fall-run Chinook salmon redds that were constructed at higher flows when Reclamation was keeping flows high to avoid dewatering winter-run Chinook salmon redds. Therefore, this action component could potentially benefit fall-run Chinook salmon in years where Reclamation ends the year with high storage in Shasta Reservoir. However, in years with low end of September storage, the prescribed low flows during the late fall and winter can have a negative effect on downstream migration of juvenile salmonids. A recent assessment of mark-recapture survival models in the mainstem Sacramento River revealed that of the numerous mortality factors considered, spanning multiple spatial scales, flow correlated most strongly with out-migration success (Iglesias et al. 2017). This assessment focused on hatchery-origin Chinook salmon, but it provides additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015).

Effect SR-5: Shasta Dam Raise
Reclamation would not change operations described in the PA until the Shasta Dam Raise ROD and separate ESA and EFH consultations are completed. In the interim, Reclamation would operate the enlarged reservoir consistent with the operations and requirements of the PA. Because this action component would not change operations until some later date, and after additional ESA and EFH consultation, NMFS considers the effect neutral for Chinook salmon EFH for this consultation.

Effect SR-6: Conservation Measure: Rice Decomposition Smoothing (Spawning Habitat HAPC)
As part of the Fall and Winter Refill and Redd Maintenance proposed action component, Reclamation would assess the water demands of the upstream CVP contractors and the Sacramento River Settlement Contractors to better coordinate water deliveries and minimize significant flow fluctuations. Typically, Sacramento Valley rice growers will flood their fields in the fall after the year's harvest to help dispose of crop residue (e.g. rice hulls and straw) which can otherwise impede seedbed preparation and contribute to disease and weed problems. The water required for rice decomposition can pose a sudden demand on the system, which in turn can cause significant fluctuation in river flow. Coordinated (i.e. smoothed) diversions in late October and early November could provide increased reliability that target flows would be met according to the Fall and Winter Refill and Redd Maintenance operations and that Reclamation would be able to build storage during this period. Because NMFS assumes that the minimum flows identified in the PA for this season would be achieved, this action component would, therefore, provide greater certainty that Reclamation would be able to reduce releases gradually to meet the base flows according to the Fall and Winter Refill and Redd Maintenance action component. Considering that this action component would contribute to stabilizing flows and increase the reliability of the Fall and Winter Refill and Redd Maintenance action component, the effects of the Rice Decomposition Smoothing are positive for Chinook salmon EFH.

Effect SR-7: Conservation Measure: Spring Management of Spawning Locations
NMFS supports research related to understanding how the timing of winter-run Chinook salmon spawning is affected by temperature and further consideration of results related to spring

temperature management. This action component, and the research that it would sponsor, could lead to an improved understanding regarding the influence of temperature on the spawning timing of winter-run Chinook salmon. While this action component may provide a future, benefit Pacific salmon species, for the purposes of this analysis it is considered neutral for Chinook salmon EFH.

Effect SR-8: Conservation Measure: Temperature Modeling Platform
The Temperature Modeling Platform action component that Reclamation is proposing to consider as a possible Cold Water Management Tool would advance a tool that could provide a more accurate characterization of reservoir temperature conditions and improve the ability to predict summer operations by providing a more accurate characterization of cold-water pool volume and reservoir temperature dynamics. However, the benefits of this measure are uncertain and those benefits will not be immediately realized, as the modeling is not available for implementation. For the purposes of this analysis, the Temperature Modeling Platform action component is considered neutral for Chinook salmon EFH.

Effect SR-9: Conservation Measure: Shasta Temperature TCD Performance Evaluation
The Shasta TCD Performance Evaluation is proposed to identify whether there are problems or limitations with the function of the device under low storage conditions. This evaluation could identify potential actions or modifications that would improve the operational efficiency of the device, improving cold-water storage management, which would similarly lead to increased species protections if modifications were identified and implemented. However, the benefits of this measure remain uncertain, as the evaluation may not identify any actions or modifications to take to improve performance. For the purposes of this analysis, the Shasta TCD Performance Evaluation action component is considered neutral for Chinook salmon EFH.

Effect SR-10: Conservation Measure: Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan (Thermal Refugia, and Spawning Habitat HAPC)
Reclamation is proposing to support and accelerate the implementation of the ongoing Battle Creek Salmon and Steelhead Restoration Project by providing up to $14,000,000 in funding for 10 years towards reintroduction of winter-run Chinook salmon to Battle Creek. The Battle Creek Salmon and Steelhead Restoration Project is intended to reestablish approximately 42 miles of prime Chinook salmon and steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. This action component has been supported with Federal, State and private funding, and as of 2019, implementation of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase one (of two). The first phase of construction for the project included removal of one fish passage barrier (a dam) and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase two of the project has completed planning, and is currently in design phase. Once complete, NMFS expects that this project will provide a direct benefit to Chinook salmon EFH by increasing access to the HAPCs of complex channels and floodplain habitats, spawning habitat and thermal refugia.

Effect SR-11: Conservation Measure: Lower Intakes near Wilkins Slough
Reclamation may consider providing grants to water users within the area of Wilkins Slough to install new diversions and screens that would operate at lower flows. As many of the fish screens at diversions in this region were not designed to operate at flows less than 5,000 cfs, they may

not function properly at the lower flows and, therefore, may not meet state and federal fish screening requirements. Poorly functioning screens could result in injury to, or death of Chinook salmon that use this section of the river as a migration corridor. However, because this action component does not include specificity in timing or defined actions, any benefits of this action were included in the analysis of effects in the NMFS Biological Opinion at the framework level. Given that the Lower Intakes near Wilkins Slough action component needs additional ESA consideration, as well as further commitment and collaborative planning to identify effects and quantify a level of benefits or incidental take, NMFS considers these effects too uncertain to determine an EFH effect. Therefore, for the purposes of this analysis, the Lower Intakes near Wilkins Slough action component is considered to be neutral for Chinook salmon EFH.

Effect SR-12: Conservation Measure: Spawning Habitat Restoration (Spawning Habitat HAPC)
Reclamation proposes to create additional spawning habitat by injecting 40 to 55 tons of gravel into the Sacramento River by 2030. There is some uncertainty regarding implementation of this action component, and although the construction-related effects of gravel supplementation have the potential to adversely affect EFH, once completed it is expected to provide a long-term benefit to EFH by increasing the quantity and quality of spawning substrate in the upper Sacramento River. This benefit is expected to affect adult fish in particular as they return to spawn because completed restoration activities would result in an increase in the availability of the Chinook salmon EFH spawning habitat HAPC.

Effect SR-13: Conservation Measure: Rearing Habitat Restoration (Complex Channels and Floodplain Habitats HAPC)
Reclamation and the Sacramento River Settlement Contractors propose to create 40–60 acres of side channel habitat in the upper and middle Sacramento River. There is some uncertainty regarding implementation of this action component, and although the construction-related effects could adversely affect EFH, once completed it is expected to have a long-term benefit to EFH by increasing the increasing the quantity and access to quality side channel rearing habitat in the upper and middle Sacramento River. This benefit is expected to affect rearing and migrating juvenile fish in particular because completed restoration activities would result in an increase in the availability of the Chinook salmon EFH complex channels and floodplain habitats HAPC.

Effect SR-14: Conservation Measure: Deer Creek Irrigation District (DCID) Dam Fish Passage (Complex Channels and Floodplain Habitats, Thermal Refugia, and Spawning Habitat HAPC)
Reclamation is proposing to contribute an additional $1,000,000 in funding to the DCID Dam Fish Passage Project. The DCID Dam is the uppermost dam on Deer Creek. The action component involves constructing a nature-like fishway downstream of the dam to provide salmonids unimpeded access to over 25 miles of prime spawning habitat upstream of the DCID diversion dam. Improving fish passage at this site will improve anadromous fish access to spawning, rearing and holding stream habitat upstream of the project site through the roughened rock ramp, and will improve anadromous fish passage, downstream of the project sites through fish screen and bypass pipe modifications. This action component is a high priority recovery action in the NMFS recovery plan (NMFS 2014) and supports the objectives of the Central Valley Project Improvement Act's (CVPIA) Anadromous Fish Restoration Program Final Restoration Plan. It also complements other ongoing efforts to improve important aquatic habitats for the benefit of naturally producing anadromous salmonids in the Central Valley.

Although the construction-related effects could adversely affect EFH, once complete, this action component would result in an increase in access to the Chinook salmon EFH spawning habitat, thermal refugia and the complex channels and floodplain habitats HAPCs.

Effect SR-15: Conservation Measure: Small Screen Program
Although there is some uncertainty regarding implementation of projects covered as part of the Small Screen Program, once completed it would provide a benefit to EFH by improving the function of existing fish screens or installing new fish screens in the Sacramento River. This action component is expected to provide a continuing benefit to rearing and migrating juvenile fish because completed screening projects have reduced the potential for lethal entrainment and impingement. As it relates to Chinook salmon EFH, this action component could continue to contribute to increasing migration success of juvenile salmon by increasing the function of the mainstem Sacramento River as a migration corridor.

Effect SR-16: Conservation Measure: Knights Landing Outfall Gates
Reclamation is proposing to contribute $680,250 in funding to the Knights Landing Outfall Gates Reconstruction Project. After a 2016 operational failure at the Knights Landing Outfall Gates led to the collapse of the fish barrier, Reclamation District 108 began planning to reconstruct the Knights Landing Outfall Gates fish barrier to limit the potential for adult salmonids to stray into the Colusa Basin Drain. Funding will be used to reconstruct the fish barrier hoist system and electric controls. Once complete, adult Chinook salmon will not be able to enter the Colusa Basin Drain through the Knights Landing Outfall Gates. The effect of this action component remains uncertain as a number of project details have yet to be determined. However, as it pertains to Chinook salmon EFH, this action component could contribute to the migration success of returning adult Chinook salmon by limiting the potential for straying into the Colusa Basin Drain and thereby increasing the function of the mainstem Sacramento as a migration corridor.

Effect SR-17: Tier 4 Intervention Measure: Winter-Run Conservation Hatchery Production
In a Tier 4 year, Reclamation proposes to increase production of winter-run Chinook salmon at the Livingston Stone National Fish Hatchery. The effects of increased hatchery production will depend on complex interactions between hatchery and natural-origin fish and their environment. The short-term benefit of expanded Livingston Stone National Fish Hatchery production is that it would provide alternative (artificial) rearing and spawning habitat when the in-river environmental conditions are not suitable for egg-fry life stages. Because this proposed action component is only proposed for Tier 4 years, the intent is for it to offset, in part, the effects of a significantly dry hydrology and poor environmental conditions. Although this action component would provide a surrogate habitat during periods of drought to benefit winter-run Chinook salmon and Pacific salmon in general, the long-term effects are more uncertain and, as such, NMFS considers the action component to be neutral for Chinook salmon EFH.

Effect SR-18: Conservation Measure: Adult Rescue
Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds. Although there is some uncertainty regarding implementation of this action

component, NMFS expects that it would provide a short-term benefit to returning adult Chinook salmon by improving migration success. Regardless of any short-term benefit, this action does not address the root problem in the function of the Sacramento River as a migration corridor. Given that there is no direct effect on Pacific salmon EFH, for the purposes of this analysis the adult salmonids and sturgeon trap and haul action component of the PA is considered to be neutral for Chinook salmon EFH.

Effect SR-19: Tier 4 Intervention Measure: Juvenile Trap and Haul
In a Tier 4 year, Reclamation proposes to implement a downstream trap and haul strategy for the capture and transport of juvenile Chinook salmon and steelhead in the Sacramento River watershed. Although there is uncertainty regarding implementation of this action component, NMFS expects that it could provide a short-term benefit to migrating juvenile Chinook salmon by improving migration success. However, regardless of any short-term benefit, this action does not have a direct effect on Pacific salmon EFH and for the purposes of this analysis; the Juvenile Trap and Haul action component of the PA is considered neutral for Chinook salmon EFH.

Essential Fish Habitat Conservation Recommendations for the Sacramento River

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Chinook salmon. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effect SR-1, SR-2, SR-3, SR-4, SR-10, and SR-13:*

For Effect SR-1: Seasonal operations
NMFS has determined that Reclamation's seasonal operations in the Sacramento River basin result in both beneficial and adverse effects to Chinook salmon EFH. To address the potential adverse EFH effects related to seasonal operations, Reclamation should operate facilities to maintain flow conditions adequate enough to provide for passage, water quality, minimize juvenile stranding and redd dewatering, and maintain and restore properly functioning channel, floodplain, riparian, and estuarine conditions.

For Effect SR-2: Spring pulses
NMFS considers the effect of the Spring Pulses action component to have a beneficial effect on Chinook salmon EFH. There is, however, some uncertainty ascribed to this benefit and as such, Reclamation should develop a monitoring plan in coordination with the relevant resource agencies [e.g. NMFS, USFWS, California Department of Fish and Wildlife (CDFW), etc.] to assess the effectiveness of a spring pulse in increasing juvenile migration success, when one is implemented. In addition, on an annual basis, Reclamation should disclose the steps taken in consideration of whether or not to implement a spring pulses action component.

Related to effect SR-2, NMFS also recommends the inclusion, by reference, of Term and Condition (T&C) 1.b from the Biological Opinion as a conservation recommendation that Reclamation shall not implement the spring pulse releases if they would cause Reclamation to drop into a lower tier of the Shasta summer temperature management.

For Effect SR-3: Cold Water Pool Management
To address adverse effects to Chinook salmon EFH related to the Cold Water Pool Management action component, Reclamation in coordination with the Sacramento River Temperature Task

Group, should consider moving the temperature target downstream in September and October to protect fall- and late fall-run Chinook salmon spawning and incubation, if this would not interfere with Reclamation's ability to meet winter-run Chinook salmon performance measures associated with temperature related mortality and egg-to-fry survival. Reclamation should work with the Sacramento River Temperature Task Group (SRTTG) to develop temperature management strategies that protect spawning and egg development of spring-run, fall-run, and late fall-run Chinook salmon.

For Effect SR-4: Fall and Winter Refill and Redd Maintenance:
To address Chinook salmon EFH effects related to the Fall and Winter Refill and Redd Maintenance action component Reclamation should establish a process through the SRTTG to consider real-time operations to manage flow and reservoir releases in the Upper Sacramento River that dissuade fall-run Chinook salmon spawning in high flow channel margins as a way to reduce the potential for redd dewatering.

For Effect SR-10: Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan (Conservation Measure):
Although NMFS considers the effect of the Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan action component to have a beneficial effect on Chinook salmon EFH, NMFS recommends the inclusion, by reference, of T&C 1.f from the Biological Opinion as a conservation recommendation.

For Effect SR-13: Rearing Habitat Restoration (Conservation Measure):

a) NMFS considers the effect of the Rearing Habitat Restoration action component to have a beneficial effect on Chinook salmon EFH. However, there are a number of side channels in the upper Sacramento River where juvenile stranding is a problem as flows recede. Therefore, NMFS recommends that Reclamation consider prioritizing and designing side-channel restoration actions that reduce the amount and extent of juvenile stranding.

b) NMFS recommends the inclusion, by reference, of T&C 1.g from the Biological Opinion to increase access to the Complex Channels and Floodplains HAPC of Chinook salmon EFH.

c) For the construction effects associated with implementation of the conservation measures noted, NMFS recommends utilizing best management practices (BMPs) for Sacramento River habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable, follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

Clear Creek

Clear Creek, originating in the Trinity Mountains, is a tributary to the Sacramento River downstream of Keswick Dam. Whiskeytown Reservoir is a hydrologic barrier between Upper and Lower Clear Creek. Lower Clear Creek provides spawning habitat for Chinook salmon, including spring-run, fall-run, late-fall-run, and occasionally winter-run Chinook salmon. Clear Creek also provides complex channel and floodplain habitat as well as thermal refugia.

The PA components for Clear Creek include new flow schedules and similar temperature management (Table 4); as well as continuing channel maintenance under the Clear Creek Restoration Program (Table 5).

Reclamation proposes to release Clear Creek flows in accordance with the 1960 Memorandum of Agreement (MOA) with CDFW, and the April 15, 2002 SWRCB permit, which established minimum flows to be released to Clear Creek at Whiskeytown Dam. Reclamation proposes a minimum base flow in Clear Creek of 150 cubic foot per second (cfs) from June through September, and 200 cfs from October through May in all year types, except Critical years. During Critical water year types, flows may be reduced based on available water from Trinity Reservoir.

Reclamation proposes to continue to manage Whiskeytown Dam releases to meet a daily average water temperature of 60°F from June 1 through September 14, and 56°F or less from September 15 to October 31 at the Igo stream gauging station on Clear Creek. During Critical water years, Reclamation will operate to as close to these temperatures as possible, but acknowledges temperature criteria may not be met.

In addition, Reclamation proposes to create pulse flows for both spring attraction and channel maintenance. For spring attraction flows, Reclamation would release 10 TAF from Whiskeytown Dam in all year-types except for Critical year types. For channel maintenance flows, Reclamation would release 10 TAF from Whiskeytown Dam, in all year types except for Dry and Critical year types. A more detailed explanation of the PA can be found in Chapter 4 of the ROC on LTO BA.

Table 4. Comparison of Action Components between the Current Operation and Proposed Action for Clear Creek.

Action Component	Current Action	Proposed Action
Base flows	Base flow of 50-100 cfs based on 1960 CDFW MOA	Base flow of 200 cfs October 1 through May 31, 150 cfs from June to September in all except Critical water years. In Critical water years, base flows may be reduced below 150 cfs based on the available water from Trinity Reservoir.
Channel maintenance flows	Channel maintenance flows when flood operations occur. Whiskeytown Glory Hole spills	10 TAF to create channel maintenance flows, with a daily release up to the safe release capacity (approximately 900 cfs,

Action Component	Current Action	Proposed Action
	during the winter and spring to produce channel maintenance flows of a minimum of 3,250 cfs mean daily spill from Whiskeytown for one day, to occur seven times in a 10-year period.	depending on reservoir elevation and downstream capacity), unless flood control operations provide similar releases, in all but Dry and Critical water years. The frequency, duration, and timing would be developed by the Clear Creek Implementation Technical Team. In Dry and Critical water year types when channel maintenance pulse flows would not occur, Reclamation proposes to use mechanical methods to mobilize gravel or shape the channel, if needed, to meet biological objectives.
Pulse flows	Two pulse flows in Clear Creek in May and June of at least 600 cfs for at least 3 days for each pulse per year.	10 TAF to create spring attraction pulse flows, with a daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity). Pulse flows would occur in all water year types, but restricted to a 3-day single event in Critical water year types. The frequency, duration, and timing would be developed by the Clear Creek Implementation Technical Team.
Temperature management	Daily water temperature of: (1) 60°F at Igo gage from June 1 through September 15; and (2) 56°F at the Igo gage from September 15 to October 31.	Daily water temperature (1) 60°F at the Igo gage from June 1 through September 15; and (2) 56°F at the Igo from September 15 to October 31; operate as close as possible to these targets in Dry and Critical water year types. Reclamation proposes to increase minimum base flows when needed to meet criteria.

Table 5. Proposed Conservation Measures for Clear Creek

Conservation Measures	Description of Activity
Enhance spawning and rearing habitat	Reclamation and DWR propose to continue channel maintenance under the Clear Creek Restoration Program.

Effects on Essential Fish Habitat for Clear Creek:

Chinook salmon EFH impacted by the PA includes Lower Clear Creek from below Whiskeytown Dam to the confluence with the Sacramento River. The Chinook salmon HAPCs that occur within Clear Creek include complex channels and floodplains, thermal refugia, and

spawning habitat. Based on the best available information, NMFS concludes that the PA would adversely affect EFH for Chinook salmon in Clear Creek. We conclude that the following adverse effects on EFH designated for Chinook salmon are reasonably certain to occur:

Effect CC-1(Complex Channels and Floodplains HAPC):
The operation of Whiskeytown Dam contributes to the decrease in magnitude and frequency of flood flows and decreases the downstream movement of sediment and large woody debris. Those effects are expected to continue under the PA, with the decreases in the magnitude and frequency of flood flows largely being attributed to proposed operations. The reductions in sediment and large woody debris recruitment limits the natural creation of complex channels and floodplain habitats important for spawning and rearing by trapping sediment, nutrients, and organic matter, creating pools, sorting gravels, and providing cover for salmon (Appendix A to the Pacific Coast salmon FMP). The hydrologic effects of PA operations are expected to result in geomorphic responses including the deposition of fine sediments in gravel; channel stabilization and narrowing; reduced channel complexity such as the formation of point bars, secondary channels, oxbows, and changes in channel planform; downstream channel erosion; bed armoring; and reduced floodplain connection (Poff et al. 1997). All of these responses adversely affect the complex channels and floodplains HAPC.

Due to proposed channel maintenance pulse flows, the adverse effects on the complex channels and floodplain habitats HAPC will be reduced over time due to enhancements of riparian floodplain habitat. Channel maintenance pulse flows are also likely to improve salmon spawning habitat by mobilizing and dispersing gravel, and reducing fine sediment.

Effect CC-2 (Thermal Refugia HAPC):
The thermal refugia HAPC provides areas to escape high water temperatures, and are critical to Chinook salmon survival. These areas include cool water tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling and other areas that are cooler than surrounding waters. They can occur at spatial scales ranging from entire tributaries to highly localized pockets of water embedded within larger rivers (Appendix A to the Pacific Coast Salmon FMP).

Reservoir operations are expected to affect thermal refugia in Clear Creek downstream of Whiskeytown Dam. Controlled reservoir releases prevent large flood events and other natural flows that would inundate floodplain habitat, recharge groundwater, and would aid in maintaining cooler water temperatures. The PA will continue water temperature management currently in place, which includes summer water temperature management (≤60°F at Igo from June 1 to September 14) and fall water temperature management period (≤56°F at Igo from September 15 to October 31). Daily average water temperatures generally remain below 60°F at Igo during the summer temperature management period. However, fall water temperatures have exceeded 56°F during the spawning period in most years. Also, the 56°F daily average water temperature has recently been determined to be suboptimal, and would likely lead to mortality of incubating eggs and reduced survival (Myrick and Cech 2004). NMFS expects the 56°F criterion to continue to be exceeded under the PA. (refer to section 8.4.4.1.1 of the ROC on LTO Biological Opinion for more details). Therefore, although the PA will continue water

temperature management releases, access to the thermal refugia HAPC for Chinook salmon in Clear Creek will continue to be limited by controlled reservoir releases.

Effect CC-3 (Spawning Habitat HAPC):
Spawning habitat typically consists of low gradient stream reaches, containing clean gravel with low levels of fine sediment and high intergravel flow. The natural recruitment of spawning habitat substrate has been impacted by Whiskeytown Dam. The PA includes low and high flow channel releases. Based on redd timing, fall-run and late-fall-run Chinook salmon eggs and emerging fry would be exposed to the effects of these flows, which could displace incubating eggs from redds, resulting in exposure to predation, abrasion, and increased water temperature if transported out of suitable habitat. Proposed channel maintenance and spring attraction flows under the PA (up to approximately 900 cfs) represent approximately 30% of the flow needed to transport sediment in the absence of flows from downstream tributaries. As a result, effects of these flows are expected to be of low magnitude and occur with low frequency.

During Critical years, mechanical methods may be used to mobilize gravel or shape the channel if needed to meet biological objectives. The construction work of mechanically moving channel substrate has the potential to adversely affect the spawning habitat HAPC for Chinook salmon, but in the long-term is expected to provide benefits.

The PA does not continue the conservation measures that add spawning substrate to Clear Creek.

For more details on the effects analysis of salmonid critical habitat in the Trinity River division, refer to section 9.2.1 (particularly Table 135) of the NMFS ROC on LTO Biological Opinion.

Essential Fish Habitat Conservation Recommendations

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Chinook salmon in Clear Creek. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effect CC-1, CC-2, and CC-3:*

For Effect CC-1 listed above,
NMFS recommends that Reclamation manage releases from Whiskeytown Dam with instream flow schedules and criteria to provide suitable water flows for all life stages, reduce stranding and isolation, protect incubating eggs from being dewatered, and promote habitat quality and availability assess whether Clear Creek flows should be further adapted to reduce adverse impacts on Chinook salmon. Providing adequate flows for migration and maintenance of spawning gravels and suitable water temperatures will increase the likelihood that Chinook salmon populations persist.

For *Effect CC-2* listed above:
NMFS recommends Reclamation consider the Clear Creek system in the proposed temperature modeling platform for the Sacramento River, as identified in T&C 2.b of the ROC on LTO biological opinion, including Whiskeytown Reservoir, to improve fall water temperature management closer to optimum water temperatures for all life stages of Chinook salmon in Clear Creek.

For *Effect CC-3* listed above:

a) NMFS recommends Reclamation develop a new spawning gravel budget and implement a long-term gravel augmentation plan in Clear Creek, including acquisition of a long-term gravel supply. Gravel augmentation would help address reductions in sediment transport caused by the PA. NMFS also recommends that Reclamation identify and implement projects to restore the creek channel closer to natural conditions. Studies have shown that CV spring-run Chinook salmon utilize gravel injection sites for spawning. This would also benefit fall-run and late fall-run Chinook salmon spawning habitat.

b) For the construction effects associated with implementation of the conservation measures noted, NMFS recommends utilizing BMPs for Clear Creek habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable, follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

American River

Reclamation operates the American River Division for flood control, municipal and industrial, and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Facilities include the Folsom Dam, reservoir (977 TAF capacity), power plant, urban water supply TCD, and the Joint Federal Project auxiliary spillway as well as the Nimbus Dam, Lake Natoma, Nimbus Power Plant, and Folsom South Canal. Folsom Reservoir is the largest storage and flood control reservoir on the American River.

Reclamation proposes to meet water rights, contracts and agreements that are both specific to the American River Division as well as those that apply to the entire CVP, including the Delta Division. For lower American River flows (below Nimbus Dam), Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017 (2017 Flow Management Standard). Flows range from 500 to 2,000 cfs based on time of year and annual hydrology. Reclamation proposes to work together with the American River stakeholders to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum").
The PA for the American River includes the 2017 Flow Management Standard; as well as conservation measures, to mitigate and offset potential negative effects (Table 6 and Table 7). A more detailed description of the PA can be found in Chapter 4 of the final BA.

Table 6. Comparison of Action Components between the Current Operation and the Proposed Action for the American River.

Action Component	Current Action	Proposed Action
Seasonal Operations	2006 Flow Management Standard	2017 Flow Management Standard: Flows range from 500 to 2,000 cfs based on time of year and annual hydrology, and "planning minimum". Under the 2017 Flow Management Standard, the proposed action includes a spring pulse flow event under certain conditions when the water has been made available from non-CVP sources or no such flow event has occurred already in the spring. This spring pulse flow provides a juvenile salmonid emigration cue before relatively low water flow and associated unsuitable thermal conditions later in the spring, and downstream in the lower Sacramento River.
Cold Water Pool Management	Daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31. 56°F temperature target November 1 through December 31.	May 15 through October 31 daily average water temperature of 65°F (or target temperature determined by temperature model) or lower at Watt Avenue Bridge. When the target temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. November 1 through December 31 daily average water temperature of 56°F target if cold-water pool allows. A temperature higher than 56°F may be targeted based on temperature modeling results.

Table 7. Proposed Conservation Measures for the American River

Conservation Measures	Description of Activity
Spawning and Rearing Habitat Restoration	Pursuant to CVPIA 3406(b) (13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar—North, El Manto, Sacramento Bar—South, Lower Sunrise, Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction.
Spawning and Rearing Habitat Restoration	Reclamation proposes to continue maintenance activities at Nimbus Basin, Upper Sailor Bar, and River Bend restoration sites.
Temperature Management Study	In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility as part of adaptive management.
Hatchery and Genetic Management Plans (HGMPs)	Reclamation will complete HGMPs for CV steelhead and fall-run Chinook salmon for use in Nimbus Fish Hatchery management.

Effects on Essential Fish Habitat for American River:

Chinook salmon EFH impacted by the PA includes the America River from below the Folsom and Nimbus Dam complex to the confluence with the Sacramento River. The Chinook salmon HAPCs that occur within the American River include complex channels and floodplains, thermal refugia, and spawning habitat. Based on the best available information, NMFS concludes that the PA would adversely affect EFH for Chinook salmon in the American River. We conclude that the following adverse effects on EFH designated for Chinook salmon are reasonably certain to occur.

Effect AR-1 (Complex Channels and Floodplains HAPC):
The current operations of the Folsom and Nimbus dam complex contribute to a decrease in the magnitude and frequency of flood flows and decrease the downstream movement of sediment and large woody debris. The reductions in sediment and large woody debris recruitment is also largely a result from the existence of Folsom and Nimbus dams, which are part of the environmental baseline. Those effects are expected to continue under the PA, with proposed operations.

Specifically, PA operations are expected to decrease the magnitude and frequency of flood flows, thereby reducing the downstream movement of sediment and large woody debris that come along with the floodwaters. Additionally, the PA does not include run-of-the-river operations that would allow sediment and large woody debris to move downstream more freely than the proposed reservoir system operations. The hydrologic effects of PA operations are expected to result in geomorphic responses including the deposition of fine sediments in gravel; channel stabilization and narrowing; reduced channel complexity such as the formation of point bars, secondary channels, oxbows, and changes in channel planform; downstream channel erosion; bed armoring; and reduced floodplain connection (Poff et al. 1997). All of these responses adversely affect the complex channels and floodplains HAPC.

The proposed spawning and rearing habitat restoration is expected to somewhat offset reductions to channel and floodplain complexity related to PA implementation. The proposed gravel and large wood augmentation will help address reductions in channel complexity caused by the PA.

Effect AR-2 (Thermal Refugia HAPC):
The presence of and role that thermal refugia may play in the quantity and quality of Chinook salmon habitat in the lower American River is not well understood. Thermal refugia typically include cool water tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling, and other mainstem river habitats that are cooler than surrounding waters (≥3.6° C cooler). Among those habitats, the lower American River includes side channels and deep pools, but it is unclear if they act as thermal refugia. Given the evidence that lower American River water temperatures are stressful for adult Chinook salmon, it seems likely that thermal refugia are lacking. The specific effect that the PA will have on thermal refugia is not clear, but stressful water temperatures for adult Chinook salmon in the American River are expected to continue under the PA.

Fall-run Chinook salmon experience egg retention or pre-spawning mortality in the American River in most years when water temperatures in the fall migration and staging period are sub-optimal. During 1993 to 2017, the proportion of unspawned adults ranged from 3% to 67% and averaged 20% and the proportion that retained some eggs (greater than 30% egg retention) ranged from 6% to 80% with an average of 33% (ROC on LTO BA). The American River has the highest level of pre-spawning mortality for fall-run/late fall-run Chinook salmon measured for any river in the Central Valley. To help address this impact to fall-run Chinook salmon adults and EFH, the 2017 Flow Management Standard (FMS) under the PA includes an objective to provide water temperatures of 60°F or less by October 1 to provide suitable conditions for fall-run Chinook salmon staging and early spawning. This water temperature objective will likely be difficult to achieve in October under the PA given the inability to meet it under past operations of the American River Division when this same water temperature objective was in place, and considering that the modeling results presented in the ROC on LTO BA suggest the objective will never be obtained under the PA during October. The water temperature modeling results presented in the ROC on LTO BA indicate that the long-term average water temperature at Watt Avenue is 64.1°F, and even during wet years, when water temperatures are at their coolest, the water temperature is 62.5°F. Providing suitable water temperatures in the lower American during October for adult Chinook salmon has historically been a management challenge and that is expected to continue under the PA.

Effect AR-3 (Spawning Habitat HAPC):
Spawning habitat consists of the combination of several components including, but not limited to, gravel, depth, flow, temperature, and dissolved oxygen. Among those components, water temperature is the one that the PA will have the greatest impact on EFH for Chinook salmon. The PA is expected to result in stressful, lethal water temperatures for Chinook salmon spawning and embryo incubation during October and November in the lower American River. Chinook salmon egg mortality increases as water temperatures warm above 53.5° F (Martin et al. 2016). The lower American River is rarely, if ever, cooler than 53.5° F at Watt Avenue during October and November. Most years water temperatures at Watt Avenue are above 60° F well into October. The combination of egg retention, pre-spawning mortality (discussed in Thermal Refugia), and embryo mortality from warm water temperatures in the lower American River likely greatly impacts Chinook salmon production. Poor quality spawning habitat is expected to occur under the PA because, despite best efforts to protect Chinook salmon spawning, water temperatures in October and November are stressful and lethal every year; and the modeling results presented in the ROC on LTO BA (Appendix D, Table 16-2) suggest that will continue.

Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in the 2017 FMS as part of the PA. The 2017 FMS includes a Minimum Release Requirement (MRR) with flows that range from 500 to 2,000 cfs based on time of year and annual hydrology. The objective of the planned minimum is to preserve storage to protect against future drought conditions and to facilitate the development of the cold-water pool when possible and improve habitat conditions for steelhead and fall-run Chinook salmon in the lower American River. Given this objective, there is some hope that the PA will provide less detrimental spawning and embryo incubation habitat.

In addition to water temperature, the PA is expected to impact salmon spawning habitat due to flow fluctuations resulting in redd dewatering. Fall-run Chinook salmon eggs and alevins in the American River are vulnerable to dewatering from the time when spawning begins in October through February when fry emergence from the streambed ends (Vogel and Marine 1991, Bratovich et al. 2005). Redd dewatering protective adjustments were included in the 2017 FMS to limit potential redd dewatering due to reductions in the MRR.

Essential Fish Habitat Conservation Recommendations for American River:

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Chinook salmon in the American River. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effect AR-1 listed above:*

a) NMFS recommends that Reclamation develop a gravel budget or utilize an existing and still applicable gravel budget to augment gravel in accordance with that budget.
b) For the construction effects associated with implementation of the conservation measures noted, NMFS recommends utilizing BMPs for American River habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable,

follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

Stanislaus River

The PA for the Stanislaus River is summarized in Table 8 and Table 9. Reclamation proposes to meet water rights, contracts, and agreements that are specific to the East Side Division and Stanislaus River. Senior water right holders (Oakdale Irrigation District and South San Joaquin Irrigation District will receive annual water deliveries consistent with the 1988 Agreement and Stipulation, and water will be made available to CVP contractors in accordance with their contracts and applicable shortage provisions. In high storage, high inflow conditions, Reclamation will operate for flood control in accordance with the U.S. Army Corps of Engineers (Corps) flood control manual. Because New Melones is a large reservoir relative to its annual inflow, flood control is relatively infrequent; however, Tulloch Lake, located downstream of New Melones Reservoir, is subject to high local inflows, and may be in flood control operations for brief periods when New Melones Reservoir is not. During these periods, releases from Tulloch Lake may be used to meet flow objectives, schedules, or requirements on the lower Stanislaus River below Goodwin Dam.

Conservation measures have been included in the PA. For the Stanislaus River, they include spawning habitat restoration: under the CVPIA (b) (13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River. Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030. Reclamation will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir.

Table 8. Comparison of Action Components between the Current Operation and Proposed Action for the Stanislaus River.

Action Component	Current Action	Proposed Action
Seasonal Operations	Releases for water rights, contracts, reservoir and flood management, other agreements	Similar *(action components described below may cause some changes to, e.g. the volume and timing of reservoir management releases in some years)*
Minimum flow schedule	Appendix 2-E flows from NMFS RPA III.1.3	Stepped release plan, and change in water year type classification
Dissolved Oxygen	Basin plan requirement of 7.0 milligram per liter (mg/L) at Ripon, year-round	Shift in compliance location of 7.0 mg/L to Orange Blossom Bridge from June 1 to September 30.

Table 9. Proposed Conservation Measures for the Stanislaus River.

Conservation Measure	Description of Activity
Spawning and Rearing Habitat Restoration	Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River. In addition, Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030.
Temperature Management Study	Reclamation will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir.

Effects on Essential Fish Habitat for Stanislaus River:

Chinook salmon EFH impacted by the PA includes the Stanislaus River from below Goodwin Dam to the confluence with the San Joaquin River. HAPCs that occur within the Stanislaus River include complex channels and floodplains, thermal refugia, and spawning habitat. Based on the best available information, NMFS concludes that the PA would adversely affect EFH for Chinook salmon in the Stanislaus River. We conclude that the following adverse effects on EFH designated for Chinook salmon are reasonably certain to occur:

Effect STAN-1 (Complex Channels and Floodplains HAPC):
The creation of complex channels and inundation of floodplain habitats that support rearing and migration will be reduced. Water management for flood reduction and water supply will continue to disrupt natural processes that form complex channels and inundate floodplain habitats. Due to the conservation measures included in the PA, the adverse effects on complex channels and floodplain habitat will be reduced over time due to enhancements of riparian floodplain habitat. Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030. The construction work to enhance riparian floodplain habitat has the potential to adversely affect EFH for Chinook salmon, but in the long-term is expected to provide benefits.

Effect STAN-2 (Thermal Refugia HAPC):
Reservoir operations are expected to affect thermal conditions in the Stanislaus River downstream of New Melones, and temperatures will sometimes be unsuitable for salmonid lifestages. See analysis of PA effects on water temperatures in Section 8.7.1 (particularly Table 120) of the NMFS ROC on LTO Biological Opinion (NMFS 2019). As a conservation measure in the Biological Opinion, Reclamation proposes approaches to improving temperature for listed species on the lower Stanislaus River, which include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir. This provides some benefit to EFH for Chinook salmon.

Effect STAN-3 (Spawning Habitat HAPC):
Recruitment of spawning habitat substrate has been impacted by the operation of New Melones Dam, and will continue to be impacted by the PA. The PA also includes conservation measures that will add spawning substrate to the Stanislaus River. The construction work of gravel supplementation has the potential to adversely affect EFH for Chinook salmon, but in the long-term is expected to provide benefits.

Essential Fish Habitat Conservation Recommendations for the Stanislaus River:

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Chinook salmon in the Stanislaus River. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effects STAN-1, STAN-2,* and *STAN-3*:

For *Effect STAN-1* listed above:
In addition to Reclamation's commitment to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030, NMFS recommends that Reclamation seek to increase opportunities (through easements or other approaches to alleviate concerns related to seepage) to release flows over 1,500 cfs for more than 10 consecutive days, even when not in reservoir or flood management. This would allow extended inundation of higher-level areas at current and future restoration sites; and improve food production and rearing and migratory habitat in the river and provide the Stanislaus Watershed Team more flexibility to shape water volumes in a manner most beneficial to Chinook salmon EFH.

For *Effect STAN-2* listed above:
NMFS recommends that resources (user-friendly temperature modeling tool or modeler time) be provided so that information on Stanislaus River water temperatures from Goodwin to the confluence with the San Joaquin River be modeled and provided to the Stanislaus Watershed Team on a monthly basis for consideration in the shaping and timing of flows in the Stepped Release Plan.

NMFS notes that restoration efforts that increase food production can help mitigate temperature effects since higher food supply can help to offset thermal stress.

For *Effect STAN-3* listed above:

a) In addition to Reclamation's annual goal of 4,500 tons of gravel placement in the Stanislaus River, NMFS recommends that Reclamation direct necessary resources to sediment modeling and other information support necessary to gain support for gravel augmentation from the Corps.
b) Reclamation should pursue additional gravel augmentation to address historical deficits, since the CVPIA gravel augmentation target has not been satisfied in every year. For example, since 2009, annual gravel placement has averaged less than 3,000 tons per year [See Table 2-2[1] in Stanislaus Operations Group (SOG) 2019].

[1] Table 2-2 in SOG 2019 reports that average gravel placement from 2009 through 2019 has been less than 2,000 cubic yards, which is equivalent to less than 3,000 tons, assuming approximately 1.5 tons per cubic yard.

c) Reclamation should provide minimum flows of at least 300 cfs in November and December for fall-run Chinook salmon spawning, even if above and beyond the minimum flows of the Stepped Release Plan.

For *Effect STAN-1* and *Effect STAN-3* listed above:
For the construction effects associated with implementation of the conservation measures noted, NMFS recommends utilizing BMPs for Stanislaus River habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable, follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

San Joaquin River

The analysis in this section, and references to "San Joaquin River," are limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale. The PA for the San Joaquin River (relevant to Chinook salmon) is summarized in Table 10 and Table 11.

Table 10. Comparison of Action Components between the Current Operation and Proposed Action for the San Joaquin River. The flow and dissolved oxygen components are specific to operations on the Stanislaus River but those operations can affect conditions on the mainstem San Joaquin River.

Action Component	Current Action	Proposed Action
Operations	-Appendix 2-E flows from NMFS RPA III.1.3 -Dissolved oxygen requirement at Ripon -Baseline boundary flows, accretions and depletions	-Stepped release plan (and associated change in year type classification) -Alteration of Stanislaus dissolved oxygen requirement -Baseline boundary flows, accretions and depletions.

Table 11. Proposed Conservation Measure for the San Joaquin River

Conservation Measure	Description of Activity
Lower San Joaquin Rearing Habitat	Reclamation may work with private landowners to create a bottom-up, locally driven regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River.

Effects on Essential Fish Habitat for the San Joaquin River

Chinook salmon EFH impacted by the PA includes the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale. HAPCs that occur within this reach of the San Joaquin River include complex channels and floodplains, and thermal refugia. Based on the best available information, NMFS concludes that operations under the PA would adversely affect EFH for Chinook salmon in this reach of the San Joaquin River. We conclude that the following adverse effects on EFH designated for Chinook salmon are reasonably certain to occur:

Effect SJ-1 (Complex Channels and Floodplains HAPC):
The creation of complex channels and inundation of floodplain habitats that support rearing and migration will continue to be limited. Due to water management for flood reduction and water supply, natural processes that form complex channels and inundate floodplain habitats will be reduced. The conservation measure for a large-scale floodplain habitat restoration effort in the Lower San Joaquin River, to the extent achieved, will help to augment rearing and migratory conditions in the system. The construction work to enhance riparian floodplain habitat has the potential to adversely affect EFH for Chinook salmon, but in the long-term is expected to provide benefits.

Effect SJ-2 (Thermal Refugia HAPC):

Thermal conditions in the San Joaquin River are often unsuitable for migrating Chinook salmon. See analysis of PA effects on water temperatures in Section 8.7.1 (particularly Tables 125 and 126) of the NMFS ROC on LTO Biological Opinion (NMFS 2019).

Essential Fish Habitat Conservation Recommendations for the San Joaquin River

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Chinook salmon in the Stanislaus River. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effects SJ-1* and *SJ-2*:

For Effect *SJ-1* listed above:

a) NMFS recommends that Reclamation also support other restoration opportunities along the lower San Joaquin River while pursuing the proposed large-scale floodplain restoration effort. Specifically, NMFS recommends, by reference, the following ESA Section 7(a)(1) conservation recommendations from the NMFS ROC on LTO Biological Opinion. Reclamation and DWR should support the following Lower San Joaquin River Habitat Projects consistent with the Collaborative Planning Action in the NMFS ROC on LTO Biological Opinion.
    i. Restoration of floodplain access and San Luis National Wildlife Refuge
    ii. Sturgeon Bend Floodplain Restoration
    iii. Durham Ferry State Recreation Area floodplain restoration

b) NMFS recommends utilizing BMPs for San Joaquin River habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable, follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

For *Effect SJ-2* listed above:
NMFS recommends that Reclamation support, specifically, restoration efforts that increase food production since higher food supply can help to offset thermal stress.

Sacramento-San Joaquin Delta

The Sacramento-San Joaquin Delta (Delta) region includes portions of the Lower Sacramento River and San Joaquin River as well as portions of Suisun, Honker, and Grizzly bays. It is characterized by freshwater inflows from the two main river systems (Sacramento and San Joaquin rivers) as well as numerous other tributaries, including the American, Mokelumne, Cosumnes, and Calaveras rivers. Salinity in the Delta region forms a continuum from full freshwater in the upper Delta locations to full marine salinity in the San Francisco estuary to the west. The estuarine portion of the Delta occurs where salinity is greater than approximately 0.5 parts per thousand and under most hydrologic conditions occurs downstream from approximately Rio Vista on the Sacramento River, and Jersey Point on the San Joaquin River. This spectrum of salinity gradients allows for multiple fish species to be present in the Sacramento-San Joaquin Delta and San Francisco Estuary, ranging from marine species, to fully freshwater species, and includes multiple species tolerant of varying salinity habitats.

The majority of the Delta region is tidally influenced, as shown by tidally driven river stage changes, which can extend upriver for considerable distances. These changes in water surface elevations in the Delta region occur under most riverine inflow conditions, except for the very highest flood flows. The influence of tidal forcing on the direction and magnitude of flows in channels of the Delta depends on the phase of the tide (i.e., flood or ebb), lunar phase (i.e., spring versus neap tides), elevation above sea level, and riverine inflows into the Delta. In most areas of the Delta, reversal of flows within the Delta channels occurs with the changing phases of the tides. Under natural conditions in tidal regions with bidirectional flows, flood tides will cause the water within most Delta channels to move upstream, and subsequently to flow downstream upon an ebb tide. In those regions where flows are dominated by riverine conditions, flows are unidirectional but may change in magnitude during the tidal cycle.
The Delta has approximately 700 miles of waterways consisting of both natural channels and manmade constructed channels. These waterways surround more than 60 leveed tracts and islands. Over 1,100 miles of constructed levees protect farmland, cities, and rural communities from flooding in the Delta region. However, the construction of these protective levees has disconnected the adjacent historical floodplains from their associated Delta waterways. Almost all of the shoreline habitat in the Delta consists of armored levees to prevent erosion, which has substantially reduced the presence of any riparian habitat along the waterside of the levees. The

current Delta consists of highly modified aquatic habitat, most of which has severely reduced ecological function for native species, including Chinook salmon.

Reclamation proposes to continue to operate the CVP/SWP facilities in the Delta to provide for delivery of water supply to areas adjacent to, and south of the Delta (Table 12 and Table 13). A more detailed description of the PA can be found in Chapter 4 of the ROC on LTO BA. Water rights, contracts, and agreements specific to the Delta include Decision (D)-1641, Coordinated Operations Agreement (COA) and other related agreements pertaining to CVP/SWP operations and Delta watershed users. In order to meet these agreements. Reclamation proposed to continue a minimum combined CVP and SWP export rate at Jones Pumping Plant and Banks Pumping Plant, respectively, of 1,500 cfs. Reclamation and DWR propose to continue to use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the south Delta (Jones, Banks, and Contra Costa Water District pumping plants) and the north Delta (Barker Slough Pumping Plant). Reclamation proposes new operations to the Delta Cross Channel (DCC); the continuation of the seasonal installation and operation of three agricultural barriers in the South Delta; new extended window of water transfers within the Sacramento and San Joaquin River basins from July through November; continued Clifton Court Forebay aquatic weed removal; and new Old and Middle River (OMR) flow management.

Conservation measures have been included in the PA. These conservation measures include non-flow actions that benefit listed species without impacting water supply. Reclamation proposes the following measures to minimize adverse effects of operations: new Suisun Marsh Salinity Control Gates Operation; new Fall Delta Smelt Habitat management; a continuation of the San Joaquin Basin Steelhead Telemetry Study similar to previous years; a new Sacramento Deepwater Ship Channel Study; a new North Delta Food Subsidies/Colusa Basin Drain study; and a new Suisun Marsh Food Subsidies study. In addition, Reclamation proposes to continue to implement existing restoration efforts including completing 6,000 acres of tidal habitat restoration in the Delta; Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project; and a new coordinated effort to remove predator hot spots in the Bay-Delta. Reclamation and DWR would continue the implementation of the following projects to reduce mortality of ESA-listed fish species: Delta Cross Channel Gate improvements; Tracy Fish Collection Facility (TFCF) improvements; Skinner Fish Facility Improvements; incorporating flexibility in salvage release sites; and the Small Screen Program.

In addition, Reclamation proposed to partner with DWR to construct and operate a new conservation hatchery in the Delta for the propagation of Delta Smelt. In the interim, the existing Fish Conservation and Culture Laboratory will be used to begin supplementation prior to construction.

Table 12. Comparison of Action Components between the Current Operation and Proposed Action in the Sacramento – San Joaquin Delta Ecosystem.

Action Component	Current Action	Proposed Action
Exports	D-1641 requirements; and OMR requirements based on USFWS	D-1641 requirements; and risk-based OMR management incorporating

Action Component	Current Action	Proposed Action
	RPA Actions 1-3 and NMFS RPA Action IV.2.3	real-time monitoring and models where possible
Delta Cross Channel (DCC)	DCC operations based on D-1641 requirements and NMFS RPA Action IV.1.2 that requires consultation to avoid exceeding water quality standards	DCC operations based on D-1641 requirements that avoid exceeding water quality standards while providing protection to listed salmonids
Delta Outflow	D-1641 requirements; and maintain average X2 for September and October no greater (more eastward) than 74 kilometers (km) in the fall following wet years and 81 km in the fall following above normal years	D-1641 requirements; Suisun Marsh Salinity Control Gate operation for up to 60 additional days from June 1 – October 31, depending on year type; increased Delta outflow in wet and above normal year types in certain conditions.
Management of reverse flows	OMR flow management based on calendar date and workgroups per USFWS RPA Actions 1-3 and NMFS RPA Action IV.2.3.	OMR flow management based on species distribution, modeling, and risk analysis, and cumulative loss of listed fish at the fish salvage facilities with provisions for capturing storm flows
Head of Old River Barrier (HORB)	HORB installed between September 15 and November 30 of most years when flows at Vernalis is <5,000 cfs and between April 15 and May 30 if Delta Smelt entrainment is not a concern and San Joaquin River flows permit	No HORB installed in spring or fall
Delta Smelt Conservation Hatchery	U.C. Davis Fish Culture Center Refugial Population	Delta Fish Species Conservation Hatchery and the introduction of cultured fish into the wild
Coordination Operations Agreement (COA)	1986 COA with 2018 Addendum	1986 COA with 2018 Addendum

Table 13. Proposed Conservation Measures for the Delta.

Conservation Measures	Description of Activity
Tracy Fish Collection Facility (TFCF)	Reclamation proposes to continue to screen fish from Jones Pumping Plant with the TFCF. The TFCF uses behavioral barriers consisting of primary louvers and four traveling screens in the secondary channel, to guide entrained fish into holding tanks before transport by truck to release sites within the western Delta.
Skinner Delta Fish Protective Facility (SDFPF)	DWR proposes to continue to screen fish from Banks Pumping Plant with the SDFPF. The SDFPF has behavioral barriers consisting of primary louvers and secondary screens (louvers and flat plate screens) to guide fish away from the pumps that lift water into the California Aqueduct and into holding tanks before transport by truck to release sites within the western Delta.
Operations	Reclamation proposes the following measures to partially offset adverse effects: Suisun Marsh Salinity Control Gates Operation; Fall Delta Smelt Habitat management; San Joaquin Basin Steelhead Telemetry Study; Sacramento Deepwater Ship Channel Study; North Delta Food Subsidies/Colusa Basin Drain; Suisun Marsh Food Subsidies.
Habitat Restoration	Reclamation proposes to continue to implement existing restoration efforts including: completing 6,000 acres of tidal habitat restoration in the Delta; Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project; and a coordinated effort to remove predator hot spots in the Bay-Delta.
Facility Improvements	Reclamation and DWR would continue the implementation of the following projects to reduce mortality of ESA-listed fish species: DCC Gate improvements; TFCF improvements; SDFPF Improvements; incorporating flexibility in salvage release sites; and the Small Screen Program.
Intervention	Reclamation proposed to partner with DWR to construct and operate a conservation hatchery for Delta Smelt. In the interim the existing Fish Conservation and Culture Laboratory will be used to begin supplementation prior to construction.

Effects on Essential Fish Habitat for Sacramento-San Joaquin Delta

Chinook salmon EFH impacted by the PA within the Delta region includes all waters of the Sacramento River and San Joaquin River within the Sacramento-San Joaquin Delta, including the multiple channels within the Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay

Estuary and tidally influenced portions of tributaries entering the Delta and San Francisco Bay Estuary. The Chinook salmon HAPCs that occur within the Sacramento-San Joaquin Delta include complex channels and floodplains, estuaries, and marine and estuarine aquatic vegetation. The Pacific coast groundfish HAPCs that occur with the Sacramento-San Joaquin Delta include estuaries, seagrasses, and rocky reefs. HAPCs for the coastal pelagic species that occur within the Sacramento-San Joaquin Delta are not defined in the FMP. Based on the best available information, NMFS concludes that the PA would adversely affect EFH for Pacific groundfish, coastal pelagic species, and Chinook salmon. We conclude that the following adverse effects on EFH designated for Pacific coast groundfish, coastal pelagic species, and Chinook salmon are reasonably certain to occur.

Effect DELTA-1: (Complex channel and floodplain, estuary, and marine and estuarine aquatic vegetation HAPCs impacted by turbidity and suspended sediments)
Construction activities in the PA related to the new Delta Smelt Conservation Hatchery, along with construction activities associated with the temporary agricultural barriers, and large-scale habitat restoration activities, are expected to result in increased levels of turbidity and suspended sediments in the surrounding water column adjacent to these construction actions. This has the potential to adversely impact water quality through increased suspended sediments and the underlying channel substrate through eventual sediment deposition. This increase in turbidity and suspended sediments is likely to temporarily or permanently alter the condition of HAPC for Chinook salmon, including those areas of complex migratory channels and floodplains, estuarine habitat, and marine and estuarine aquatic vegetation adjacent to construction activities related to the PA, as appropriate based on location.

In addition, EFH habitats related to juvenile Chinook salmon rearing, adult, and juvenile Chinook salmon migratory corridors is likely to be negatively affected by turbidity and increased suspended sediments from construction activities through the changes in behavioral and physiological responses of exposed fish to the increased turbidity. Increased levels of turbidity and suspended sediments in areas that overlap with submerged vegetation would reduce the quality of rearing and migratory habitat for Chinook salmon juveniles by adversely impacting submerged aquatic vegetation and macrophytes through light attenuation and smothering from deposition of suspended sediments on plant surfaces (Kemp et al. 1983, Sand-Jensen et al. 1989). Loss of the submerged vegetation beds would reduce cover, as well as the invertebrate populations associated with the submerged vegetation beds. The invertebrates serve as food resources for juvenile Chinook salmon migrating and rearing within the Delta region. These same effects related to turbidity and suspended sediments would also impact HAPCs for Pacific coast groundfish (i.e., estuaries and seagrass) in those construction areas located in estuarine waters (intertidal estuarine habitat restoration areas in the western Delta). It is unlikely that EFH for coastal pelagic species would be affected by turbidity or suspended sediments associated with construction activities.

Reclamation proposes to implement general avoidance and minimization measures such as a Worker Awareness Training Program, a Construction BMP and Monitoring Plan, a Stormwater Pollution Prevention Plan, an Erosion and Sediment Control Plan, a spill prevention, containment, and countermeasure plan (SPCCP), Disposal and Reuse of Spoils Plan, a fish rescue and salvage plan, and underwater noise control and abatement if pile driving actions are

included in the PA. These actions have been described in Appendix E of the BA for the PA "General Avoidance and Minimization Measures".

Effect DELTA-2: *(Complex channel and floodplain, estuary, and marine and estuarine aquatic vegetation HAPCs impacted by construction related releases of contaminants)*
Construction-related activities would also affect water quality within EFH habitat for Pacific coast groundfish, coastal pelagic species, and Chinook salmon, due to accidental spills of contaminants, including uncured cement, oil, fuel, hydraulic fluids, paint, and other construction-related materials, within the temporary and permanent footprints of the Delta Smelt Conservation Hatchery, temporary agricultural barriers, and large scale restoration activities within the Delta. Water quality degradation due to contamination during construction and restoration would reduce the quality of rearing and emigration habitat for Chinook salmon by direct adverse physiological or behavioral effects upon exposure to the contaminants as well as reducing the abundance and quality of lower trophic level prey resources through biological uptake of contaminants (Phipps et al. 1995, Fleeger et al. 2003). Release of contaminants in areas containing submerged vegetation is expected to inhibit or prevent the growth of marine and estuarine vegetation, thereby reducing habitat for invertebrates associated with the submerged vegetation beds. The invertebrates serve as food resources for juvenile Chinook salmon. The magnitude of these adverse effects on Chinook salmon EFH are generally expected to remain relatively low due to project related BMPs. Reclamation proposes to implement a SPCCP, and a Hazardous Material Management Plan, as described in Appendix E of the ROC on LTO BA.

These same effects would also be expected to impact Pacific coast groundfish EFH as well as the identified HAPCs (i.e., estuaries and seagrass) in areas that are proximal to the construction-related activities located in estuarine waters (intertidal estuarine habitat restoration areas in the western Delta). Since EFH for coastal pelagic species is primarily based on habitat water temperatures, the effects of contaminants is more tenuous on the functioning of this EFH. However, the presence of environmental contaminants would be expected to have a negative impact on the health of coastal pelagic species in the estuarine waters of the Delta.

Effect DELTA-3: *(Complex channel and floodplain, and estuary HAPCs impacted by resuspension of contaminated sediments)*
Construction-related activities may also affect water quality within EFH habitat for Pacific coast groundfish, coastal pelagic species, and Chinook salmon due to the resuspension of contaminated sediments within the PA area, which includes waters in the estuarine portion of the Delta, as well as the channels and waterways within the Delta. Impacts to EFH from re-suspended contaminated sediment include repetitive potential exposure to legacy contaminants such as mercury, methyl mercury, polychlorinated biphenyls, heavy metals, and persistent organochlorine pesticides, and repeatedly degrading the quality of EFH for juvenile Pacific coast groundfish, coastal pelagic species in the western Delta, and rearing habitat, and migratory pathways of Chinook salmon throughout the Delta. Resuspension of contaminated sediments creates areas within the complex channel structure of the Delta and within the estuarine waters of the western Delta where fish are likely to have reduced physiological fitness following their exposure to the plume of contaminated sediments. Once the plumes of contaminated sediment settle out of suspension, they create conditions where local benthic invertebrates may take up the contaminants and become a contaminated food source. Subsequent consumption of these

contaminated food sources by Chinook salmon or Pacific coast groundfish are expected to lead to trophic transfer of the contaminants up the food chain. Many of these contaminants biomagnify in the upper trophic levels, reaching concentrations in the bodies of the top trophic consumers that are many times greater than the environmental concentration in the water and sediments, and are predicted to lead to negative physiological responses when they reach high body burdens.

Effect DELTA-4:
Modification of EFH associated with removal or permanent or temporary placement of engineered structures in EFH that may offer cover or advantageous habitat for predators of special-status species. The low spatial complexity and reduced habitat diversity (e.g., lack of cover) of channelized waterways in the Delta could reduce refuge space for juvenile Chinook salmon from predators (Raleigh et al. 1984; Missildine et al. 2001; 70 FR 52488). The PA includes localized reduction of predatory fish abundance at locations such as CCF and regional predation hot spots such as the scour hole at the Head of Old River, and thereby reduce predation risks to juvenile salmonids; however, the efficacy of such action is uncertain. This action is primarily focused on reducing Chinook salmon predation, and is not expected to materially reduce predation on Pacific coast groundfish or coastal pelagic species within the Delta region.

Effect DELTA-5: (Complex channel and floodplain, estuary, and marine and estuarine aquatic vegetation HAPCs impacted by PA related changes in flows and local hydrodynamics)
Modifications of Delta flows is expected to disrupt the spawning migration of adult Chinook salmon and the rearing and migratory corridor habitat of juvenile Chinook salmon within the complex channels of the Delta, as well as migratory pathways of juvenile Pacific coast groundfish within the waters of the western Delta. These modifications may arise through the export of water via the CVP and SWP pumping facilities, operations of the DCC gates, and installation and operation of the south Delta temporary agricultural barriers. Delta inflows and outflows are anticipated to affect the rearing and distribution of Pacific coast groundfish within the Delta and San Francisco Bay estuary through changes in the location of the low salinity mixing zones of the Delta and estuary and the resulting changes in the areas of primary and secondary productivity that support these species. Likewise, changes in Delta outflow may affect the attributes of coastal pelagic species utilization of Delta and San Francisco Bay estuary habitats as to the upstream extent of their movements. Changes in the seasonal distribution of marine and estuarine vegetation are expected based on the amount of Delta outflow related to PA operations. The areas of vegetation are likely to increase or shrink depending on the ambient salinity and the preferred habitat characteristics of the different species of aquatic plants.

Essential Fish Habitat Conservation Recommendations for Sacramento-San Joaquin Delta:

As described in the above effects analysis, NMFS has determined that the PA would adversely affect EFH for Pacific coast groundfish, coastal pelagic species, and Chinook salmon in the Sacramento-San Joaquin Delta. NMFS recommends the following conservation measures to avoid, minimize and/or otherwise mitigate for *Effects DELTA-2, DELTA-3, DELTA-4,* and *DELTA-5*:

For *Effect DELTA-2* listed above:
NMFS recommends that Reclamation require additional BMPs to be used to further protect EFH present within the Delta region for Chinook salmon, and various species of Pacific coast groundfish and coastal pelagic species. For the construction effects associated with implementation of the conservation measures noted, NMFS recommends utilizing BMPs for Sacramento-San Joaquin Delta habitat restoration. In addition to implementation of the relevant avoidance and minimization measures outlined in Appendix E of the ROC on LTO BA, Reclamation should, to the extent practicable, follow the BMPs described in NMFS's Biological Opinion for the NOAA Restoration Center's Program to Facilitate Implementation of Restoration Projects in the Central Valley of California (NMFS 2018). Reclamation should implement the BMPs that are most protective of aquatic habitats.

For *Effect DELTA-3* listed above:
NMFS recommends soil testing of a statistically representative sample of soils contained within the Delta Smelt Conservation Hatchery construction footprint for contaminants. Findings of the soil testing will inform the future soil removal protocols, including preventative sediment curtains (or other measures) surrounding proposed work areas and removal or mitigation measures for uncontained sediments.

For *Effect DELTA-4* listed above,
NMFS recommends T&C 5.a from the ROC on LTO Biological Opinion be incorporated as a conservation recommendation to reduce predator "hot spots" in the Bay Delta region. NMFS recommends that monitoring of fall-run and late fall-run Chinook salmon be included in the decision process for operations of the DCC gates and south Delta temporary barriers to reduce potential predation associated with routes through the Delta interior or associated with the south Delta temporary barriers. Protective actions regarding the DCC gate operations include closing the gates during periods when juvenile Chinook salmon are emigrating regardless of run designation. Installation of the south Delta temporary barriers should be delayed until the spring emigration of fall-run Chinook salmon from the San Joaquin River basin is nearing completion. After installation of the barriers, the culverts are recommended to remain tied open to allow downstream passage of juvenile Chinook salmon until the monitoring at Mossdale indicates that there are few fish migrating downstream through the San Joaquin River system. NMFS recommends that T&C 5.h from the ROC on LTO Biological Opinion be incorporated as a conservation recommendation to provide real-time information regarding the timing of installation and operations of the south Delta temporary barriers and their potential impacts to migrating Chinook salmon routing through the south Delta.

For *Effect Delta-5* listed above:
NMFS recommends that if large pulses of Chinook salmon are detected migrating through the Delta or are observed in salvage, regardless of run type, protective actions should be employed to reduce the entrainment and loss of these fish at the CVP and SWP export facilities. These actions include export reductions to reduce hydraulic impacts within waterways leading to the south Delta export facilities, closure of the DCC gates to prevent routing of juvenile Chinook salmon into the Delta interior, and preferentially exporting from the CVP facilities to reduce loss during salvage operations. In addition, closing the DCC gates in the fall during pulse flows on the

Mokelumne River designed to attract adult Chinook salmon will reduce straying of these fish into the open DCC route.

Reclamation and DWR should support the implementation of physical and non-physical barrier projects that are designed to re-route fish movements to increase through-Delta survival of juvenile salmonids. Reclamation and DWR should install and operate the non-physical exclusion barrier at Georgiana Slough consistent with DWR's prior pilot study results. DWR should implement the Salmon Protection and Technology Study at Steamboat and Sutter Sloughs to determine the effectiveness of different barrier technologies at these locations in their ability to increase through Delta salmonid survival.

In order to reduce uncertainties regarding the mechanisms and extent of take in the form of juvenile salmonid behavioral modifications to hydrodynamic changes in the south Delta that are associated with water operations, Reclamation and DWR should implement the recommendations of the Collaborative Adaptive Management Team work plan for salmonids (Salmonid Scoping Team 2017a, b). As part of this work plan, Reclamation and DWR should fund continued development of enhanced particle tracking modeling that is sensitive to realistic changes in south Delta operations, incorporates realistic fish behavior, analyzes existing data, and conduct experiments to assist in model development.

Furthermore, Reclamation and DWR should develop sound experimental designs to test key alternative hypotheses regarding salmon survival (e.g., exports are important in addition to inflow in some circumstances in influencing juvenile salmon behavior, etc.). This experimental approach should build on lessons learned from recent and current studies within the Delta region to inform future study designs.

Finally, NMFS supports the tidal habitat restoration of 8,000 acres in the PA. In addition, NMFS recommends that Reclamation and DWR consider implementing the recommendations from the Collaborative Adaptive Management Team-sponsored evaluation of rearing habitat potential, which is expected to be released in early 2020.

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