BUREAU OF RECLAMATION

Long-Term Operation

Initial Alternatives

Central Valley Project, California

Interior Region 10 – California-Great Basin

U.S. Department of the Interior **September 2022**

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

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

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Bay-Delta Office

Contents

1. Introduction

This Initial Alternatives Report documents the analysis of options to inform alternative formulation for the proposed Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP). The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) developed potential options through the National Environmental Policy Act (NEPA) scoping process, coordination under the Water Infrastructure Improvement for the Nation (WIIN) Act, interagency coordination teams, outreach to interested parties, and Reclamation's decades of experience in operating the CVP. Reclamation will analyze a reasonable range of alternatives in a Public Draft Environmental Impact Statement (Public Draft EIS). The initial alternatives presented in this document highlight different potential approaches. Alternatives for the Public Draft EIS may be informed by options provided in these initial alternatives and related analyses. A Notice of Intent (87 *Federal Register* 11093–11095) published February 28, 2022, provides background for this LTO. The subsequent scoping report includes the public comments received from the Notice of Intent and during scoping meetings (Bureau of Reclamation 2022). This Initial Alternatives Report considers comments related to alternatives.

This main body of this report provides a summary for readers familiar with the operation of the CVP and SWP and related actions to protect and support listed fish species. Appendices provide background and more detailed information. Appendix A- *Facility Description* describes the facilities addressed by the LTO, their capabilities, and their requirements. Appendix B identifies the likely direction and magnitude of potential hydrologic modifications by evaluating the available inflow to CVP reservoirs, operating to meet the requirements of the *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (Bay-Delta Plan) (State Water Resources Control Board 2018), and operating under the No Action scenario. Based on previous consultations with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), Reclamation anticipates the measures required to protect fish species listed under the Endangered Species Act (ESA) will drive the alternatives. An evaluation of when federally listed species are present (Appendix C- *Species Spatial-Temporal Domains*) informed an initial deconstruction of potential seasonal operations (Appendix D- *Seasonal Operation Stressors on Aquatic Species*). The initial deconstruction of potential seasonal operations used conceptual models to link water operations to stressors on fish populations and to identify when and where the operation of the CVP and SWP may affect listed fish species and their critical habitats.

Development of initial alternatives relied upon exploratory modeling (Appendix E) to simulate potential water operations under a range of criteria. Results inform potential modifications and limitations on the seasonal operation of the CVP and SWP. Conservation measures may avoid, minimize, or compensate for adverse effects on the species. The seasonal water operations and the conservation measures anticipated for inclusion in each alternative are identified as common components (Appendix F- *Potential Common Components*). Common components are those actions without identified unresolved conflict that do not need consideration of different approaches. Options for the operation and maintenance of specific facilities and conservation measures are similarly analyzed for effectiveness and analyzed for potential adverse effects on listed species (Appendix G- *Specific Facility and Water Operations Deconstruction* and H- *Conservation Measure Deconstruction*).

Water operations and conservation measures with a range of potential approaches are variable components and described in Appendices I through T. On areas with new information and/or scientific disagreement, Reclamation solicited input from interested parties through topic-specific "knowledge base papers" to compile available literature, datasets, and models for multiple lines of evidence to inform and undertake analyses. Preliminary analyses included impacts on fish species, water deliveries, and power generation. Finally, an initial disposition of scoping comments related to alternatives and to the analysis of alternatives are described in Appendix V- *Screen Scoping Comments*.

Reclamation will use this report to develop public draft alternatives to be analyzed in the Public Draft EIS for potential impacts on the environment. The Public Draft EIS will address all comments received during scoping. Reclamation will issue a Notice of Availability for the Public Draft EIS in the *Federal Register* and seek comments from interested parties and the public. Reclamation intends to identify a preferred alternative in the Public Draft EIS. The preferred alternative is likely to affect listed species and their critical habitats; therefore, Reclamation plans to prepare a Biological Assessment to formally consult with USFWS and NMFS. Through the consultation process, USFWS and NMFS are anticipated to develop biological opinions. Comments received on the Public Draft EIS will be shared with the USFWS and NMFS during the formal consultation. The comments received and the final biological opinions will inform a Final EIS, which may or may not require further consideration prior to a final decision. No sooner than 30 days after issuing a Notice of Completion in the *Federal Register* for the Final EIS, Reclamation may sign a Record of Decision (ROD) implementing the new LTO.

This consultation includes the California Department of Water Resources (DWR) operation of SWP facilities in the Delta. DWR is anticipated to request an Incidental Take Permit (ITP) from the California Department of Fish and Wildlife (CDFW) for compliance with the California Endangered Species Act (CESA). Partner federal and state agencies are coordinating to develop a joint Proposed Action; however, the state agencies elected to engage in alternative formulation solely as a "Cooperating Agency" under NEPA. While informed by coordination, this Initial Alternative Report is a Reclamation product.

This analysis provides a snapshot of the work performed to date and will be refined or replaced as necessary. Reclamation does not intend to seek comments on nor revise this Initial Alternatives Report but may issue errata. Input received during outreach to interested parties will inform and may be incorporated into the Public Draft EIS alternatives, a Proposed Action, Biological Assessment, and/or the Public Draft EIS.

2. Revised Purpose and Need

Reclamation received comments on the purpose and need for this action during scoping and made revisions. The purpose of the Proposed Action considered is to continue the operation of the CVP and the SWP, for authorized purposes, in a manner that:

- Meets requirements under federal Reclamation law; other federal laws and regulations; and State of California water rights, permits, and licenses pursuant to Section 8 of the Reclamation Act;
- Satisfies Reclamation contractual obligations and agreements; and
- Implements authorized CVP fish and wildlife project purposes, including the Central Valley Project Improvement Act (CVPIA).

Operation of the CVP and SWP is needed to meet multiple authorized purposes including flood control and navigation; water supply; fish and wildlife mitigation, protection, and restoration and enhancement; and power generation. Operation of the CVP and SWP also provides recreation and water quality benefits.

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3. Common Components

The action area includes CVP service areas and CVP dams, power plants, diversions, canals, gates, and related Federal facilities located on the watersheds of Clear Creek; the Sacramento, American, Stanislaus, and San Joaquin rivers; and the Sacramento–San Joaquin Delta (Delta). Development of the actions on the Trinity River are proceeding on a separate process and are not included in this report. The action area includes SWP service areas downstream of the Feather River and SWP facilities in the Delta, Cache Slough Complex, and Suisun Marsh. Reclamation structured initial alternatives with consideration of the following factors.

- **Governance**: Requirements for additional consultations and concurrence, collaboration through technical assistance, reporting, and adaptive management.
- **Watersheds**: Basin-by-basin description of facilities and the proposed operation for fish and wildlife, water supply, and power generation including proposed conservation measures to promote the recovery of federally listed species and/or to minimize or compensate for Proposed Action effects.
- **Status and Trend Monitoring**: The long-term evaluation of performance to assess overall effectiveness over time.
- **Special Studies**: Efforts to address uncertainties that affect a reasonable balance among competing demands for water, including the requirements of fish and wildlife, agricultural, municipal, and industrial uses of water, and power contractors.
- **Drought Contingency**: Drought actions to recognize extreme conditions that may occur during operations.

Reclamation and DWR anticipate ongoing engagement by USFWS, NMFS, and the CDFW following completion of biological opinions; therefore, governance identifies future commitments to technical assistance. Although each watershed has unique requirements, Reclamation and DWR integrate monitoring across watersheds; therefore, monitoring is organized in a single section. In developing the plans and seeking commitment for ongoing engagement, certain studies are of such significance that their inclusion in this consultation informs how to address key uncertainties. Finally, the boom-and-bust nature of California hydrology and the resulting effects on species warrants special consideration for operation during droughts. Although each drought is unique, contingency planning can facilitate a response. Governance, monitoring, and drought contingency will depend on alternatives, remain under development, and are not addressed at this time.

Potential common components across all initial alternatives are included in Appendix F with placeholders for the variable components. The common components in Appendix F generally included measures such as ramping rates and minimum instream flows. Interagency coordination and a review of literature and comments did not identify substantial disagreement with the physical and biological science defining those actions nor substantial disagreement with the potential resource tradeoffs. The Public Draft EIS must still evaluate impacts and the Biological Assessment must still consider effects to listed species and their critical habitats.

4. Initial Alternatives Themes

Themes provide a way to explore combinations of components, options, and impacts (both beneficial and adverse). Themes seek the bounds of potential decisions to inform alternatives and highlight contrasts in approaches. The Public Draft EIS alternatives may draw from more than one theme to seek compromises and are likely to be different from initial alternatives. Figure 1 shows the conceptual assembly of different ideas into thematic initial alternatives.

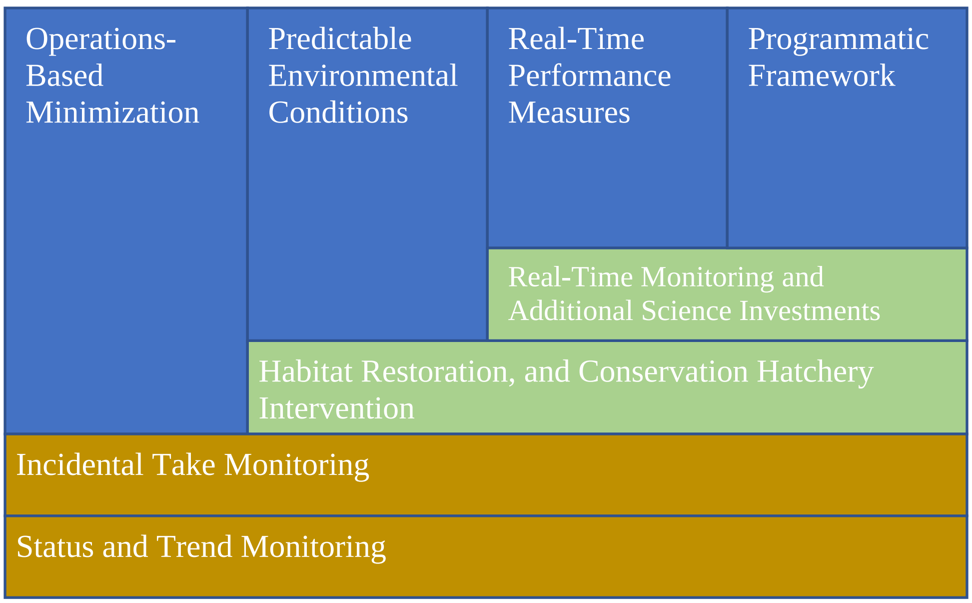

Figure 1. Thematic Initial Alternatives

The following themes were used to conceptualize the development of initial alternatives because they capture overarching tradeoffs between flow and non-flow actions, calendar-based certainty for regulations and multi-purpose benefits through flexible real-time operations, and uncertainty in hydrology and species response. The conceptual approach for each thematic initial alternative is as follows:

1. **Operations-Based Minimization:** This theme involves minimization and compensation of adverse effects through changes to, and limitations on, the operation of the CVP and SWP. This theme explores flow-based approaches to support and maintain species and provides a basis to inform the potential benefits of non-flow actions.

2. **Predictable Environmental Conditions:** This theme relies upon calendar-based environmental and biological criteria that maximize regulatory certainty. The addition of habitat restoration, conservation hatcheries, and other non-flow actions minimize and compensate for the adverse effects of the operation of the CVP and SWP to reduce limitations and improve water supply, fish and wildlife, and power generation project

purposes. This theme provides a basis of comparison to inform the potential benefits of real-time operations.

3. **Real-Time Performance Measures:** This theme explores real-time monitoring and assessment protocols to tailor water operations for fish and water supply based on current data on environmental and biological conditions. This theme explores tradeoffs between regulatory certainty and the potential to target more protective criteria to improve the performance of the CVP and SWP for water, fish, and/or power generation. This theme also incorporates habitat, facility, and non-flow actions.

4. **Programmatic Framework:** This theme involves consultation on the range of potential conditions with a framework for subsequent year-specific consultations. This theme explores approaches to support ESA compliance in the absence of sufficient ability to describe the action in a manner USFWS and NMFS can analyze and/or provide an exemption for take. This theme accounts for hydrologic uncertainty, operational uncertainty, and habitat restoration programs directed by adaptive management. This theme would establish a framework to facilitate subsequent regulatory compliance to reduce the need for and requirements of a subsequent reinitiation of consultation (USFWS 2018, pg. 5.6).

Within each initial alternative, there may be different approaches involving the same resources or for the same goals. Any or none of the approaches may be carried forward into alternatives to be analyzed in the Public Draft EIS. A “No Action” alternative is a requirement of NEPA and supports the ability to compare to current conditions.

5. Variable Components

The components for the operation of the CVP and SWP with different potential approaches are described below as variable components. For each variable component, the initial alternatives correspond to the four themes explained in the previous section. Refinements made for the Public Draft EIS and through interested party outreach may result in some variable components becoming common to all alternatives for the Public Draft EIS.

5.1 Old and Middle River Flow Management

Old and Middle River (OMR) flow management addresses entrainment of sturgeon, salmonids and smelts into the central Delta, south Delta, and/or into salvage facilities. Appendix I- *OMR Flow Management* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- Should the onset of OMR flow management be based on real-time conditions or does a fixed schedule based on the historical migration timing protect species with limited impacts on water supply?
- How does the magnitude of different OMR flow management restrictions change the relative risk of species entrainment at the export facilities and in the central and/or south Delta?
- How does the duration of temporary OMR flow management restrictions change the entrainment of species within the influence of export facilities?
- Does an offramp of OMR flow management based on real-time conditions protect species and improve water supply performance or does a fixed schedule protect species with limited impacts on water supply?
- What is the effect of different levels of near- and far-field entrainment on population viability?

5.1.1 Options

All initial alternatives include "first flush" and turbidity bridge avoidance actions. Potential options for different subcomponents include: the onset of OMR flow management, level of restrictions on OMR flow, response to detections in salvage, actions during storm-related events, and the offramp of OMR.

Initial Alternative 1 includes a fixed schedule for the onset and offramp of OMR flow management with high-magnitude OMR flow restriction criteria:

- Fixed start and end: Dec. 1–Jun. 30 (historical presence of fish, Appendix C)

- OMR reverse flow no more negative than -3,500 cfs
- Positive OMR upon fish salvage, subject to Public Health and Safety

The broad OMR window, limited OMR flows, and response to detections at the salvage facilities rely upon water operations to avoid or minimize effects on listed species while operating the CVP and SWP at a cost to water deliveries. An OMR no more negative than -3,500 cfs represents a limited zone of influence from exports and an inflection point where exports levels do not contribute to the likelihood of winter-run Chinook salmon detections in salvage.

Initial Alternative 2 includes a fixed schedule for the onset and offramp of OMR with an intermediate-magnitude OMR restriction criterion:

- Fixed start and end: Dec. 1–Jun. 30 (same as Alternative 1)
- OMR reverse flow no more negative than -5,000 cfs
- No response upon salvage and mitigation would rely on non-flow actions.

A less limiting OMR flow may increase water supply performance but may also result in additional impacts on species. Consideration of habitat restoration, or alternative conservation measures, may offset those impacts through other variable components. An OMR flow no more negative than -5,000 cfs corresponds to limited zone of influence and inflection points for delta smelt entrainment.

Initial Alternative 3 includes a variable onset and offramp of OMR management based on real-time species risk assessment and an initial lower-magnitude OMR flow restriction criterion that may be made more restrictive in real-time:

- Flexible start and end: Dec. 1–Jun. 30 (real-time presence of fish and/or suitable water temperatures)
- OMR reverse flow no more negative than -6,250 cfs
- Restricted OMR flow upon fish salvage or in anticipation of salvage, less sensitive trigger, also has non-flow mitigation

A less limiting OMR flow may increase water supply performance but may also result in additional impacts on species. However, real-time species risk assessment with corresponding protective actions may reduce species impacts. Consideration of habitat restoration, or alternative conservation measures, may also offset species impacts through other variable components. An OMR reverse flow no more negative than -6,250 represents the upper bound of SWP permitting for storm-related flexibilities. The CVP cannot export at a rate that would cause OMR flow more negative than -6,250 cfs.

Initial Alternative 4 is a programmatic approach to address a range of potential conditions if the uncertainty of seasonal operations precludes specific consultation. The start and end of management would be anticipated to occur within the migration window. OMR flow would be anticipated to range from positive flows under public health and safety levels to more negative values under State Water Resources Control Board (State Water Board) Decision 1641 (D-1641) depending upon the year-specific consultation and related criteria.

5.1.2 Analysis

Reclamation solicited input for the knowledge base paper *Old and Middle River Reverse Flow Management – Smelt, Chinook Salmon, and Steelhead Migration and Survival*, which is included as an attachment to Appendix I- *Old and Middle River Flow Management*. Reclamation addressed management questions and analyzed options with datasets from salvage, rotary screw traps, trawls under the Delta Juvenile Fish Monitoring Program, and acoustic tagging; literature on thresholds and fish response; and a number of specific numerical and statistical models that incorporated the datasets and literature.

A sensitivity analysis using CalSim II, DSM2-HYDRO, and DSM2-PTM models was conducted to assess relative risk of species at the export species and water supply effects under a set of different OMR limits on Delta operations. The CalSim II model simulated operational conditions (flows into the Delta and exports) under an OMR limit of -3,000 cfs, -4,000 cfs, -5,000 cfs, -6,000 cfs, and -7,000 cfs. Using results of these CalSim II scenarios, DSM2-HYDRO was used to determine Delta flow conditions and the DSM-PTM module was used to assess entrainment of particles at export facilities under these varying conditions. DSM2-PTM was run in two modes: one assuming neutrally buoyant particles and one assuming surface-oriented particles. For each year in the 82-year CalSim II simulation period and for each mode, the model was run for 39 particle insertion locations in the Delta. For each insertion location the model was run for two seasons: December through March, starting each month for each period and lasting for 45 days; and March through June, starting each month for each period and lasting for 30 days. The resulting 50,000+ simulations provided a wide variety of flow, particle insertion, and particle behavior conditions from which to draw conclusions. Modeling assumptions and modeling results are provided in Attachment 1 of Appendix I.

Behavioral models that add to potential fish response such as ECO-PTM and the ePTM were considered; however, these models were not ready or compatible to run with CalSim II and DSM2-HYDRO v8.06 at the time this analysis was conducted.

A separate sensitivity analysis using DSM2-HYDRO was conducted to analyze the spatial extent of influence of exports under varying OMR conditions. For this analysis, inflows to Delta were assumed to be fixed between scenarios and DSM2 was used to vary export levels (synthetically, without any consideration of system-wide operations) to generate varying export conditions under the same inflow scheme to the Delta. This modeling scheme allowed the teasing out of effects of Delta exports on Delta flows. The DSM2-HYDRO flow and velocity results were then used to generate “zone of influence” contour maps in the Delta. Modeling assumptions and modeling results are provided in Attachment 2 of Appendix I.

In addition to these two sensitivity studies, three 82-year simulations were conducted using CalSim II, DSM2, and Delta Passage Model (DPM) to assess water supply effects and near- and far-field entrainment effects under the operations described for Initial Alternative 1, Initial Alternative 2, and Initial Alternative 3 described above. Initial Alternative 4 was evaluated qualitatively using all of the available analyses.

Modeling assumptions and modeling results are provided in Attachment 3 of Appendix I.

5.1.3 Findings

Should the onset of OMR flow management be based on real-time conditions or does a fixed schedule based on the historical migration timing protect species with limited impacts on water supply?

- The "first flush" approach to OMR flow based on flow and turbidity remains well supported.
- Winter-run typically arrive in the Delta before other species and may trigger a need for entrainment protection (OMR) based on species protections.
- Based on historical information (2005–2020), the earliest first detection of winter-run sized fish at salvage occurred on December 3 in 2010 and the latest detection occurred in 2014 on March 3 with more typical first detections in late December and through January.
- Length at date estimates show winter-run presence in the Delta much earlier than detections in salvage.

How does the magnitude of different OMR flow restrictions change the relative risk of species entrainment at the export facilities and in the central and/or south Delta?

- Zone of influence maps show little change in reverse velocities in the Sacramento River between an OMR flow of -1,000 cfs and -5,000 cfs. As San Joaquin flows increase, the zone of influence shrinks into the Old and Middle River corridor.
- Particle tracking for OMR flow management from -3,000 cfs to -7,000 cfs in December showed little variability in particles exiting the Delta from the Sacramento (~Δ10%) and Yolo (~Δ5%) regions. The difference in entrainment between an OMR of -3,000 and -5,000 was ~3%.
- The central and Mokelumne regions varied by across the OMR range by ~30%.
- Particles in the San Joaquin River, OMR flow, and south Delta were unlikely to pass west of Chipps Island regardless of OMR flow (<10%).

How does the duration of temporary OMR flow restrictions change the entrainment of species within the influence of export facilities?

- Autocorrelation following the salvage of fish show that effects of exports on salvage is prominent for approximately 7 days.

Does an offramp of OMR flow management based on real-time conditions protect species and improve water supply performance or does a fixed schedule protect species with limited impacts on water supply?

- Temperature offramp criteria may trigger as early as the second week in June or never.

- Species presence was not yet evaluated.
- Offramp of OMR flow management based on real-time conditions provides operational flexibility to improve water supply performance.

What is the effect of different levels of near- and far-field entrainment on population viability?

- No information was available on the effect of entrainment and different OMR flow management on population viability.
- DPM modeling for Initial Alternatives 1, 2, and 3 described above is still under development.

The range of change in total Delta exports due to different OMR flow management scenarios in the Initial Alternative options spanned approximately 650 thousand acre-feet (TAF).

5.2 Spring Pulses and Delta Outflow

Limitations on exports and/or tributary inflow to maintain and increase spring Delta outflow address the physical and biological processes driven by the historical rain and snowmelt hydrology that supported native species. Appendix J- *Spring Pulses and Delta Outflow - Smelt, Chinook Salmon, and Steelhead Migration and Survival* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- During the spring, what is the proportion of primary and secondary productivity supplied to the Delta from tributary inflows, Yolo bypass and other floodplain inundation versus produced within the Delta?
- Does the inundation of Yolo Bypass and other floodplain areas change the productivity compared to in-channel and shallow tidal habitat within the Delta?
- What is the proportion of spring primary and secondary productivity passed to Suisun Marsh and the Bay, versus removed by CVP and SWP exports, versus captured, for example, clams?
- Can spring exports and tributary releases stimulate phytoplankton blooms and/or disperse central Delta phytoplankton biomass to habitats that are likely occupied by Delta smelt and longfin smelt?
- Can spring exports and tributary releases stimulate detrital-based zooplankton production and/or disperse central Delta food resources to habitats that are likely occupied by Delta smelt and longfin smelt?
- Does maintenance of low-salinity zone connectivity to Suisun Marsh and San Pablo Bay for Delta smelt and longfin smelt bolster spring survival?
- How much does spring export reductions, tributary releases, and/or both improve migratory conditions for Chinook salmon and steelhead?

- Do spring Delta outflows driven by tributary releases reduce the need for OMR management?
- What are the costs of Delta outflow actions to the current year's water supply, storage, water quality, and/or hydropower?

5.2.1 Options

Potential options for different subcomponents include combinations of export limitations and tributary contributions. Habitat restoration is a contributor to productivity, but addressed as a separate variable component. Spring Delta outflow includes the flow and salinity requirements in the D-1641 implementation of the Bay-Delta Plan, considerations of operations under proposed updates to the Bay-Delta Plan, and the needs of listed species.

Initial Alternative 1 includes additional Delta outflow through restrictions on exports with the following criteria:

- Delta outflow requirement of 65% unimpaired inflow (UIF) January through June distributed to upstream reservoirs proportionally to Sacramento tributaries and assuming 40% from the Stanislaus River.
- A San Joaquin inflow to export (I:E) ratio of 2:1 in April and May.

This alternative creates Delta outflow through export reductions and prioritizes storage in upstream reservoirs.

Initial Alternative 2 includes releases from upstream reservoirs that may be exported subject to D-1641 criteria:

- CVP reservoir releases in certain year types
  - Sacramento River releases from Keswick Dam up to 150 TAF in dry (D), below normal (BN), and above normal (AN) years, subject to project impacts. Up to 100 TAF from non-project compensation by rice fallowing under Voluntary Agreements.
  - American River releases from Folsom Dam of up to 30 TAF in critically dry (C), 40 TAF in D, and 10 TAF in BN and AN years
  - San Joaquin River Delta inflows from Friant Dam reservoir releases of up to 50 TAF in D, BN, and AN years minimum as Delta outflow
  - Stanislaus River flows from Goodwin Dam releases according to 2019 Stepped Release Plan
- Export to Delta inflow (E:I) ratio per D-1641
- San Joaquin I:E Ratio of 1:1 mid-April to mid-May (30 days, D-1641)

This alternative creates Delta outflow through increased tributary inflows and allows export of a portion of those inflows.

Initial Alternative 3 includes measures under the Voluntary Agreements for real-time management of export reductions, the release and conveyance of tributary pulse flows from CVP reservoirs, and the passage of contributions from non-CVP facilities with the following criteria:

- An export reduction of 125 TAF in D and BN years and 175 TAF in AN
- CVP reservoir releases as described in Alt. 2 with CVP public water agency contributions to make the volumes available.
- Passing water from non-CVP public water agencies

This alternative creates Delta outflow through releases from upstream reservoirs and reductions in exports in certain water year types.

Initial Alternative 4 identifies a potential range of conditions from exports at public health and safety levels to exports under D-1641 criteria.

5.2.2 Analysis

Reclamation solicited input for the knowledge base papers, *Delta Spring Outflow Management Smelt Growth and Survival* and *Pulse Flow Effects on Salmonid Survival*, both included as attachments to Appendix J- *Spring Pulses and Delta Outflow - Smelt, Chinook Salmon, and Steelhead Migration and Survival*. Reclamation addressed management questions relying upon literature. Modeling for Initial Alternatives 1, 2, and 3 described above using CalSim II, DSM2, and DPM is still under development.

5.2.3 Findings

During the spring, what is the proportion of primary and secondary productivity supplied to the Delta from tributary inflows, Yolo Bypass, and other floodplain inundation versus the productivity originating within the Delta?

- The literature to date partially informs this question and the literature review will continue.
- Changes in spring outflow due to floodplain inputs can temporarily increase riverine ecosystem productivity in riverine floodplain habitats like the Yolo Bypass. The floodplain habitat can contribute substantial loads of primary producer biomass, and particularly biomass of wide diameter diatoms and green algae, to downstream reaches of the Sacramento River entering the north and west Delta.
- These levels of primary productivity in the Yolo Bypass following flooding were approximately two times (or more) greater than levels in the main Sacramento River channel (Lehman et al. 2008).
- Primary productivity in the Delta is influenced by the water residence time. At higher river inflows, water residence time in most of the estuary decreases. Decreased residence time limits the build-up of primary producers and typically results in lower plankton biomass.

Does the inundation of Yolo Bypass and other floodplain areas change the productivity compared to in-channel and shallow tidal habitat within the Delta?

- The literature to date does not address this question, but the literature search will continue.

What is the proportion of spring primary and secondary productivity passed to Suisun Marsh and Suisun and Grizzly Bays, versus removed by CVP and SWP exports, versus captured, for example, clams?

- The literature review to date partially addresses this question and will continue.
- Higher copepod and mysid prey have been observed with greater spring Delta outflow in Suisun Bay; however, there are more significantly negative relationships of zooplankton to spring Delta outflow than positive relationships at the scale of the regions sampled by the Environmental Monitoring Program and 20-mm Survey.
- The effects of residence time on primary productivity in areas in the south Delta like Suisun Bay, appear muted by the grazing pressure of the invasive clam *Potamocorbula amurensis*.

Can spring export reductions and tributary releases stimulate phytoplankton blooms and/or disperse central Delta phytoplankton biomass to habitats that are likely occupied by Delta smelt and longfin smelt?

- The literature to date does not address this question, the literature review will continue.
- Grazing from clams and zooplankton has exceeded net phytoplankton growth in some regions, requiring a subsidy from other regions.

Can spring exports and tributary releases stimulate detrital-based zooplankton production and/or disperse central Delta food resources to habitats that are likely occupied by Delta smelt and longfin smelt?

- Detrital-based organic carbon from river inflows to the Delta can match or exceed carbon produced by local phytoplankton, depending on annual river flow (Jassby et al. 1993).
- Detrital matter has been observed to be only weakly linked to the Delta's pelagic food web, however, due to its reliance on the microbial loop to be made bioavailable (Sobczak et al. 2002; Sobczak et al. 2005).

Does maintenance of low-salinity zone connectivity to Suisun Marsh and San Pablo Bay for Delta smelt and longfin smelt bolster spring survival?

- The literature to date does not address this question, the literature review will continue.

How much does spring export reductions, tributary releases, and/or both improve migratory conditions for Chinook salmon and steelhead?

- The magnitude of flow influences predation risk in riverine channels within the Delta.
- Increased inflow reduces entry into the relatively low survival interior Delta.
- There are positive relationships between flow and juvenile Chinook salmon migration survival in the rivers upstream of the Delta.
- Inflow has less effect as tidal action becomes the predominant force controlling water velocity and direction of flow, for example, downstream of Georgiana Slough.

Do spring Delta outflows driven by tributary releases reduce the need for OMR management?

- Spring pulses and Delta outflows are not yet modelled.

What are the costs of Delta outflow actions to the current year's water supply, storage, water quality, and/or hydropower?

- Spring pulses and Delta outflows are not yet modelled.

5.3 Summer and Fall Delta Outflow and Habitat

Summer and fall Delta outflow and habitat addresses the measured correlation between X2 and Delta smelt recruitment captured in the USFWS 2008 Biological Opinion and modified in their 2019 Biological Opinion and the need for the low-salinity zone to overlap with suitable temperature, turbidity, and food habitat conditions.

Reclamation's management questions for the formulation of an alternative include:

- Does the area of suitable habitat increase given salinity, turbidity, temperatures, and/or contaminants?
- Does summer and fall habitat action increase food resources in historical Delta Smelt summer and fall habitats from production and/or food transport?
- Does summer and fall habitat action support migration of Delta smelt to areas of improved suitable habitat?
- Are effects on water Supply different between habitat actions from Suisun Marsh Salinity Control Gate operations, export reductions, or reservoir releases?
- What are the effects on different Delta smelt life history strategies (freshwater, migratory, brackish water)?
- Does this improve population recruitment and viability?

5.3.1 Options

Potential options for different subcomponents include: export reductions for targeting the location of X2, releases from storage for targeting the location of X2, operation of the Suisun

Marsh Salinity Control Gate, and food web actions such as the management of agricultural drainage and flow in the Sacramento Deep Water Ship Channel.

Initial Alternative 1 includes the management of X2 with the following criteria:

- Delta outflow (export reductions/releases) to keep X2 at 80 kilometers (km) in AN and 74 km W during September and October

This option reflects the requirement from the 2020 ROD in AN years and the requirement of 74 km from the USFWS 2008 Biological Opinion in W years.

Initial Alternative 2 includes the development of habitat connectivity through operation of the Suisun Marsh Salinity Control Gates with the following criteria:

- Delta outflow (export reductions/releases) to keep X2 at 81 km in AN and 80 km in W years during September and October
- Operation of the Suisun Marsh Salinity Control Gate, 4 parts per thousand (ppt) at Belden's Landing
    - BN, AN, and W for 60 days

This option has the less restrictive AN year requirement from the USFWS 2008 Biological Opinion, and the Shasta storage measures from the 2020 ROD. It relies on gate operations to create connectivity with less water costs.

Initial Alternative 3 includes the real-time implementation of gate operations and food web actions with the following criteria:

- Delta outflow (export reductions/releases) through export reduction to keep X2 at 80 km in AN and W years during September and October
- Operation of the Suisun Marsh Salinity Control Gate to target 4–6 ppt at Belden's Landing for the following durations by year-type
    - D for 30 days
    - BN, AN, and W for 60 days
    - Offramp during unsuitable temperatures
- Food web augmentation actions such as agricultural drainage and the Sacramento River Deep Water Ship Channel

This option uses a single X2 target and allows for targeting a range of salinities to potentially extend operations for connectivity. Offramps save water when suitable habitats are unlikely and additional actions seek to support the food web.

Initial Alternative 4 is a programmatic approach to address a range of potential summer and fall Delta outflow conditions would range between habitat quantities reflecting D-1641 monthly flow requirements and year-specific consultation and related criteria. Year-specific criteria would be informed by studying management questions identifying the biological response of specific management actions and environmental conditions.

5.3.2 Analysis

In the spring of 2022, Reclamation solicited input for the knowledge base paper titled *Summer and Fall Habitat Management Actions- Smelt Growth and Survival*, included as an attachment. Knowledge base papers compile potential datasets, literature, and models for analyzing potential effects from the operation of the CVP and SWP on species, water supply, and power generation. The knowledge base papers helped determine the most relevant approach for Reclamation to answer management questions and evaluate options for potential alternatives.

Reclamation and DWR have implemented individual components of the Summer and Fall Outflow and Habitat options in the past, such as increased gate options or increased Delta Outflow to 80 km. However, a complete suite of options has not been implemented due to persistent dry conditions over the last decade. Reclamation and DWR have developed an implementation team guided by structured decision-making (SDM) (i.e., Delta Coordination Group (DCG)) and multiple documents to understand and monitor the effects of these actions, identify science and monitoring needs, identify relevant models and data sets. Multiple publicly available datasets from ongoing abiotic and biotic monitoring programs help inform the structured decision-making process.

Reclamation utilized all the available datasets, relevant literature and models to analyze the potential impacts from for Initial Alternative 1, Initial Alternative 2, and Initial Alternative 3 described above. Initial Alternative 4 was evaluated qualitatively using all the available analyses. In addition, three 82-year simulations were conducted using CalSim II to assess water supply effects and DSM2-HYDRO and DSM2-QUAL were used to assess changes of water quality in the Delta as they pertain to habitat suitability.

The complete analysis of Summer and Fall Delta Outflow and Habitat is provided in Appendix K.

5.3.3 Findings

Does the area of suitable habitat increase given salinity, turbidity, temperatures, and/or contaminants?

- The degree to which habitat is suitable for Delta smelt depends on the overlap of appropriate salinity, temperature, and turbidity levels. The area of suitable Delta smelt habitat, based solely on salinity, increases when X2’s physical area is located downstream of the Confluence of the Sacramento and San Joaquin Rivers near Suisun and Grizzly Bays. Operation of the SMSCG also decreases salinity and increases physical habitat suitability in Suisun Marsh.
- Turbidity has been demonstrated to be a key determinant factor in the occurrence and abundance of Delta smelt in the field. Turbidity within the Delta is driven by tidal currents. Increased Delta outflow results in a greater overlap between X2 and the naturally turbid waters of the Suisun and Grizzly Bay.

- Water temperature greater than 25° is a limiting factor for Delta smelt. The relationship between Delta outflow and water temperatures in the Summer and Fall is unclear.
- Contaminant loading may fluctuate under high flow conditions, as pollutants are mobilized and transported downstream within waterways but diluted by flow. There is a lot of uncertainty regarding the effects of flow on contaminants and its relationship to other habitat attributes.

Does summer and fall habitat action increase food resources in historical Delta smelt summer and fall habitats from production and/or food transport?

- While food enhancement actions have been observed to cause localized increases in chlorophyll and phytoplankton, large scale food web responses have been inconsistent (only observed in 2016) and modeling efforts show little effect on growth and survival.
- Studies of managed flooding and drainage are ongoing in multiple locations in the Delta.

Does summer and fall habitat action support migration of Delta smelt to areas of improved suitable habitat?

- A large portion of the population exhibits a migratory life history in which they are transported or actively migrates between the low salinity zone and freshwater habitats of Cache slough Complex and the Sacramento Deep Water Shipping Channel.
- Summer and fall habitat actions may increase the physical extent of favorable characteristics (e.g., lower salinity conditions in areas with higher turbidity, lower temperatures, access to complex bathymetry, sufficient prey availability) between these geographical areas.

Are effects on water supply different between habitat actions from Suisun Marsh Salinity Control Gate operations, export reductions, or reservoir releases?

- Initial Alternative 1 Wet year Fall X2 requirements cost the CVP an extra 400 TAF in exports cuts and storage withdrawals over the NAA, and the SWP contributes an additional 63 TAF. The SMSCG summer and fall operations in Initial Alternative 2 and Initial Alternative 3 have lesser effect on storage and deliveries compared to the Fall X2 effects.

What are the effects on different Delta smelt life history strategies (i.e., in freshwater, migratory, brackish water)?

- Three life histories, freshwater, brackish, and migratory, have been identified, but assessing the impact of Summer-Fall Habitat actions is difficult due to the current small population size of Delta smelt. If the Summer-Fall Habitat actions offer benefits to Delta smelt, the X2 and SMSCG actions would primarily impact the migratory and brackish water resident portion of the population, while the NDFS action (if beneficial) would likely impact the freshwater resident portion of the population.

Does this improve population recruitment and viability?

- Greater survival and growth in the summer-fall period should generally lead to higher fecundity and therefore recruitment for Delta smelt in the subsequent spring. However, the spatial extent and temporal duration of the actions are expected to influence the scale of measurable benefits and may be confounded by limiting factors such as climate change.

5.4 Shasta Reservoir Coldwater Pool Management

Shasta Reservoir cold-water pool management addresses water operations and development of a temperature management plan for Shasta Reservoir operations, including operation of a Temperature Control Device (TCD), to protect incubating winter-run Chinook salmon eggs. Appendix L- *Shasta Cold Water Pool Management* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- Does real-time onset and shaping of temperatures improve winter-run production or does a fixed schedule based on historical observations protect fish with limited water supply impact?
- How do water releases prior to the temperature management season influence the cold-water pool volume and temperature management capability during the temperature management season?
- How do releases within the season influence the temperature management capability for the remainder of the season?
- How do different carryover storage targets influence the cold-water pool volume in subsequent years and corresponding temperature management capability?
- What is the ability of other CVP and SWP operations to support cold water in Shasta reservoir?
- What is the effect of different coldwater pool management strategies on population viability?
- How does temperature control end dates effect loss after the end of spawning?
- What flows are most sensitive to redd dewatering?

Reclamation typically stores water in Shasta Reservoir in the winter and spring and releases water from Shasta in the summer and fall. Reclamation bypasses inflow and makes releases for senior water rights and State Water Board water quality control plan requirements (D-1641). Shasta releases for downstream demands depend, in part, on decisions and actions by parties other than Reclamation and DWR including the State Water Board, Sacramento River Settlement Contractors, Feather River Service Area contractors, and other Central Valley and Delta diverters. Initial alternatives describe how Reclamation and DWR may operate in response to the range of potential decisions by these other parties.

5.4.1 Options

Potential options for different subcomponents include: early season releases for water quality, water rights holders, and water service contracts; spring pulse flows; releases for end-of-season carryover; operation of the TCD; redd stranding tradeoffs between winter-run, fall-run, and storage the following year; and, system-wide opportunities and tradeoffs with Folsom Reservoir.

Initial Alternative 1 includes operations-based cold-water pool management where storage, inflow, and carryover maximize storage in Shasta Reservoir and the potential for cold-water pool to support winter-run egg incubation. Criteria include:

- Early season minimum releases of 3,250 cfs for end-of-April storage at 3.6 million acre-feet (MAF). To achieve the minimum releases, Reclamation and DWR would take the following actions, in order.
    - Reduce deliveries for CVP water service contracts.
    - Reduce releases for water rights holders subject to voluntary reduction and curtailment assumptions
    - Temporary Urgency Change Petition to D-1641
- Spring pulse releases when actions to achieve end-of-April storage are not required and when projected end-of-April storage is 4.1 MAF.
- In-season releases reduced to achieve end-of-September storage of 2.6 MAF. To achieve the minimum releases, Reclamation and DWR would take the following actions, in order:
    - Reduce deliveries for CVP water service contracts
    - Reduce releases for water rights holders subject to voluntary reduction and curtailment assumptions.
    - Temporary Urgency Change Petition to D-1641
- Cold-water pool management season May 15–Oct. 30, with stage dependent targeting for the development of winter-run embryos (tiered strategy for optimization).
- Minimum base flows of 3,250 cfs after October 30.

Storage targets and fixed temperature management strategies seek to avoid or minimize adverse effects on winter-run.

Initial Alternative 2 includes other systemwide measures, including non-flow actions supporting winter-run. Criteria include:

- Early season minimum releases of 3,250 cfs subject to senior water rights and water quality control plan requirements. No senior water right measures and no Temporary Urgency Change Petitions.
- Spring pulse releases in Tier 1 years.
- In-season releases based on CVP water service contracts.
- Coldwater pool management season May 15–Oct 30, with stage-dependent targeting of winter-run embryos.
- Storage-based ramp down table.

Actions for winter-run rely upon operation of the TCD to achieve water temperatures.

Initial Alternative 3 includes real-time monitoring of biological and operations performance measures where storage, inflow, and real-time observations of environmental conditions and winter-run spawning guide Shasta water releases and cold-water pool management. Criteria include:

- An early season minimum release objective of 3,250 cfs with planning based on an expanded tier system of projected TDMs. Actions based on forecasts and projected TDMs include:
  - Reduce releases for CVP water service contracts.
  - Meet and confer actions with Sacramento River Settlement contractors.
  - Reduce releases for Sacramento and Feather senior water right holders.
  - Temporary Urgency Change Petition.
- Spring pulse releases when early season actions are not required and in-season management is not anticipated.
- In season releases based on TDM tiers and storage objectives. Actions based on projected TDMs include:
  - Reduce releases for CVP water service contracts.
  - Reduced releases for deliveries to water rights holders subject to voluntary reduction and curtailment assumptions.
  - Temporary Urgency Change Petition.
- Tiered cold-water pool management season May 15–Oct 30, with onset timing.
- Redd stranding risk management.

Actions anticipate substantial coordination and risk management. TDM objectives.

Initial Alternative 4 is a programmatic approach. A reasonable range of Shasta Reservoir cold-water pool management options is covered by Initial Alternatives 1, 2, and 3.

5.4.2 Analysis

Reclamation solicited input for the knowledge base paper, *Shasta Coldwater Pool and Storage Management – Chinook Salmon and Steelhead Growth and Survival*, included as an attachment to Appendix L- *Shasta Cold Water Pool Management*.

Reclamation analyzed Shasta Dam operations utilizing the CalSim II models developed for the Exploratory Modeling. Modeling showed the Shasta releases needed for regulatory requirements, ESA actions, and deliveries through the exploratory layers with increasing operational complexity. Next, CalSim II in position analysis mode used Exploratory Modeling Layer 5P (EXP 5P) to represent operations with full complexity and project deliveries when water was available and Exploratory Modeling Layer 4.95 (EXP 4.95) to represent full operational complexity and Project deliveries at public health and safety levels only. These model runs spanned 18 potential initial end-of-September storage conditions for Shasta Reservoir and 82 1-year simulations using the 82-year period of record available. The results of these analyses were then passed on to the HEC-5Q (temperature) and TDM models that helped connect operational variability to temperature management and potential fisheries effects. This Shasta Operations Analysis and its findings were shared with interested parties in multiple meetings and is summarized in Attachment 1 of Appendix L.

The analysis above informed initial alternatives. Reclamation conducted full 82-year CalSim II simulations for Initial Alternative 1, Initial Alternative 2, and Initial Alternative 3; followed by temperature and TDM models for the three initial alternatives described above. Model assumptions and results of these initial alternatives are summarized in Attachment 2 of Appendix L.

5.4.3 Findings

Does real-time onset and shaping of temperatures improve winter-run production or does a fixed schedule based on historical observations protect fish with limited water supply impact?

- This finding is under development and will be provided as part of the Public Draft EIS. How do water releases prior to the temperature management season influence the cold-water pool volume and temperature management capability during the temperature management season?
- Releases include minimum instream flows, D-1641, actions for fish, water delivery, and flood control in October-April.
- Releases for D-1641 depend on the water year type; therefore, uncertainty in forecast hydrology makes forecasting the required releases and Spring fill uncertain.
- Reducing minimum instream flow releases for Wilkins Slough and water deliveries for Sacramento River Settlement Contractors and Refuges can potentially increase end-of-April storage by an average of 110 TAF – values range from 0 to 795 TAF.

- Releases for fish (e.g., redd maintenance, Fall X2, Spring Pulse) depend on the previous water year type and storage. Releases for redd maintenance (fall flow stability) have an average total volume of 180 TAF October–February when September carryover is greater than 2,200 TAF. Releases in October to support Delta outflow for Fall X2 criteria can reach 675 TAF under unique conditions, but average about 210 TAF over all W and AN years. Releases for Spring Pulse flows are only made when fill is likely to reach at least 4100 TAF, and these are at most 150 TAF by definition.
- During this season, releases for CVP water service contracts and exports can potentially increase end-of-April storage by an average of 60 TAF – values range from 0 to 437 TAF.
- When carryover plus inflow is greater than approximately 6 MAF, flood conservation pool controls releases and other actions have a limited effect.

How do releases within the season influence the temperature management capability for the remainder of the season?

- Releases within the management season are largely driven by minimum instream, fish flows and delivery needs.
- In drier years, the need to reserve cold water for temperature management through the season drives decisions on timing of releases.

How do different carryover storage targets influence the cold-water pool volume in subsequent years and corresponding temperature management capability?

- Temperature management capability is strongly correlated with end-of-April fill and the contributing spring hydrology and meteorology throughout the season.
- Carryover storage can affect end-of-April storage if the subsequent winter and spring are very dry.
- Higher levels of carryover can result in significant spill in the following winter and spring, possibly representing foregone deliveries in the previous year, and increasing flood damage risk.
- In critically dry years, project allocations are minimal, and operations focus is on meeting environmental criteria and delivering water supply as possible to senior water users. A carryover target under such conditions may be hydrologically and operationally impossible to meet.

What is the ability of other CVP and SWP operations to support cold water in Shasta reservoir?

- CVP's facilities are operated collectively, balancing local obligations with overall system needs and taking advantage of opportunities for flexibility. Margins for exploring tradeoffs between Folsom and Shasta, and between Trinity and Shasta are already thin in years where water supply conditions present operational challenges.

- Restricting early season releases at Keswick to improve Shasta fill potential shifts the burden of CVP release to Folsom – this can render the role of the December planning minimum for Folsom storage ineffective.
- Tradeoffs with SWP operations have not been evaluated in these studies.

What is the effect of different cold-water pool management strategies on population viability?

- This finding is under development and will be provided as part of the Public Draft EIS

How does temperature control end dates affect loss after the end of spawning?

- This finding is under development and will be provided as part of the Public Draft EIS

What flows are most sensitive to redd dewatering?

- 80% of winter-run spawn in locations inundated at ~6,200 cfs.
- Historical dewatering of total winter-run redds (2013 through 2021) has ranged from 0 to 0.67% in 2020 averaging 0.13%.

5.5 Folsom Flow and Temperature Management

Folsom flow and temperature management addresses the tradeoffs for minimum releases and the use of available cold-water pool in Folsom Reservoir for water supply and for steelhead and fall-run Chinook salmon in the American River. Appendix M- *Folsom Reservoir Flow and Temperature Management* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- What habitat is created for steelhead and fall-run Chinook salmon at different releases?
- What is the additional water temperature capability at different storage levels?
- How does planning minimum storage for both the end of September and the end of December improve potential cold-water habitat?
- What planning minimum reservoir storage maintains water supply intakes in Folsom Reservoir?
- What risks occur from operating to a 50% exceedance forecast early in the water year?
- What temperature targets reasonably protect steelhead while leaving sufficient cold water for fall-run Chinook salmon?
- How do releases on the American River affect Shasta Reservoir, WQCP, and exports?

5.5.1 Options

Potential operations for different subcomponents for the Modified Flow Management Standard include: (1) minimum release requirements for the fall, winter, spring, and/or summer seasons; (2) a spring pulse flow; (3) target location for steelhead water temperatures of 65°F, and planning minimums for reservoir storage.

Initial Alternative 1 includes additional release above the 2017 modified flow management standard, downstream water temperature targets, and an emphasis on storing water rather than meeting Delta needs with the following criteria:

- Minimum Release Requirement (Increase by 10%)
    - Spring volumes
    - Fall volumes
    - Spring pulse (March 15–April 15)
- Coldwater Pool
    - Annual Temperatures Selection Procedure (ATSP) priority for listed species only
  - Steelhead Juvenile Criteria (May–Oct.) 65°F at Watt Avenue
  - Fall Run Adult Spawning Criteria (May–Sept./Oct) 65°F at Watt Avenue
    - Power bypasses as required
- Minimum Storage Planning Goal
    - End-of-December storage of 350 TAF in forecasts

Initial Alternative 2 relies on other measures to meet species needs and relies on the 2017 Modified Flow Management Standard, as described in the 2020 ROD, with updates to temperature management to reflect dry year conditions and no spring pulse.

- Minimum Release Requirement
    - Spring Volumes from the 2019 LTO Proposed Action (i.e., 2017 Modified Flow Management Standard with modifications)
    - Fall Volumes from the 2019 LTO Proposed Action
- Coldwater Pool
    - Steelhead Juvenile Criteria of 65°F at Hazel Avenue
    - Fall-Run Adult Spawning Criteria of 65°F at Hazel Avenue
    - No power bypass
- Minimum Storage Planning Goals

        - End-of-December storage of 300 TAF in forecasts

Initial Alternative 3 incorporates real-time shaping of a spring pulse and fall dewatering adjustments with a flexible temperature management and planning minimums

- Minimum Release Requirement
    - Spring Volumes at 2019 Minimum Release Requirements
    - Fall Volumes at 2019 Minimum Release Requirements
    - Spring Pulse (March 15–April 15, C, D) with possible reshaping of flows
    - Fall dewatering adjustments
- Coldwater Pool
    - Flexible
  - Steelhead Juvenile Criteria at Watt Avenue or Hazel Avenue
  - Fall Run Adult Spawning Criteria at Hazel Avenue
    - Power bypass based on a biological evaluation
- Minimum Storage Planning Goals
    - End-of-December storage of 275 to 350 TAF in forecasts

Initial Alternative 4 is a programmatic approach. The range of releases may include contributing a proportional share of 65% unimpaired Delta outflow to the instream flow agreements that predate the flow management standard, for example, D-1641.

5.5.2 Analysis

Reclamation solicited input through "small group" meetings with the state and federal agencies and alternative formulation with public water agencies and interested environmental nongovernmental organizations (NGOs).

Three 82-year simulations were conducted under the operations described for Initial Alternative 1, Initial Alternative 2, and Initial Alternative 3 described above. CalSim II simulations were used to assess water supply effects; and HEC-5Q (temperature) model simulations were used to assess effects of resulting operations on species. Initial Alternative 4 was evaluated qualitatively using all of the available analyses. A sensitivity study evaluating the influence of 50% vs 90% exceedance forecasts on implementation of the American River Flow Management Standard was also performed.

5.5.3 Findings

The combination of increased Minimum Release Requirement flows and higher planning minimum for December storage in Initial Alternative 1 have offsetting implications for operations on the American River. Fall releases at Nimbus, which are often controlled by Minimum Release Requirement, trend slightly higher than the No Action Alternative, but later in the summer releases are lowered by the effort to target the higher planning minimum for December storage. These operations cause lower storage conditions in Shasta in most years, particularly in drier periods. The average effect on end-of-September Shasta storage is 50 TAF, and in drier years is triple that. The modest increase to December planning minimum storage in Initial Alternative 2 and Initial Alternative 3 has a limited effect on Nimbus flow, increases December Folsom Reservoir storage as expected, and has an average effect of 6 TAF on Shasta Reservoir storage. Answers to the specific management questions are under development.

5.6 New Melones Stepped Release Plan

The New Melones Stepped Release Plan addresses the volume of instream flows that can occur over a multi-year hydrology without impacting reservoir levels to the extent of depleting the cold-water pool to cause the release of warm water. Appendix N- *New Melones Stepped Release Plan* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- What is the relationship between releases and downstream water temperatures?
- What reservoir storage levels result in the release of warm water?
- Does the long-term instream release result in storage levels that would result in the release of warm water that would impact salmonid survival?
- What risks occur from operating to a 75% exceedance forecast early in the water year?
- What hydrograph shape optimizes Central Valley steelhead anadromy and survival? Is there a flow intensity threshold to cue migration?
- What is the optimal pulse flow timing by water year-type to increase salmonid survival, increase life history diversity, and contribute to successful spawning adult population? What migratory phenotypes (i.e., fry, parr, smolts) are more likely to survive under different flow regimes?
- How do releases on the Stanislaus River impact WQCP and exports?

5.6.1 Options

The stepped release plan provides a default daily hydrograph with base flows to optimize available Central Valley steelhead habitat for adult migration, spawning, and juvenile rearing. The base flows are scaled to a water supply parameter that is a function of end-of-February New Melones Reservoir Storage and forecasted inflow from March through September. Potential operations for different subcomponents address the volume of water in the default daily hydrograph and the ability to shape monthly and seasonal flow volumes to meet specific biological objectives including fall attraction flows, winter instability flows, and spring pulse flows that also accomplish channel maintenance.

Initial Alternative 1 include additional volumes under the default hydrograph to meet 40% unimpaired inflow volumes through larger and longer spring pulse flows.

Initial Alternative 2 includes the 2020 ROD flows adjusted to use a 90% forecast but without reshaping the default hydrograph.

Initial Alternative 3 uses the same flows as the 2020 ROD, but includes real-time shaping.

Initial Alternative 4 is a programmatic range with flows that include the maximum required under the 2020 ROD Stepped Release Plan or Unimpaired Inflow, whichever is greater, down to the releases needed under D-1641, but without assignment of the spring pulse flow requirement to Reclamation's New Melones water rights.

5.6.2 Analysis

Reclamation solicited input through "small group" meetings with the state and federal agencies and alternative formulation with public water agencies and interested environmental NGOs.

Three 82-year simulations will be conducted under the operations described for Initial Alternative 1, Initial Alternative 2, and Initial Alternative 3 described above. CalSim II simulations will be used to assess water supply effects; and HEC-5Q (temperature) model simulations will be used to assess effects of resulting operations on species Initial Alternative 4 will be evaluated qualitatively using all of the available analyses. This modeling will be completed after the release of this document.

5.6.3 Findings

Modeling is under development.

5.7 Tributary Habitat Restoration

Tributary habitat restoration addresses spawning and rearing habitat on the Sacramento River, American River, Stanislaus River, Clear Creek. Project activities include primarily side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions. Appendix O- *Tributary Habitat Restoration* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- Where is a tributary habitat limitation affecting life stages?
- Does habitat restoration increase primary and secondary productivity and improve growth?
- Does habitat restoration provide refuge habitat and improve survival?
- How does habitat restoration impact operations for flood conveyance, water supply, water quality, and/or hydropower?
- Where can connectivity be restored to provide fish access to suitable habitats and reduce potential habitat restoration needs downstream?

Reclamation has authorities for habitat restoration most specifically through the Central Valley Project Improvement Act (CVPIA), Public Law 102-575. Reclamation and USFWS implement habitat restoration through competitive grants with science-based priorities developed through structured decision making by the CVPIA Science Integration Team. Given the existing program, initial alternatives evaluate tributary habitat restoration in terms of potential impacts and effects, not a range of options.

5.7.1 Analysis

Reclamation solicited input for the knowledge base paper *Central Valley Tributary Habitat Restoration Effects on Salmonid Growth and Survival*, included as an attachment to *Appendix O-Tributary Habitat Restoration*. Reclamation addressed management questions primarily through literature review.

5.7.2 Findings

Where is a tributary habitat limitation affecting life stages?

- Decision analyses showed that restoration of either spawning or in-channel rearing habitat was optimal under most evaluated conditions.
- Optimal restoration activities consistently included juvenile habitat restoration either on the mainstem Sacramento River and Clear Creek, suggesting that habitat limitation more strongly affects salmon production in these systems.

Does habitat restoration increase primary and secondary productivity and improve growth?

- If habitat restoration includes construction of seasonally inundated floodplain habitat, restoration can increase primary and secondary productivity and improve growth based on studies of growth rates in floodplain and in-channel habitats (Jeffres et al. 2008).
- Estimated juvenile growth in seasonal floodplain habitat can be twice that observed in perennial habitat (Sommer et al. 2001).
- The effects of perennially inundated habitat restoration on productivity and growth are less clear.
- Monitoring of several side channel restoration projects observed no clear differences in growth rates among restoration and control side channels; however, lengths of Chinook salmon sampled from restoration sites tended to exhibit greater fork lengths than mainstem sites, which could suggest either increased growth rates or differential habitat use by different size classes.
- More recent monitoring of side channel monitoring did observe high macroinvertebrate abundance in restored side channels than in baseline channel habitats (Banet et al. 2022). Monitoring of a side channel restoration project in the lower Mokelumne River observed rapid colonization of newly created habitat by macroinvertebrates and habitat use by juvenile steelhead and Chinook salmon, but did not compare fish or invertebrate densities to control sites (Heady and Merz 2007).

- Comparison of growth rates among multiple rearing habitats in the lower San Joaquin River revealed lower growth rates in main-channel habitat and suggested enhancements in habitat productivity may be necessary in these regions (Zeug et al. 2019).
- Spawning habitat restoration via gravel augmentation also can increase observed macroinvertebrate biomass, but effects on growth are less clear (Merz and Chan 2005).

Does habitat restoration provide refuge habitat and improve survival?

- The scientific literature suggests that fish response to restoration varies greatly depending on the watershed template, location, and characteristics of the habitat restoration, and the life history of and limiting factors for a species.
- Results obtained from monitoring habitat projects in the upper Sacramento River (Keswick to Red Bluff area) Anadromous Fish Habitat Restoration Project from 2015 to 2021 show that the work effectively produced additional high-quality juvenile salmonid habitat that supports higher numbers of fish.
- Higher abundance of macroinvertebrates (determined by sampling rate) observed in restored side channels as compared to baseline channels suggests that there may be a positive effect of restoration on food availability, although biomass and diet information were unavailable (Banet et al. 2022).

How does habitat restoration affect operations for flood conveyance, water supply, water quality, and/or hydropower?

- The flood conveyance baseline continually changes as riverbeds downgrade from sediment movement without replacement. The downgraded condition becomes the new baseline for subsequent habitat projects and this limits the scope of the project. When habitat projects can expand flood conveyance laterally, they can increase habitat while maintaining and potentially increasing conveyance capacity. These same projects can increase the time water remains on streamside areas to increase groundwater storage for the future.
- Downcutting of river mainstems has disconnected off-channel habitat such as side channels and floodplains. Habitat projects can be designed to provide suitable habitats at flow regimes with less variability than the historic habitats experienced.
- Habitat restoration can improve water quality by providing backwater areas for suspended sediment to settle out, resulting in cleaner water and fertile soils for riparian vegetation establishment.

Where can connectivity be restored to provide fish access to suitable habitats and reduce potential habitat restoration needs downstream?

- The table below shows priority actions identified by the CVPIA program to address limiting factors in Central Valley watersheds with a focus on watersheds with CVP facilities.

Table 1: Priority Actions identified by the CVPIA program

Near Term Restoration Strategy Action	Chinook Runs Primarily Benefiting
Action 1: Juvenile habitat restoration in mainstem Sacramento River above the American River confluence.	All
Action 2: Reconnect ephemeral non-natal tributaries below Keswick Dam to the mainstem Sacramento River.	Winter
Action 3: Juvenile habitat restoration in Battle Creek in winter-run Chinook salmon juvenile rearing locations.	Winter
Action 4: Juvenile habitat restoration in American River.	Fall
Action 5: Juvenile habitat restoration in the Stanislaus River downstream through the San Joaquin River at Vernalis.	Fall
Action 6: Juvenile habitat restoration in Clear Creek.	Spring, Fall
Action 7: Improve survival in Butte Creek in downstream areas.	Spring, Fall
Action 8: Juvenile habitat restoration in the lower Feather River below the confluence of the Yuba River.	Fall, Spring
Action 9: Maintain existing spawning habitats in upper Sacramento, American, and Stanislaus Rivers; and Clear and Butte Creeks.	All

5.8 Delta Habitat Restoration

Delta habitat restoration addresses the historical loss of tidal marsh habitat that provided food and refugia for listed species and other native fish. Appendix P - *Delta Habitat Restoration* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- Where is a Delta habitat limitation impacting life stages?
- Does habitat restoration increase primary and secondary productivity and improve growth?
- What is the energy flow of habitat restoration productivity to different regions of the Delta, fish, and/or clams?
- Does habitat restoration provide refuge and improve survival?
- How does habitat restoration impact operations for flood conveyance, water supply, and/or water quality?

Tidal habitat restoration required in the USFWS 2008 Biological Opinion was included within the 2020 ROD and its accompanying 2019 Biological Opinions. The Yolo Bypass Salmonid Habitat and Fish Passage ROD and the Suisun Marsh Habitat Management, Preservation, and

Restoration Plan ROD implements additional Delta habitat actions. Contrary to other variable components, initial alternatives for tidal habitat restoration address whether to include or exclude habitat restoration from consideration, and not a range of options.

5.8.1 Analysis

Although there is limited direct habitat studies in the Delta and there was no knowledge base paper for Delta habitat restoration, many of the datasets, literature, and models overlapped. Since implementation of the ROD and Incidental Take Permit, Reclamation and DWR have applied a series of non-flow, habitat-restoration actions within the Delta to improve spawning and rearing habitat and foodweb conditions. *The Long-Term Operations Habitat Restoration Report*, updated annually or as needed, lists planned, under-construction, and recently completed habitat-restoration actions. Reclamation and DWR have developed multiple documents that are being used to understand and monitor the effects of these actions, identify science and monitoring needs, identify relevant models and data sets, and guide structured decision making. Documents include the following: (1) Science and Monitoring Plan, updated annually; (2) action-specific operations and science plans, updated every 1 to 3 years; (3) structured decision-making process document and performance measure information sheets (California Department of Water Resources 2022, Appendix B); and (4) 2022 Action Plan (California Department of Water Resources 2022).

Delta habitat restoration can affect the growth of juvenile Chinook salmon through modifications to water temperature, food availability, and competition for resources. Shallow Delta habitats, including wetlands and floodplains, typically exhibit greater temperatures, higher residence times, and greater production and retention of macroinvertebrates, with resulting positive effects on growth rates relative to channeled habitat (Schemel et al. 2003; Jeffres et al. 2008). Delta habitat restoration can also affect juvenile Chinook salmon by providing greater food resources and increasing cover or bathymetric heterogeneity as refugia from predators (Rahel and Stein 1998; Hering et al. 2010). Increased connectivity and habitat heterogeneity also can allow salmon to adapt and move in response to locally stressful conditions (Armstrong et al. 2013).

For Delta smelt habitat restoration is aimed toward increasing food subsidies. During the spring and summer, Delta smelt rear in the low-salinity zone. Thus, restoration projects that target areas adjacent to rearing areas (e.g., western Delta, Suisun Bay, Cache Slough Complex) and create suitable conditions are expected to benefit Delta smelt.

5.8.2 Findings

Where is a Delta habitat limitation affecting life stages?

- In 2020, a San Francisco Estuary Institute (SFEI) analysis identified that salmonids are limited in rearing habitat availability in the Sacramento River mainstem, San Joaquin River mainstem north of Stockton, Georgiana Slough and north fork Mokelumne River, and south Delta. The SFEI analysis estimated an additional 23,475 acres (9,500 hectares) of marsh and other floodplain habitats are needed for salmon rearing in the Delta, beyond habitat that already exists or is planned for restoration.

- A separate analysis by Cramer Fish Sciences estimated 11,200 and 4,600 acres of suitable rearing habitat are necessary to achieve Anadromous Fish Restoration Program doubling goals, based on territory size (California Department of Water Resources 2016).
- IEP MAST (2015) reports little information about Delta smelt habitat and attributes needed for successful spawning.
- Delta smelt and longfin smelt migrate throughout the course of the year, so different regions of the Delta may benefit the fish at different times of the year (Sommer et al. 2011).
- Delta and longfin smelt are affected by habitat limitations associated with warm water temperatures and food availability to meet energetic demands.

Does habitat restoration increase primary and secondary productivity and improve growth?

- The production of primary and secondary productivity depends on restoration design and environmental conditions, and can be highly variable even between similar sites (Lucas et al. 2002, 2009; Sherman et al. 2017).
- Information on habitat restoration relies upon studies performed in other estuaries. Studies of habitat restoration effects in the Delta are rare.

What is the energy flow of habitat restoration productivity to different regions of the Delta, fish, and/or clams?

- Effects of habitat restoration actions may require a regional perspective to capture connectivity among other habitats, and site-specific design understanding transportation is important for supporting phytoplankton reaching targeted species and reducing the impact of nonnative species competing and consuming these food resources (Herbold et al. 2014).
- Areas colonized by the invasive clam *Corbicula fluminea* functioned as food sinks, due to consumption, while uncolonized areas may serve as food sources.

Does habitat restoration provide refuge and improve survival?

- Information on habitat restoration relies upon studies performed in other estuaries. Studies of habitat restoration effects in the Delta are rare.
- Based on studies in Washington State estuaries, survival of wild migrant fry Chinook salmon was higher in pocket estuary habitat (i.e., areas with less saline water near creek mouths or coastal embayments), which could serve as structural and salinity-based refugia (Beamer 2006).
- For Delta and longfin smelt, habitat restoration may improve survival where sites meet the habitat requirements of species (e.g., water quality); where there are few predators, contaminants, clams, and invasive species; where sites are far from export facilities; and

where there is potential to accommodate sea-level rise (Herbold et al. 2014; Sherman et al. 2017; Sommer and Mejia 2013).

How does habitat restoration affect operations for flood conveyance, water supply, and/or water quality?

- The flood conveyance baseline continually changes as riverbeds downgrade from sediment movement without replacement and become the new baseline for subsequent habitat projects, which limits the scope of the project.
- When habitat projects can expand flood conveyance laterally, they can increase habitat, while maintaining and potentially increasing conveyance capacity. These same projects can increase the amount of time that water remains on streamside areas.
- Habitat projects can be developed to inundate in lower flow conditions and result in less water needed to maintain suitable habitats.
- Habitat projects can improve water quality by providing backwater areas for suspended sediment to settle out, resulting in cleaner water and fertile soils for riparian or marsh vegetation establishment.

5.9 Georgiana Slough Non-Physical Barrier

The Georgiana Slough Non-Physical Barrier addresses the effects of releases and exports on the migration of Sacramento River-origin salmon and steelhead. Appendix Q describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- How does the presence of the barrier influence routing of salmonids in the interior Delta?
- What is the difference in survival to Chipps Island with or without the barrier?
- What is the difference in salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protective Facility with or without the barrier?
- What is the effect of routing at Georgiana Slough on salmonid population viability?

Initial alternatives for Georgiana Slough Non-Physical Barrier address whether to include or exclude the barrier.

5.9.1 Analysis

DWR tested the installation of non-physical barriers at Georgiana Slough and provided two reports on the effectiveness for local routing and survival to Chipps Island: *2012 Georgiana Slough Non-Physical Barrier Performance Evaluation Project Report* (California Department of Water Resources 2015.) and *2014 Georgiana Slough Floating Fish Guidance Structure Performance Evaluation Project Report* (California Department of Water Resources 2016).

5.9.2 Findings

DWR determined a non-physical barrier is effective and is consulting through the U.S. Army Corps of Engineers to implement the Georgiana Slough Salmonid Migratory Barrier project. From 2023 through 2030, a Bio-Acoustic Fish Fence will be deployed at the Georgiana Slough junction during the time of year when juvenile salmonids are outmigrating from the Sacramento River. Reclamation will coordinate with and support DWR on the non-physical barrier.

5.10 Head of Old River Barrier

The purpose of the spring Head of Old River Barrier is to improve migration conditions for salmonids entering the Delta from the San Joaquin River, and its tributaries, by increasing flows down the San Joaquin River and preventing salmonids from entering Old River and being entrained into the CVP and SWP export facilities. Appendix R- *Head of Old River* describes and analyzes options for this component to support refinement into Public Draft EIS alternatives. Reclamation's management questions for the formulation of an alternative include:

- How does presence of the barrier affect survival to Chipps Island compared to a combined salvage and San Joaquin River route without the barrier?
- What is the effect of flow and fish routing at the Head of Old River on steelhead population viability?
- What is the effect of the barrier on Delta hydrodynamics?
    - Does the barrier cause additional export restrictions to maintain OMR criteria?
    - For the same OMR flow management, does the barrier increase Delta and/or longfin smelt entrainment?
- How much additional flow is routed down the San Joaquin River when the barrier is present?
- Are there water temperature benefits associated with the installation of the barrier?

Initial alternatives for Head of Old River Barrier address whether to include or exclude the barrier.

5.10.1 Analysis

Interagency coordination resulted in NMFS preparing a knowledge base paper, *Head of Old River Barrier*, included as an attachment to Appendix R- *Head of Old River Barrier*. Water temperature data was collected at the Head of Old River Barrier and Prisoner's Point stations.

A sensitivity analysis was conducted using CalSim II, with and without Head of Old River Barrier installation. The scenario assumed the barrier to be installed from mid-April to end of May. Results of this analysis is presented in Appendix R.

5.10.2 Findings

How does presence of the Head of Old River Barrier affect survival to Chipps Island compared to a combined salvage and San Joaquin River route without the barrier?

- Entrainment loss accounted for less than 5% of the total mortality for a majority of coded-wire tag (CWT)-releases made with San Joaquin River Chinook salmon.
- Chinook salmon acoustic telemetry suggests little difference in survival to Chipps Island with or without the barrier; however, survival through salvage facilities may be the highest survival route.
- With the barrier, increased flows in the San Joaquin River between Head of Old River and Turner Cut may increase steelhead survival; however, reduced velocities upstream of Head of Old River may reduce steelhead survival.
- For both species, survival is lower for fish that enter Turner Cut (and presumably the other junctions). When more fish are routed into the San Joaquin River at Head of Old River, more would also be expected to be entrained into Turner Cut and other downstream junctions where survival is poor and not affected by the barrier.
- Despite large changes to the routing of flows and fish with the barrier, the difference in steelhead survival to Chipps Island is equivocal compared to without the barrier.

What is the effect of flow and fish routing at the Head of Old River on steelhead population viability?

- We do not yet have a model to evaluate this question.

What is the effect of the Head of Old River Barrier on Delta hydrodynamics?

- In the San Joaquin River downstream of the Head of Old River, flows increased and flow direction was downstream more often.
- In more tidal reaches of the Delta, such as Old River at Rail Road Cut and the San Joaquin River at Turner Cut, there was little influence on flows.
- As inflow increased to 4500 cfs, the effects of flow at the stations downstream of Head of Old River were amplified, whereas more muted effects were seen downstream in the more tidal reaches.
- Exports appeared to have only minor effects on flows, primarily in Old River just downstream of the Head of Old River.

Does the barrier cause additional export restrictions to maintain OMR criteria?

- The barrier increases Delta outflow flow by 73 TAF on average with up to 160 TAF in wet years and less in drier years.
- The average monthly flows at the Head of Old River are reduced an average of 256 TAF over the April–May period, with reductions triple that not uncommon. Loss of flow from

the San Joaquin toward export facilities results in a more negative OMR flow for the same amount of export in those months.

- More of the water for export needs to come through the OMR and restrictions on negative OMR flow are more likely to restrict exports.
- The with-barrier alternative results in reduced exports in the order of 70 TAF per year, which results in reduced south-of-Delta deliveries and modeled south-of-Delta shortages.

For the same OMR, does the Head of Old River Barrier increase Delta smelt and longfin smelt entrainment?

- DSM2-PTM analysis is under development.

How much additional flow is routed down the San Joaquin River when the Head of Old River Barrier is present?

- There was a strong tidal signal at this location regardless of barrier status with bidirectional flows.
- When San Joaquin River inflows were 1,000 cfs and exports were 1,500 cfs, modeling suggests a moderate increase; however, this distribution shifted more positive with higher flows (49.4% overlap).
- As inflow increased to 4,500 cfs, the barrier effect also increased, with a larger increase in the distribution of flows (0% overlap) and a shift to fully unidirectional flow in the San Joaquin River downstream of Head of Old River.

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6. Species Life-Cycle Analyses

Input during scoping identified performance measures to consider during alternatives formulation. The long-term survival of species depends on completing their lifecycles across the range of conditions. Diversity in migration timing, life-history, and geographic populations can support the ability of the population to recover from poor environmental conditions. Where available, the sections below describe the relative survival in different life stages to identify the relative importance of common components and options for variable components. Initial Alternatives consider components separately. The Biological Assessment will include a life cycle analysis for the Proposed Action.

6.1 Winter-Run Chinook Salmon

The CVPIA Science Integration Team developed decision support models to identify investments to improve populations of anadromous fish, including winter-run Chinook salmon. Figure 2 shows simulated winter-run Chinook salmon mortality and returning adults by life stage and geographic reach under the 2009 NMFS Biological Opinion.

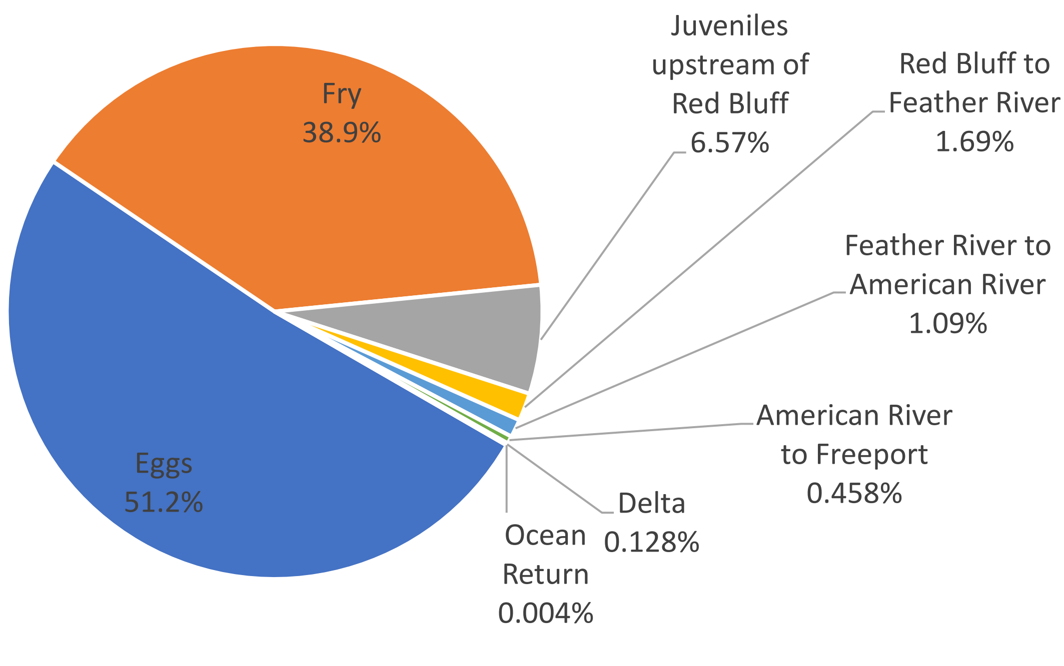

Figure 2. Average Disposition of Winter-Run Chinook Salmon by Mortality in Different Life Stages or Ocean Entry

Most fish perish as eggs or fry with smaller numbers migrating to the Delta and returning from the ocean as adults. Achieving cohort replacement would require an ocean entry of 0.005%, an approximately 10-fold improvement. Average numbers mask year to year variability in populations that may rebound after a drought and do not consider supplementation from the Livingston-Stone National Fish Hatchery.

Changes in mortality in any single stage do not directly correspond to increases in populations. Figure 3 provides an elasticity diagram showing the potential increase in fish returns for a similar improvement in survival for each of the stages (e.g., 20% improvement in egg to fry survival, a 20% improvement in Delta survival, etc.).

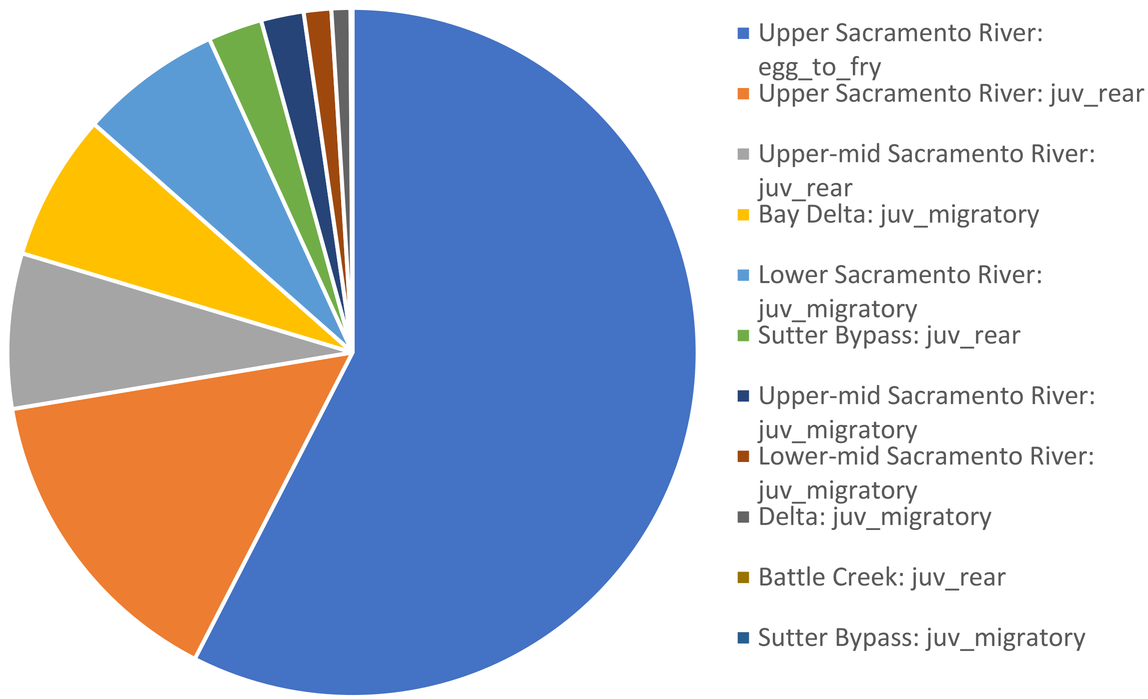

Figure 3. Winter-Run Chinook Salmon Elasticity across All Water Year Types

A proportional improvement in egg to fry survival would yield the most additional returns followed by an improvement in Upper Sacramento River juvenile rearing; however, the level of effort required for an improvement may not be the same for both life stages. The population of winter-run Chinook salmon are influenced by droughts; therefore, a worst-case year identifies the potential for increasing drought resiliency, Figure 4.

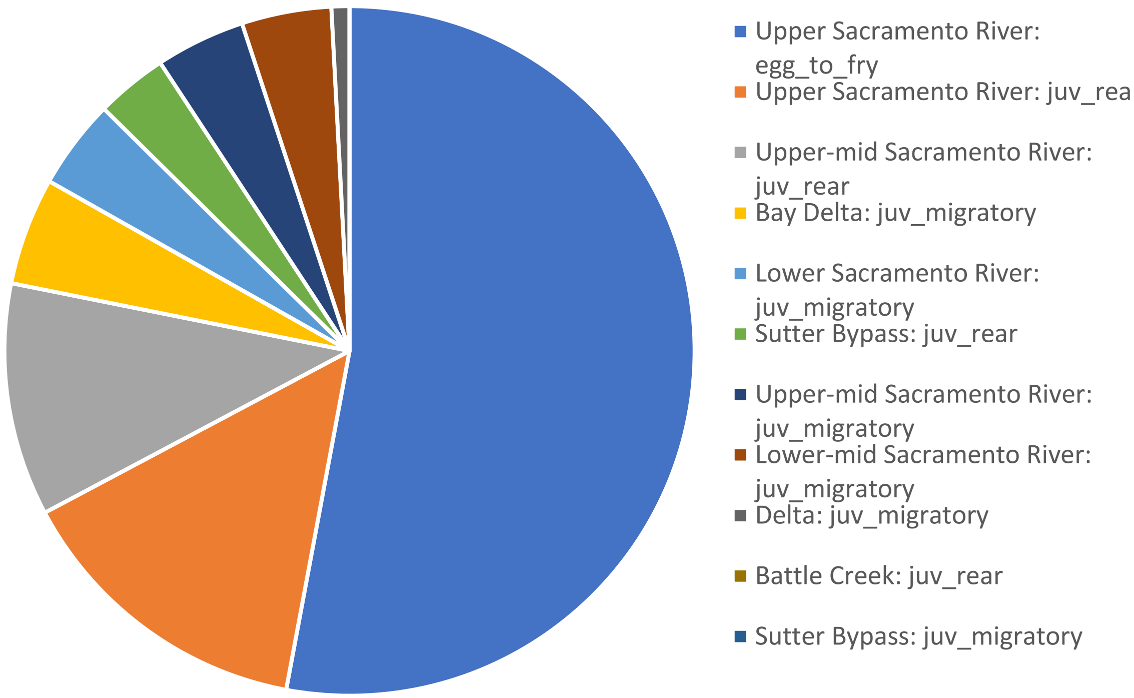

Figure 4. Winter-Run Chinook salmon Elasticity in a Historically Worst-Case Year

A proportional increase in egg to fry survival would still yield the most additional returns followed by Upper Sacramento River (Keswick Dam to Red Bluff Diversion Dam) juvenile rearing; however, the relative benefits of improving Upper-Middle (Red Bluff Diversion Dam to Wilkins Slough) and Lower-Middle Sacramento River (Wilkins Slough to the American River Confluence) migration increases. Current conditions and population elasticity may inform the development of potential fisheries objectives.

6.2 Spring-Run Chinook Salmon

The CVPIA Science Integration Team developed decision support models to identify investments to improve populations spring-run Chinook salmon. Figure 5 shows the elasticity diagram.

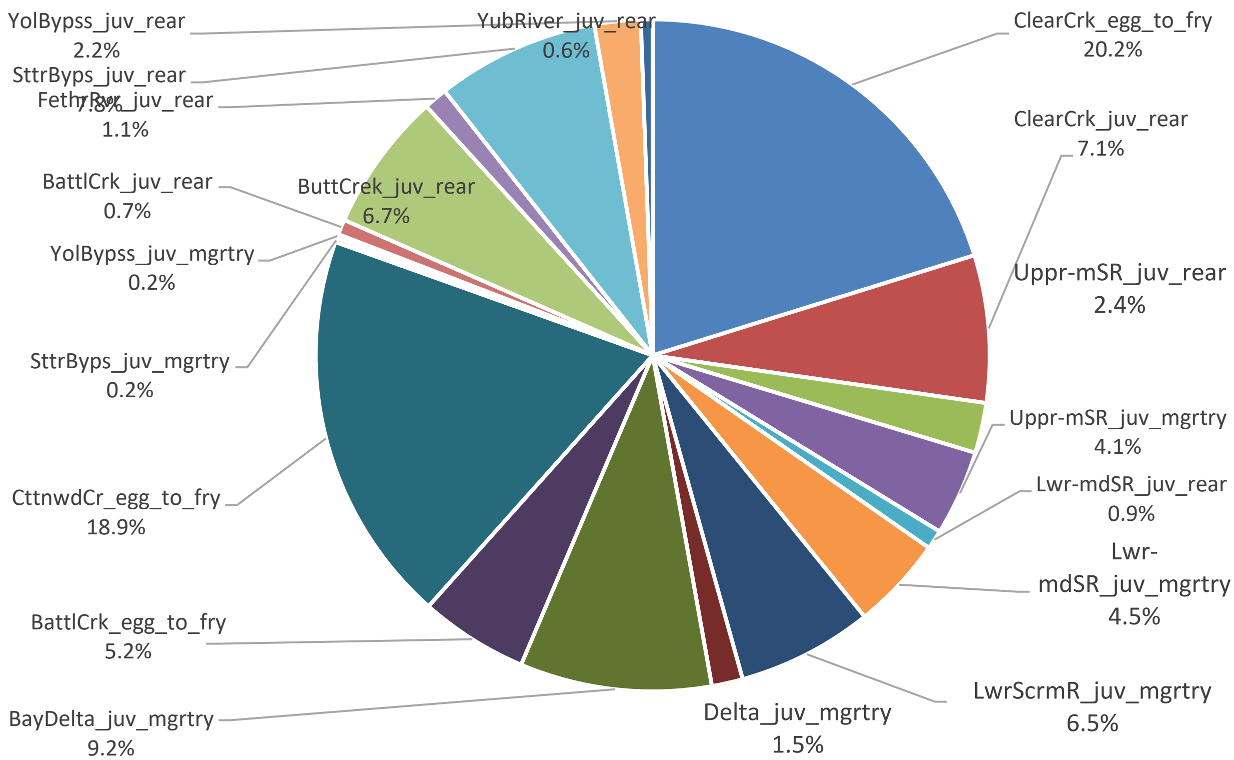

Figure 5. Elasticity for Spring-Run Chinook Salmon

For the CVP, improvements in Clear Creek egg to fry survival and juvenile rearing would increase adult returns but may not benefit geographic diversity. Operation of the CVP and SWP to improve migration in the Sacramento River may provide an additional XX percent of the elasticity. Improvement in Delta migration accounts for 1.5%.

6.3 Steelhead

This finding is under development and will be provided as part of the Public Draft EIS.

6.4 Delta Smelt

Delta smelt typically experience the highest mortality rate during the early life stage and lower mortality rate during the juvenile/sub-adult life stage before spawning occurs in the following spring and essentially all adults die off (Figures 6 and 7). The probability of survival of different life stages of Delta smelt has been explored using nonlinear state-space modeling (Polansky et al. 2020). Survival is influenced by covariates related to abiotic habitat conditions (e.g., temperature, X2 position, outflow, turbidity) and biological factors (e.g., prey availability, competitors, predators; Polansky et al. 2020, Web Appendix C Table C.1). Post-larval survival was influenced by outflow and turbidity; juvenile survival by turbidity and temperature; and sub-adult survival by turbidity in the south Delta, OMR, and adult striped bass (*Morone saxatilis*, Polansky et al. 2020). Delta smelt adult equivalent units were used to estimate the percent mortality of eggs, larvae, and juveniles (Table 2, Figure 6). It is unclear what life stage proportional improvement in survival would yield the highest population growth rate, as such analysis has yet to be done. However, Smith et al. (2021) found substantial variation in fall mortality in years 1995–2015, which suggests that management actions to reduce Delta smelt demographic bottlenecks in earlier part of the year may be worth pursuing.

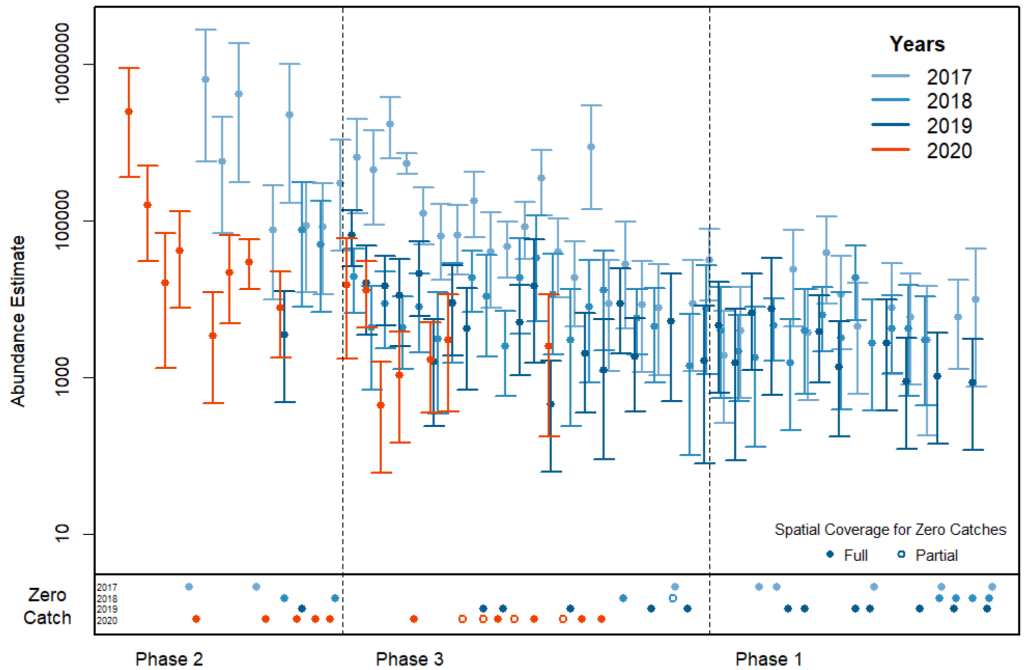

Figure 6. Weekly Delta Smelt Abundance Estimates from Enhanced Delta Smelt Monitoring Program (EDSM) between 2017 and 2020.

Years indicates the years in which each Delta smelt cohort was born. Phase 1 of EDSM runs from December through March and focuses on adult Delta smelt. Phase 2 sampling takes place from April through June and targets post-larval and juvenile Delta smelt. Phase 3 runs from July through November and targets juvenile and sub-adult Delta smelt. Closed circles indicate normal sampling effort for the week and open circles indicate a reduced sampling effort. Summer and Fall of 2020 (Phase 2) had multiple weeks with incomplete spatial coverage due to wildfire smoke/hazardous air quality.

Table 2. Delta smelt adult equivalent units for different life stages (L. He, USFWS, personal communication).

Life Stage	Size Range (mm FL)	Adult Equivalent
Eggs	~1	5824
Larvae	< 20	116
Juvenile	20-58	10
Adult	> 58	1

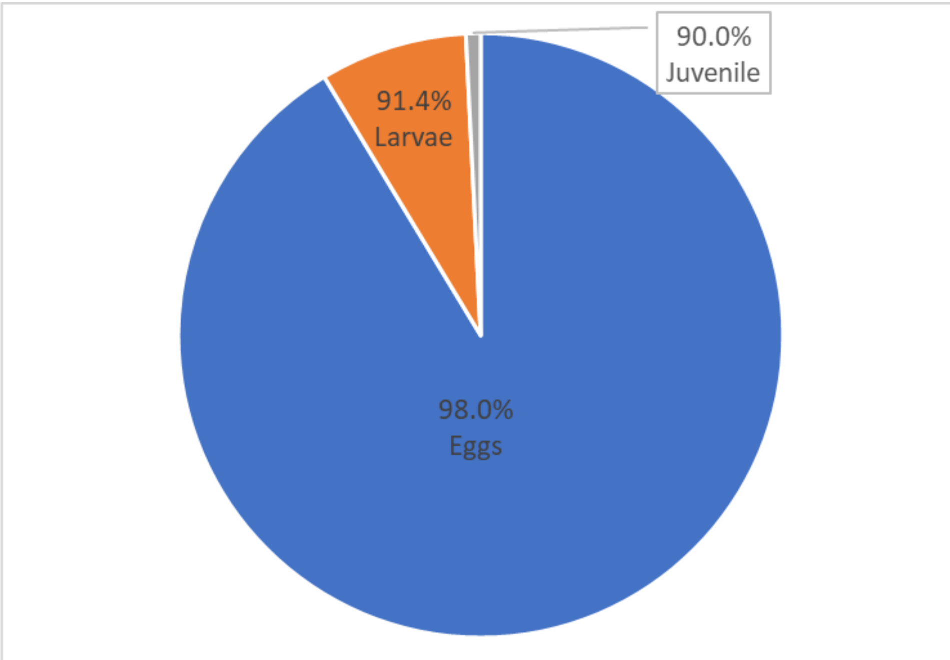

Figure 7. Delta Smelt Mortality by Life Stage Based on the USFWS Adult Equivalents for Each Life Stage

6.5 Green Sturgeon

Lifecycle statistics were not available for green sturgeon.

6.6 Killer Whale

Killer whale analyses are under development.

7. Conclusions

The initial alternatives in this report provide a framework bounding the impacts, both beneficial and adverse, of potential actions for the LTO. This report also introduces the tools available for analysis in the Draft Environmental Impact Statement. Reclamation has applied several these tools to the initial alternatives, and will continue to refine the analyses. The Public Draft EIS for the LTO will consider a reasonable range of alternatives that will be developed using the insights from this report. The next steps include refining conservation measures for listed species, and potentially combining different options.

Reclamation will continue to evaluate options in coordination with state and federal agencies, public water agencies, and interested parties. Reclamation anticipates that the Public Draft EIS alternatives will include, but not necessarily be limited to, an agency consensus alternative and one or more NGO alternatives, public water agency alternatives, and public comment alternatives.

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